Semiconductor Supply and Pricing Worldwide—SSPS-WW

Check to Re-order	Document Code	Publication Date	Document Title
Tab: Perspective			
❑	SSPS-WW-DP-9801	January 19, 1998	First Quarter 1998 Procurement Pulse and 1997 in Review: As Order Rates Stabilize, Lead Times Flatten and Inventories Bounce, while Spot Prices Dive
❑	SSPS-WW-DP-9802	February 23, 1998	1998 Semiconductor Cost Model Update
❑	SSPS-WW-DP-9803	April 6, 1998	1998 Second Quarter Price Forecast Highlights: Continued Oversupplies Keep Prices on a Downward Slope
❑	SSPS-WW-DP-9804	April 20, 1998	Second Quarter 1998 Procurement Pulse: Order Rates Plateau, Lead Times Flatten, Inventories Moderate, and Spot Prices Slip into Darkness
❑	SSPS-WW-DP-9805	June 15, 1998	Central and Eastern European Semiconductor Usage Trends
❑	SSPS-WW-DP-9806	June 22, 1998	North American Semiconductor Price Outlook, Third Quarter 1998
❑	SSPS-WW-DP-9807	July 20, 1998	Third Quarter 1998 Procurement Pulse: Order Rates Seesaw, Inventories React, Lead Times Remain Flat, and Spot Prices Bounce at/below Cost
❑	SSPS-WW-DP-9808	September 7, 1998	Semiconductor Inventory Holding Analysis
❑	SSPS-WW-DP-9809	September 21, 1998	1998 Fourth Quarter Price Forecast Highlights: The Skinny on the Slump
❑	SSPS-WW-DP-9810	November 9, 1998	Fourth Quarter 1998 Procurement Pulse: Order Rates Slip, Inventories Rebound, Lead Times Remain Flat, and Spot Prices Flatten (below Cost)
Tab: Market Statistics			
❑	SSPS-WW-MS-9801	March 23, 1998	North American Semiconductor Price Outlook, Second Quarter 1998
❑	SSPS-WW-MS-9802	April 27, 1998	Final 1997 Worldwide Semiconductor Market Share
❑	SSPS-WW-MS-9803	June 29, 1998	North American Semiconductor Prices, Third Quarter 1998
❑	SSPS-WW-MS-9804	November 9, 1998	North American Semiconductor Prices, Fourth Quarter 1998
Tab: Reports			
❑	SSPS-WW-FR-9801	February 2, 1998	Focus Study: 1998 Semiconductor Industry Capital Spending Overview
❑	SSPS-WW-FR-9802	August 24, 1998	Semiconductor Analysis: Product/Market Update
❑	SSPS-WW-UW-9801	September 7, 1998	1998 Semiconductor User Wants and Needs: Save Me the Money

Dataquest

Global

IT Market

Insight

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.

Key Business Issues

Want to learn more about Dataquest?

Please visit our Internet web site at

www.dataquest.com

The Semiconductor Supply and Pricing program provides advice and analysis to help clients make successful business decisions. Publications include a mix of analytical articles, weekly news bulletins and event-driven faxes, focused reports, and timely market statistics published on a regular schedule throughout the year.

Briefings and conference presentations bring clients together with analysts to share insights and opinions.

Key business issues covered throughout the year in our publications and briefings will include:

- How can the best methods of semiconductor inventory management be implemented?
- How are VOC programs evolving throughout the electronics industry?
- How is semiconductor pricing changing throughout the world?
- How far will the contract manufacturing trend go? Are companies' destinies at stake?
- How can semiconductor cost models be used to get the best price and product?
- How are product and technology changes in the semiconductor industry affecting users?
- What does TCO mean and how is it being handled by different companies?
- What are the reasons for supply base management and the user implications?

Market Coverage

Quarterly Price Forecasts

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

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

Geographic Coverage

- Americas
- Western Europe
- Asia/Pacific
- Japan
- Worldwide

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 inventory levels

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 analyses are provided for:

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

WHAT YOU WILL RECEIVE AS A CLIENT

SEMICONDUCTOR SUPPLY AND PRICING WORLDWIDE

Perspectives

Dataquest Perspectives: These research documents provide analysis and commentary on key technologies, companies, products, market opportunities, events, trends, and strategic issues in semiconductors and procurement. A minimum of 12 Dataquest Perspectives will be delivered to you on a regular schedule throughout the year, including product/market updates and a quarterly procurement pulse. ***Published Monthly Throughout 1998***

Market Trends

Semiconductor Five-Year Forecast Trends Reports: These reports give a comprehensive review of key semiconductor trends by region and by product family. ***Q2 and Q4 1998***

Worldwide Semiconductor Forecast: Five-year revenue forecasts for the global semiconductor market by region. ***Q2 and Q4 1998***

Guides

Each Dataquest research program publishes an annual Market Segmentation Guide to assist clients in understanding its market segmentation scheme. In addition, clients receive an annual guide to Dataquest's research methodology.

Electronic News

News and analysis delivered directly to your desktop

DQ Monday Report: Top news and commentary on semiconductor industry events and issues with a monthly snapshot of semiconductor pricing for 25 key semiconductors in six regions. ***Available Weekly via Internet E-mail***

Dataquest Alerts: These fax bulletins provide analysis of fast-breaking news, events, or announcements in the market, as they unfold. ***Event-Driven Faxes***

Inquiry Support

Personalized inquiry support is a primary component of your annual subscription program. Dataquest analysts work with you to tailor the program to meet your needs.

Information Resource Centers

Clients may visit Dataquest information resource libraries worldwide to perform their own research using our extensive print and online resource collections.

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 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. ***Q2 1998***

Reports

Focus Report—Capital Spending: Provides a summary of the latest trends in capital spending and how they affect semiconductor users. ***Q1 1998***

Focus Report—Semiconductor Product and Market Update: Provides a concise update of all the major semiconductor product families with life cycle analysis, supplier rankings, and alliance information critical to sourcing semiconductors in today's changing market. ***Q3 1998***

User Wants and Needs Report—Semiconductor Procurement: In conjunction with our European analysts, we will provide a comprehensive analysis of what is critical to semiconductor users in the areas of technology, product, packaging, and supplier likes/dislikes. ***Q3 1998***

Focus Report—Contract Manufacturing: Provides an overview of the likes and dislikes of current contract manufacturing (CM) customers as well as looking at how CM size and the global marketplace impact OEM semiconductor procurement organizations. ***Q4 1998***

Conferences and Briefings

Semiconductors '98, this year's annual Semiconductor Group conference, will be held in San Diego, California on October 19-21, 1998. Contact GartnerGroup Events at 1-800-778-1997 for more information. Conference seat is priced separately.

Dataquest
A Gartner Group Company

Corporate Headquarters
251 River Oaks Parkway
San Jose, CA 95134-1913
United States
Phone: 1-408-468-8000
Fax: 1-408-954-1780
Web site: www.dataquest.com

Boston Area
Nine Technology Drive
P.O. Box 5093
Westborough, MA 01581-5093
United States
Phone: 1-508-871-5555
Fax: 1-508-871-6262

United Kingdom
Tamesis
The Glanty
Egham
Surrey TW20 9AW
United Kingdom
Phone: +44 1784 43 1611
Fax: +44 1784 48 8980

Asia/Pacific
Suite 5904-7, Central Plaza
18 Harbour Road
Wan Chai
Hong Kong
Phone: 852-2824-6168
Fax: 852-2824-6138

Japan
Aobadai Hills 4-7-7
Aobadai
Meguro-ku
Tokyo 153
Japan
Phone: 813-3481-3670
Fax: 813-3481-3644

Dataquest
A Gartner Group Company

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

January 1998

Dear Dataquest Client,

Best wishes for the festive season and welcome to 1998! This is destined to be a year of exciting changes in the IT industry, and we are looking forward to working closely with you to make it your best year ever.

Like the industries we track, Dataquest is always evolving to keep pace with the times. I am writing to inform you of some of the important changes we have made to better serve you — our valued client — in 1998.

First, you will notice a change to our binder distribution procedures this year —

It has been our policy in past years to provide clients with new research program binders every January. However, because more and more of our clients are moving to electronic delivery via our web site and CD-ROM, binders are becoming less important for filing and retrieving our research publications than in the past. In recognition of this trend, beginning this year we are moving to an "evergreen" binder which is reused year upon year. This means that you will use your current binder to house your 1998 DQ document collection. A binder spine, tab dividers, and instructions for updating your binder are provided in this mailing.

Second, please look for your "DQ Archive CD-ROM" in January * —

Toward the end of January, you will receive your *DQ Archive CD-ROM*. This customized tool — created just for you — will house electronic copies of documents published through December 1997 for all of the research programs to which you subscribed during that year. We believe that this CD-ROM will serve as a handy electronic archive whenever you need to look back at a document from 1997, and will enhance your productivity in using past issues of Dataquest's market research publications. (* Current clients of our CD-ROM will receive this archive CD as part of the normal, monthly CD-ROM mailing.)

Third, we are improving our publishing system in 1998 —

I am pleased to announce that we will be moving to continuous publishing during 1998 — a tremendous step forward for Dataquest. As our research documents are released from editing, this automated publishing system converts them to web, CD-ROM, and paper formats with only minor intervention required by our Interactive Services staff. The benefit to you is that documents are published more quickly and efficiently in hard copy format, and reach the web site more rapidly.

Lastly, we will be introducing our new brand identity —"Gartner Market Dynamics"—
All companies in the GartnerGroup family will reflect a new corporate brand identity, which will roll out over the course of 1998. We will continue to be called ***Dataquest,*** but you will also see us referred to as a part of Gartner Market Dynamics, the market research arm of Gartner's Advisory Services. You will see this branding reflected as we update our letterhead and marketing collaterals during the year.

So, you can see that 1998 is going to be a year of changes for Dataquest. By streamlining operations and introducing you to electronic delivery via the *DQ Archive CD-ROM*, we are positioning Dataquest to better serve you — now and in the future.

As always, I welcome your comments and feedback on Dataquest directions.

Sincerely,

R. Andrew Holtvedt

R. Andrew Holtvedt
President of Dataquest and Senior Vice President, GartnerGroup

Binder Update Instructions

Attached you will find the 1998 binder spine, tabs, and marketing materials/datasheet for the Dataquest research program to which you currently subscribe. To prepare your current binder to receive the new research publications we will send you during 1998, please follow these instructions:

Move 1997 materials to storage:

1. Remove the 1997 binder spine.
2. Open your 1997 binder and remove all contents, including tabs.
3. Move these publications into storage, as desired.

Prepare binder to receive 1998 publications:

1. Insert the new 1998 spine.
2. Insert the new tabs into binder.
3. Place the program datasheet and marketing materials into the front binder pocket, for future reference.
4. As you receive your 1998 Dataquest Perspectives, Market Statistics books, and special reports from this program throughout the year, use this binder to file and organize these publications, as usual.

PLEASE NOTE: If for any reason you require a new binder (your old one is damaged or lost), please use the attached ***FaxBack*** form to order a new one. Just fill it out, fax it to the number listed on the form, and we will be happy to send you a replacement binder.

Binder Request — FaxBack

To: GartnerGroup Production Department
City: Stamford, Connecticut
Country: U.S.A
FAX #: + 203-975-9029

If you require a replacement Dataquest binder, please fill out this form and return it to the fax number listed above. Your binder will be shipped to you promptly.

Thank you for helping us to serve you better.

Name of Dataquest research program for which you need a binder:
(Must be filled in so that we will know what size binder to mail you.)

____

Your Name: ______________________________

Company: ______________________________

Street Address: ______________________________

____

____

City: ________________ State/Province: ________________

Country: ________________ Postal/Zip Code: ________________

Telephone: ________________ Fax: ________________

GartnerGroup Production Dept.
1 Barry Place
Stamford, CT, 10212, USA

Dataquest

Global

IT Market

Insight

1998 RESEARCH PROGRAMS

From semiconductors to systems, software to services, telecommunications to document management, Dataquest's research programs provide clients with a clear view of the relationships among information technology segments—relationships that can have a profound impact on making successful strategic planning and development decisions.

Computer Systems and Peripherals

Computer Systems
- Computer Systems & Servers *Worldwide*
- Computer Systems & Servers *Europe*
- Servers *Europe*
- Intranet & Web Servers *Worldwide*

Workstations
- Advanced Desktops & Workstations *Worldwide*
- Advanced Desktops & Workstations *Europe*

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

Personal Computing
- Personal Computers *Worldwide*
- Personal Computers *Europe*
- Personal Computers *Central & Eastern Europe*
- Personal Computers *Asia/Pacific*
- Mobile Computing *Worldwide*

PC Technology Directions
- Desktop PC Technology Directions *Worldwide*
- Mobile PC Technology Directions *Worldwide*

Distribution Channels
- Distribution Channels *Worldwide*
- PC Distribution Channels *Europe*
- PC & Printer Distribution Channels *Asia/Pacific*

Consumer Research
- The Digital Consumer *United States*
- The Home Technology Scorecard *United States*

Quarterly Statistics
- Advanced Desktops & Workstations Q-Stats *Worldwide*
- Advanced Desktops & Workstations Q-Stats *Europe*
- Servers Quarterly Statistics *United States*
- Servers Quarterly Statistics *Europe*
- Servers Quarterly Statistics *Japan*
- PC Quarterly Statistics *United States*
- PC Quarterly Statistics *Latin America*
- PC Quarterly Statistics *Europe*
- PC Quarterly Statistics *Japan*
- PC Quarterly Statistics *Asia/Pacific*
- PC Quarterly Statistics *Worldwide by Region*
- Global PC Forecast & Shipments Quarterly Statistics

Online, Multimedia, and Software

Emerging Technologies
- Internet & Enterprise Strategies *Worldwide*
- Digital Commerce *Worldwide*
- Multimedia *Worldwide*

Tools, Databases, System Management
- Database & Data Warehousing *Worldwide*
- Development Tools & Middleware *Worldwide*
- Network, System, & Storage Management *WW*
- Client/Server Software *Europe*

Productivity
- Collaborative Computing *Worldwide*
- Personal Computing Software *Worldwide*

Technical Applications
- AEC & GIS Applications *Worldwide*
- Electronic Design Automation *Worldwide*
- Mechanical CAD/CAM/CAE *Worldwide*

Regional Market Statistics
- AEC & GIS Applications *Europe* and *Asia/Pacific*
- Electronic Design Automation *Europe* and *Asia/Pacific*
- Mechanical CAD/CAM/CAE *Europe* and *Asia/Pacific*

IT Services

Product Services
- Hardware Services *North America*
- Hardware Services *Europe*
- IT Services *Japan (Japanese language program)*
- Software Integration & Support Services *NA*
- Software Integration & Support Services *Europe*
- Network Integration & Support Services *NA*
- Network Integration & Support Services *Europe*
- Network Integration & Support Services *A/P*

Market Statistics
- IT Services Market Statistics *Worldwide*

Business Services
- Consulting & System Integration *North America*
- Consulting & System Integration *Europe*
- Life Cycle Management Services *North America*
- Life Cycle Management Services *Europe*
- Outsourcing Services *North America*
- Outsourcing Services *Europe*
- Professional Services Trends *Asia/Pacific*
- Vertical Market Opportunities *North America*
- Vertical Market Opportunities *Europe*
- Strategic Marketing & Service Partnerships *North America*

1998 DATAQUEST RESEARCH PROGRAMS

Document Management

Copiers
- Copiers *North America*
- Copiers *Europe*

Printers
- Printers *North America*
- Printers *Europe*
- Printer Distribution Channels *Europe*

Digital Document Management
- Facsimile & Multifunctional Products *North America*

Quarterly Statistics
- Printer Quarterly Statistics *United States*
- Printer Quarterly Statistics *Europe*
- Printer Quarterly Statistics *Asia/Pacific*

Semiconductors

Regional Markets
- Semiconductors *Worldwide*
- Semiconductors *Europe*
- Semiconductors *Japan*
- Semiconductors *Asia/Pacific*
- Semiconductors *China*

Devices
- ASIC/SLI *Worldwide*
- Embedded Microcomponents *Worldwide*
- Memories *Worldwide*
- DRAM Supply & Demand Quarterly Statistics *Worldwide*

User Issues
- Semiconductor Supply & Pricing *Worldwide*

Application Markets
- Semiconductor Application Markets *Worldwide*
- Semiconductor Application Markets *Europe*
- Semiconductor Application Markets *Asia/Pacific*
- Communications Semiconductors & Applications *Worldwide*
- Consumer Multimedia Semiconductors & Applications *Worldwide*
- PC Semiconductors & Applications *Worldwide*
- Electronic Equipment Production Monitor *Europe*
- Teardown Analysis Reports

Manufacturing
- Semiconductor Equipment, Manufacturing, & Materials *Worldwide*
- Semiconductor Contract Manufacturing Services *Worldwide*

Telecommunications and Networking

Networking
- Networking *Worldwide*
- Networking *Europe*
- Networking *Japan*
- Network Distribution Channels *Europe*

Internet and Remote Access
- Remote LAN & Internet Access *Worldwide*
- Remote LAN & Internet Access *Europe*
- Internet Infrastructure *Worldwide*

Quarterly Statistics
- LAN Quarterly Statistics *Europe*
  - Hubs Quarterly Statistics *Europe*
  - Switches Quarterly Statistics *Europe*

Voice Systems
- Voice Systems Worldwide
- Voice Systems *North America*
- Voice Systems *Europe*
- Call Centers *North America*

Public Networking
- Public Network Services & Infrastructure *Worldwide*
- Public Network Services & Infrastructure *Asia/Pacific and Japan*
- Public Network Services & Infrastructure *Latin America*
- Public Network Infrastructure *North America*
- Public Network Infrastructure *Europe*
- Public Network Management *Worldwide*
- Public Telephony Services *North America*
- Public Telephony Services *Europe*
- Public Data Services *North America*
- Public Data Services *Europe*

Mobile Communications
- Mobile Communications *Asia/Pacific and Japan*
- Mobile Communications Services & Infrastructure *North America*
- Mobile Communications Services & Infrastructure *Europe*
- Mobile Communications Terminal Devices *North America*
- Mobile Communications Terminal Devices *Europe*

Demand-side Research

East Consulting
- Data Communications *Asia/Pacific*
- Value Added Networking *Asia/Pacific*
- Voice Communications Asia/Pacific

Consumer Research
- MIS Database Asia/Pacific
- IT InSite Asia/Pacific

Cross-Technology Programs

Technology Insights for:
- Financial community
- Government agencies
- Publishing, media, and consulting firms
- IT business development or financial organizations
- IS and purchasing organizations
- IT supporting industries

Dataquest
A Gartner Group Company

Corporate Headquarters
251 River Oaks Parkway
San Jose, CA 95134-1913
United States
Phone: 1-408-468-8000
Fax: 1-408-954-1780
Web Site: www.dataquest.com

Boston Area
Nine Technology Drive
P.O. Box 5093
Westborough, MA 01581-5093
United States
Phone: 1-508-871-5555
Fax: 1-508-871-6262

United Kingdom
Tamesis
The Glanty
Egham
Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431611
Fax: +44 1784 488980

Asia/Pacific
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852 2824 6168
Fax: 852 2824 6138

Japan
Aobadai Hills 4-7-7
Aobadai
Meguro-ku
Tokyo 153
Japan
Phone: 81-3-3481-3670
Fax: 81-3-3481-3644

 Program Code: DQWW-WW Programs are subject to change. MKTG 1/98 (PSB)

1998 United States Conference Calendar

(Accurate as of October 1, 1997, and subject to change without notice)

DATE	TITLE	LOCATION
December 8-10, 1997	The Next-Generation Operations Center: Much More Than Mainframes	Scottsdale, AZ
March 30-April 1, 1998	Lowering TCO: Controlling the Business Investment	Palm Springs, CA
April 29-May 1, 1998	Supply Chain Management	Nashville, TN
April	Remote Access: Building and Managing the Workplace of the Future	TBD
April 7-9	GartnerGroup Predicts: The IT Marketplace	San Diego, CA
May 4-5	Service Trends *presented by GartnerGroup's Dataquest*	La Jolla, CA
May 11-13	GartnerMeasurement: Continuous Improvement of IT	Orlando, FL
May 11-13	Enterprise NT: Can Microsoft Deliver?	San Francisco, CA
May 18-20	Storage '98	Scottsdale, AZ
June 8-9	IT Asset Management: Navigating from Acquisition to Obsolescence	Scottsdale, AZ
June 10-11	SWAMI '98: Charting Rough Waters (Software Asset Management Interest Group)	Scottsdale, AZ
June 10-11	Storage Track *presented by GartnerGroup's Dataquest*	Monterey, CA
June 10-12	Information Security: Securing the Infrastructure, Securing the Future	Chicago, IL
June 24-26	IT Management: Getting Maximum Leverage and Value from IT Investments	La Jolla, CA
September 16-18	Enterprise Software Systems *(formerly CPP)*	Chicago, IL
October 19-21	Semiconductors '98 *presented by GartnerGroup's Dataquest*	San Diego, CA
October 12-16	Symposium/ITxpo 98	Lake Buena Vista, FL
October 21-23	Symposium/ITxpo 98	Tokyo, Japan
October 26-28	Symposium/ITxpo 98	Brisbane, Australia
November 2-5	Symposium/ITxpo 98	Cannes, France
December	17th Annual Data Center Conference	Scottsdale, AZ

April 27-29	Internet and Electronic Commerce Conference and Exposition *(Sponsored in part by Expocon Management Associates, Inc.)*	New York, NY
June 15-19	The AS/400 Environment: Opportunities, Risks and Strategies *(Sponsored in part by DCI)*	Chicago, IL
TBD	Technology-Enabled Sales, Marketing & Customer Service Conference and Exposition *(Sponsored in part by Expocon Management Associates, Inc.)*	TBD
TBD	i + e: intranet and extranet Conference and Exposition *(Sponsored in part by Expocon Management Associates, Inc.)*	TBD

Registration/ Information Request Form

___ Yes, register me now.
___ This is a confirmation of my telephone registration.
___ Please send me information on the following event(s) as it becomes available.

Conference Title **Conference Date**

____

____

____

Name:______________________________ Title:______________________________

Company:____

Address:____

City:______________________________ State:______________ Zip:______________

Country:____

Telephone:______________________________ Fax:______________________________

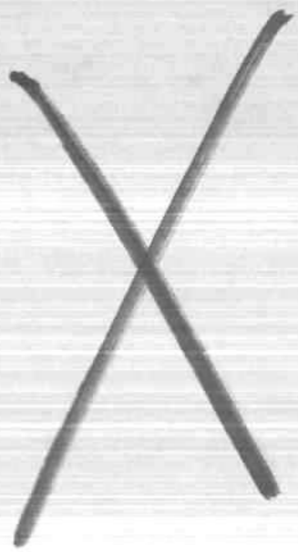
FAX No.:
1-800-778-1998 or +1 203-316-6774 Attn.: Ashley Pearce

TELEPHONE No:
1-800-778-1997 or +1 203-316-6757 Attn.: Ashley Pearce

MAIL:
Attn: Ashley Pearce
GartnerGroup
56 Top Gallant Road, P.O. Box 10212
Stamford, CT 06904-2212

For a full listing of 1998 conferences and to receive detailed information as it becomes available, visit www.gartner.com, click on "Conferences" and then complete the "Mailing List" form; or call 1-800-778-1997 or +1-203-316-6757. Or complete this information request form and fax it to 1-800-778-1998 or +1-203-316-6774.

 USSC 971028



Perspective

Semiconductor Supply and Pricing Worldwide

Technology Analysis

How Many Microprocessors Does It Take to Surf the Net?

Abstract: *Dataquest examines what all those microprocessors hidden in the Internet's infrastructure actually do, by following the path of a data packet through the Internet. This report uses 30 years of history in computing and communications to extrapolate the outlook for the next 30 years. This Perspective comes to you courtesy of the Embedded Microcomponents Worldwide program.*
By Nathan Brookwood

Dataquest Has a New Neighbor

Two years ago, Cisco Systems Inc. purchased a 139-acre site that partially abuts Dataquest's San Jose headquarters. One year ago, it began construction of a 19-building, 3.3 million-sq. ft. campus, to augment the 1.7 million sq. ft. of office space it has built over the past four years. In much the same way as Cisco's products stream data into the high-capacity communications lines that drive the Internet, the company's construction proceeds in a highly pipelined manner. Specialized crews move from building to building. It took 12 months for the company to fill the construction pipeline. The site preparation crew has progressed to Building No. 13, immediately behind Dataquest. As employees move into Building No. 1, landscapers plant trees by Building No. 2, painters and electricians complete Building No. 3, and so on. For the next 18 months, new buildings will emerge at the rate of one per month, even though it takes 12 months to complete each of the buildings.

As this Dataquest analyst looked up from the Dataquest Interactive (DQi) display on the computer screen in his office and watched the bulldozers reshape the landscape, he realized that his research activities and Cisco's construction efforts were highly intertwined. The need to build out Internet bandwidth, facilitating access to Web sites such as DQi, drives much of

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
ProductCode: SSPS-WW-DP-9811
PublicationDate: November 30, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

Cisco's growth. Cisco's routers consume large numbers of high-end embedded microprocessors, as Dataquest noted in an earlier report, *Pushing the Envelope: Performance-Starved Embedded Applications* (MCRO-WW-DP-9708).

Dataquest anticipates that Internet service providers (ISPs) will purchase $4.3 billion of communications hardware in 1998. This revenue figure is projected to show a compound annual growth rate (CAGR) of 22 percent through 2002, as indicated in Table 1. Table 2 shows semiconductor consumption in LANs and routers. Networking hardware sold to ISPs and corporations is projected to consume almost $4 billion worth of semiconductors in 1998, growing to $6.2 billion in 2001. Overall, companies building networks for their own use, or to carry other companies' traffic, spent about $5.8 billion on routers in 1997, as detailed in Table 3. These devices come with hefty price tags. ISPs and corporations deploy $75,000 routers in the same casual manner as Cisco drops 150,000-sq. ft. buildings onto San Jose's landscape.

Why does the Internet need so much hardware to transport data from an office in San Jose to the Web site of Gartner Group Inc. in Colorado? And why, given the explosive growth of the Internet, does Dataquest project flat sales for the high-end routers that power today's Internet and absorb so many high-end embedded processors?

Table 1
Sales of Internet Access Equipment to ISPs (Millions of Dollars)

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Access Concentrators	420.8	643.5	1,093.1	1,511.3	2,002.4	2,485.7	3,045.7	36
Remote Access Servers	96.5	68.0	121.9	126.4	125.5	120.1	108.1	10
100-Mbps Ethernet Hubs	5.4	9.1	9.4	11.9	15.6	20.6	23.9	21
100-Mbps Ethernet Switches	119.6	593.3	1,100.0	1,601.9	1,930.8	2,115.8	2,181.6	30
10-Mbps Ethernet Hubs	2.1	1.7	1.3	1.1	1.0	0.8	0.8	-14
10-Mbps Ethernet Switches	97.3	117.4	160.7	160.4	181.5	215.6	241.7	16
Route Switch (Layer 3 Switches)	-	154.4	244.0	388.0	611.1	885.3	1,099.9	48
High-End Routers	794.9	810.0	868.2	963.4	1,048.2	822.4	804.0	0
Midrange Routers	248.8	205.2	174.3	167.9	164.2	142.7	152.2	-6
Branch Office Routers	219.4	258.5	257.8	325.6	416.4	485.7	505.2	14
Frame Relay	65.4	88.5	112.7	122.7	124.2	117.2	109.0	4
ATM Backbone Switches	20.4	50.5	60.6	89.1	114.9	133.9	154.0	25
FDDI Switches	123.7	60.6	119.3	129.9	120.0	90.4	65.6	2
FDDI Hubs	45.3	23.1	22.6	19.5	16.3	11.3	7.7	-20
Total	**2,259.6**	**3,083.8**	**4,345.9**	**5,619.1**	**6,872.1**	**7,647.5**	**8,499.4**	**22**

Source: Dataquest (November 1998)

Table 2
Semiconductor Consumption in LANs and Routers (Millions of Dollars)

Application	Device Category	1996	1997	1998	1999	2000	2001	CAGR (%) 1996-2001
Router	MPU/MCU	102.2	122.8	170.0	220.4	281.4	341.5	27.3
Router	System Functions	207.3	243.3	322.7	419.0	513.7	624.7	24.7
Router	ASSP	57.1	68.5	90.8	117.6	144.0	174.7	25.1
Router	ASIC	149.8	173.6	230.0	298.1	364.8	442.7	24.2
Router	Other	512.4	462.7	518.6	639.2	757.2	776.4	8.7
Router	Subtotal Router	821.9	828.8	1,011.3	1,278.6	1,552.3	1,742.6	16.2
LAN	MPU/MCU	199.8	246.0	312.8	381.0	454.6	527.9	21.5
LAN	System Functions	1,077.5	1,364.9	1,634.6	1,872.3	2,039.1	2,180.1	15.1
LAN	ASSP	675.2	844.2	980.9	1,106.5	1,206.4	1,294.5	13.9
LAN	ASIC	401.8	519.5	651.8	762.5	827.8	878.5	16.9
LAN	Other	949.9	885.2	1,014.9	1,271.3	1,583.0	1,737.8	12.8
LAN	Subtotal LAN	2,227.2	2,496.1	2,962.3	3,524.6	4,076.7	4,445.8	14.8
All	**Total LAN/Router**	**3,049.1**	**3,324.9**	**3,973.6**	**4,803.2**	**5,629.0**	**6,188.4**	**15.2**

Source: Dataquest (September 1997)

Life in the Pre-Microprocessor Era

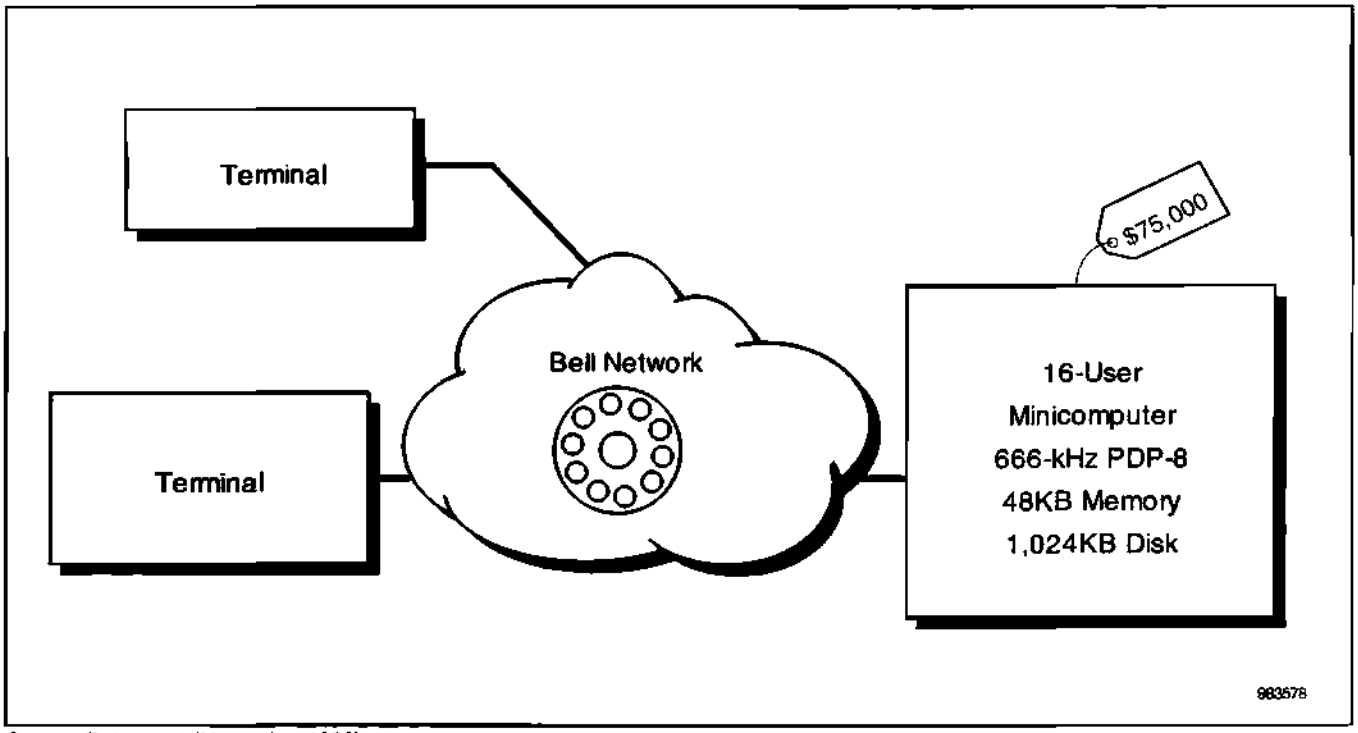
The analyst could recall an earlier time, when data traveled with far less electronic assistance, albeit at somewhat lower transmission rates. In 1968, long before becoming an analyst, he had often accessed a time-shared minicomputer located in Maynard, Massachusetts, from his home a few miles away. The minicomputer, a 48KB PDP-8, with almost a megabyte of hard disk storage, ran at 660 kHz, sold for approximately $75,000, and supported 16 simultaneous users. It was considered a bargain in its day. His teletype terminal contained an incredible array of gears and linkage arms, printed at 10 characters per second, and sold for $800. The telephone company (there was only one) had not yet replaced the area's mechanical crossbar switch with a more modern equivalent (its 40-year depreciation cycle had a few more years to run). He could hear the switch click as it connected his rotary-dial phone with the remote computer. Figure 1 illustrates how things worked in this much simpler era.

Table 3
The 1997 Router Market

	Revenue ($M)	Units (K)	ASP ($)
High-End	2,556.80	34.1	74,979
Midrange	1,483.00	110.6	13,409
Branch Office	1,731.70	792.3	2,186
Total	**5,771.50**	**937.0**	**6,160**

Source: Dataquest (November 1998)

Figure 1
Data Communications Network, Circa 1968



Source: Dataquest (November 1998)

Back then, as the analyst depressed the keys on his keyboard, gears whirred. Mechanical brushes swept a rotating disk and generated the bits for each character going down the line. A 110-bps modem, for which the telephone company charged $35 per month, converted the bits into tones and pushed them into the network. (Forget autodial; that was not available at any price.) At the other end of the line, a modem attached to the minicomputer converted the data back into bits. The minicomputer's main (and only) processor converted these bits into characters. To accomplish this, it set aside its computing activities 550 times each second and checked each incoming data line for the bits that made up a character. This task alone consumed over 20 percent of the 660-kHz processor's power, but the alternative (to implement this activity in hardware) would have been prohibitively expensive. One hundred milliseconds after a key was depressed, the character arrived at the host system. Software at the host accepted the character, generated a response, and sent its output down the same torturous path back to the terminal. At best, this round-trip took 200 milliseconds (100 each way), and usually a lot longer. When all went well, the entire ensemble chugged along at the impressive rate of 10 characters per second. In the course of the entire transaction between terminal and minicomputer, only one programmable device (the minicomputer's processor) ever touched the data.

It cost a lot to build programmable devices prior to the invention of the microprocessor. Consequently, not many programmable devices were built, and not many semiconductor devices were needed to build them. Dataquest estimates that 1968 worldwide semiconductor revenue totaled approximately

$1.47 billion. In the following 30 years, innovations such as the microprocessor allowed the industry to maintain a 16.6 percent CAGR, leading to total revenue of $147 billion in 1997.

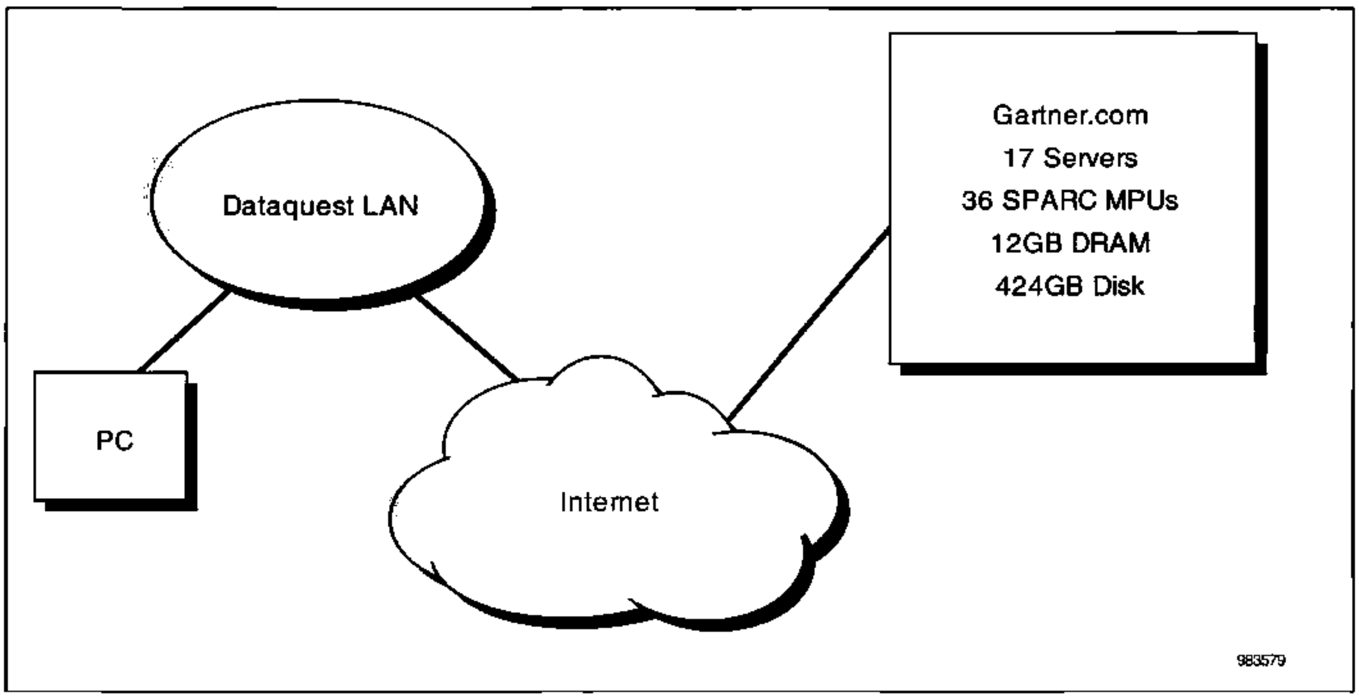
How It's Done Now

In an attempt to understand why today's data networks require so much more hardware than those of yore, the analyst undertook a bold experiment. He allowed himself to be digitized and entered his personal computer. There he hopped onto the packet that signaled the click of his mouse and traveled through the computer, through Dataquest's LAN, and through the Internet, until he arrived at the Gartner Web site (www.gartner.com). On his arrival, he immediately boarded an outbound packet and returned via the Internet to his system's display monitor, where he appeared briefly as "nbrookwood.gif." Once back in San Jose, he exited the system and was restored to his original carbon-based life form. Figure 2 illustrates his overall journey, which consumed a total of 82 milliseconds. Table 4 identifies the major stops along the way. The remainder of this document reflects his observations regarding the microprocessors, microcontrollers, and unusual ASICs he saw on his journey through a small portion of today's electronic universe.

Inside the Computer and in the LAN

A microcontroller inside the mouse transmits the click to the specialized microcontroller on the PC motherboard that communicates with the keyboard and mouse. Following a brief stopover in the system's DRAM, the

Figure 2
Data Communications Network, circa 1998



Source: Dataquest (November 1998)

Table 4
The Packet's Itinerary

Hop	Transit Time (ms)	Elapsed Time (ms)	IP Address	Function	Equipment	Owner	Location	MPU Configuration
1	0	0	-	LAN Switch	Kalpana	Dataquest	San Jose	MIPS
2	1	1	206.79.111.239	Router	Cisco 2500	Dataquest	San Jose	68030
3	0	1	206.79.141.165	Firewall	Sun Ultra 1	Dataquest	San Jose	UltraSPARC
4	1	2	206.79.141.97	Router	Cisco 4500	Dataquest	San Jose	68030
5	2	4	206.40.94.93	Router	Cisco 2500	Exodus	Santa Clara	68030
6	0	4	207.82.200.77	Switch	Cisco 5500	Exodus	Santa Clara	MIPS
7	2	6	207.82.200.1	Core Router	Cisco 7513	Exodus	Santa Clara	MIPS R4000
8	0	6	209.1.169.17	Core Router	Cisco 7513	Exodus	Santa Clara	MIPS R4000
9	0	6	209.1.169.146	Border Router	Cisco 7505	Exodus	Santa Clara	MIPS R4000
10	1	7	209.1.169.234	Inter-Packet Exchange (IPX)	Cisco 7505	BBN	Santa Clara	MIPS R4000
11	1	8	4.0.1.62	Backbone	Cisco 7505	BBN	Oakland	MIPS R4000
12	15	23	4.0.1.134	Backbone	Cisco 7505	BBN	Denver	MIPS R4000
13	0	23	4.0.52.5	Backbone	Cisco 7505	BBN	Denver	MIPS R4000
14	18	41	4.0.208.254	IPX	Cisco 7505	BBN	Denver	MIPS R4000
15	0	41	204.131.250.41	Border Router	Cisco 7505	SuperNet	Denver	MIPS R4000
16	0	41	-	LAN Switch	Cabletron 9000	SuperNet	Denver	i960
17	0	41	205.168.252.209	Firewall	Sun Ultra 1	Gartner	Denver	UltraSPARC
18	0	41	-	LAN Switch	Xyplex 3140	Gartner	Denver	68060
19	0	41	204.133.127.68	Host	Sun Ultra 1	Gartner	Denver	UltraSPARC

Source: Dataquest (November 1998)

system's powerful x86 processor stuffs the click into a data packet and hands it to the system's Ethernet adapter, which pushes it onto a 10-Mbps switched Ethernet connection. A few hundred microseconds after the mouse clicked, the message signaling that event heads out of the PC onto Dataquest's LAN.

It takes roughly 50 microseconds for the packet to travel over the local Ethernet cable to a nearby wiring closet. There, a Kalpana Ethernet switch quickly shuttles it onto an upstream Ethernet connection to a small Cisco 4500 router in an adjacent building. Kalpana pioneered the switched Ethernet concept, and its boxes use ASICs that quickly move data between upstream and downstream connections. Shortly after Dataquest acquired its network, Cisco acquired Kalpana, as it has acquired many other successful networking startups. Traces of the Kalpana genealogy can be found in Cisco's newer Catalyst Ethernet switches. Traces of some Kalpana progenitors will likely find their way into the massive complex rising out of the dust behind Dataquest.

The 4500 router, controlled by a 40-MHz Motorola 68030 with 16MB of DRAM, collects traffic from all of Dataquest's on-site systems. Cisco still builds and markets systems that use these 68030 processors, although this chip ceased to be interesting in desktop applications more than six years ago. (Unlike the more fickle computational microprocessor market, where products come and go in two- or three-year cycles, some embedded design wins last forever.) The 4500 passes the packet to a Sun UltraSPARC workstation (150-MHz MPU, 512MB DRAM) that serves as a firewall. Firewalls monitor all packets passing between internal systems and the outside world and trap those that might cause trouble or compromise security. Most networks connected to the Internet use firewalls to preserve their own integrity. The UltraSPARC forwards the packet to a Cisco 2500 (containing a 20-MHz 68030 and 8MB of DRAM), which in turn pushes it onto a T-1 carrier line operating at 1.54 million bits per second. Lines such as this usually rent for $2,500 per month and link many buildings like Dataquest's to telephone central offices or to other building sites on a point-to-point basis. Local carriers charge for such lines by the mile and view such services as a healthy source of revenue. Dataquest's relatively short T-1 circuit is fairly inexpensive as communications channels go. No wonder the telecommunications companies (telcos) resist digital subscriber line (DSL) offerings that can provide the same bandwidth at prices well below $100 a month.

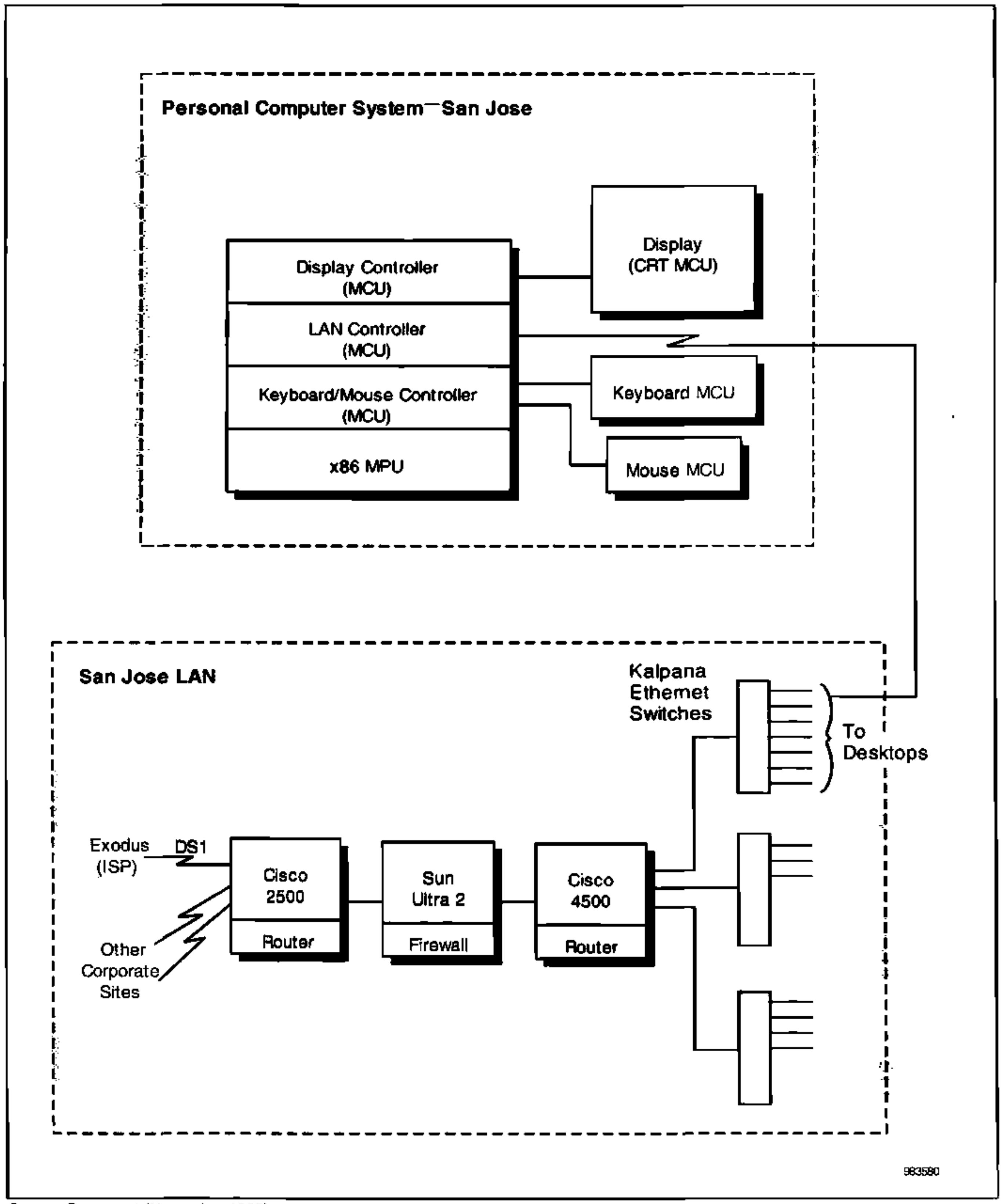
It has taken roughly 2 milliseconds for the packet containing the click to travel less than 200 yards from the mouse to the edge of the building. Eleven microcontrollers and four microprocessors have nudged it along the way. Figure 3 traces its path up to this point.

Through the Internet

It takes another 2 milliseconds for the packet to travel the few miles between Dataquest and Exodus Communications Inc., Dataquest's ISP. Many corporate Web sites (but not Dataquest's) physically reside at the Exodus site in Santa Clara, where they have affordable access to the high-speed links that tie Exodus to other Internet carriers.

The packet enters the Exodus on-site LAN via a Cisco 2500 router. The 2500 passes it to a Cisco 5500 Ethernet switch that aggregates data traveling to and from Exodus' on-site clients. The 5500, descended from the Kalpana switch mentioned earlier, contains a MIPS microprocessor, but depends on custom ASICs to accomplish most of its work. From the 5500, the packet travels to the Exodus "core" router, a massive Cisco 7513, which directs it toward one of several "border" routers that connect Exodus with the rest of the Internet. The core router knows the shortest path to 204.133.127.68, more commonly known as www.gartner.com, will pass through another ISP, BBN-Planet. It directs the packet along that path, toward an Exodus router linked to the BBN-Planet network. To minimize message transit delays, most large ISPs maintain direct high-speed links to other large ISPs, in an arrangement referred to as "peering." Often, a dedicated node, known as an Internet Packet eXchange (IPX) point, serves as the go-between. The packet flows through the Exodus/BBN IPX and speeds down a fiber-optic link to a nearby BBN-Planet point of presence (POP). During the 3 milliseconds it spent in the Exodus facility, seven high-performance MIPS microprocessors and one 68030 gently nudged it through the various hardware interfaces.

Figure 3
Inside the Personal Computer and LAN



Source: Dataquest (November 1998)

The packet, now in the care of BBN-Planet, speeds to Oakland over a 45-Mbps DS3 link. There, it hangs a sharp right at the local BBN-Planet router (another Cisco 7500) and heads east toward Denver. Yet another Cisco 7500 links BBN-Planet with SuperNet, the site in Denver where Gartner.com physically resides. Within each 7500, at least three MIPS R4000 microprocessors touch the packet. Other processors in each system busy themselves shuttling packets on and off other lines attached to the system. The trip through BBN-Planet covers almost 1,000 miles, touches 16 MIPS microprocessors—some running as fast as 200 MHz—and takes a total of 34 milliseconds. About half of this time was consumed in the long link between Oakland and Denver, while the remainder was spent in local traffic after the packet arrived at the Denver IPX. Figure 4 depicts the path the packet takes through the Internet.

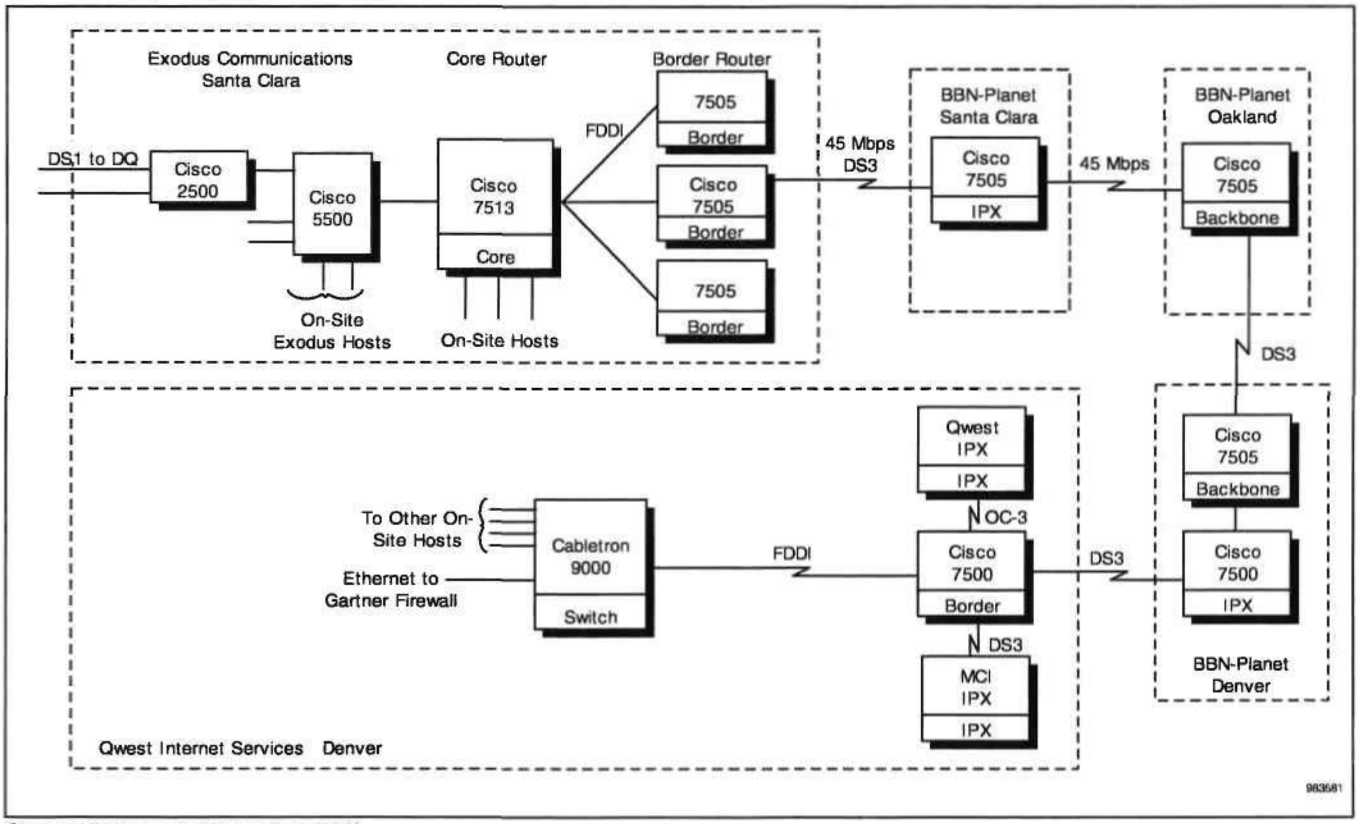
Finally, the packet arrives at SuperNet, an ISP that, like Exodus, specializes in hosting Web sites physically colocated on its premises. Over 100 companies maintain Web sites at SuperNet, each in its own caged and secure area. Three high-speed fiber-optic connections enter the site via yet another Cisco 7500 router. Two DS3 (45-Mbps) links tie SuperNet to BBN-Planet and MCI Communications Corporation; a third links SuperNet to Qwest Communications International Inc., the long distance company that recently acquired SuperNet. Qwest employs packet switching, like that used within the Internet, to achieve substantially lower long distance costs than traditional carriers for voice communications. Qwest brings some of this packetized voice traffic into its Denver site via an OC-3 (155-Mbps) link.

After the long run of MIPS-based Cisco routers that carried the packet along the Internet backbone, the packet encounters some different architectures. SuperNet uses a Cabletron Superswitch 9000 (formerly known as MMAC-Plus) to distribute data to its many on-site hosts, in much the same way that Exodus uses a Cisco 5500. The Cabletron system contains almost a dozen Intel 960 microprocessors on its varied interface boards. (Dataquest always wondered who bought all those Intel 960s, which have survived in the market for a long time but which have been overshadowed by Intel's huge x86 microprocessor shipments.) As it leaves the Cabletron switch, the packet formally crosses the border into Gartner.com. It took less than 1 millisecond for the packet to traverse SuperNet's switching equipment, and it used six microprocessors en route. The one-way trip through the Internet took a total of 39 milliseconds and required 30 microprocessors along the way.

Arriving in the Promised Land: Gartner.com

After meandering through the Internet for what seemed like an eternity, but actually measured 39 milliseconds, the packet signaling the mouse click arrived at the front door of Gartner.com. A Sun UltraSPARC firewall inspects it and passes it into the site. A massive Xyplex 3140 switches it to one of the 17 hosts that make up the Gartner Web site. Six of the machines front-end the site and manage the interactions with the thousands of Gartner clients that visit the site each day. The remainder work behind the scenes, storing, searching, and accessing the vast array of research materials created by Dataquest and Gartner analysts.

Figure 4
The Long Voyage through the Internet

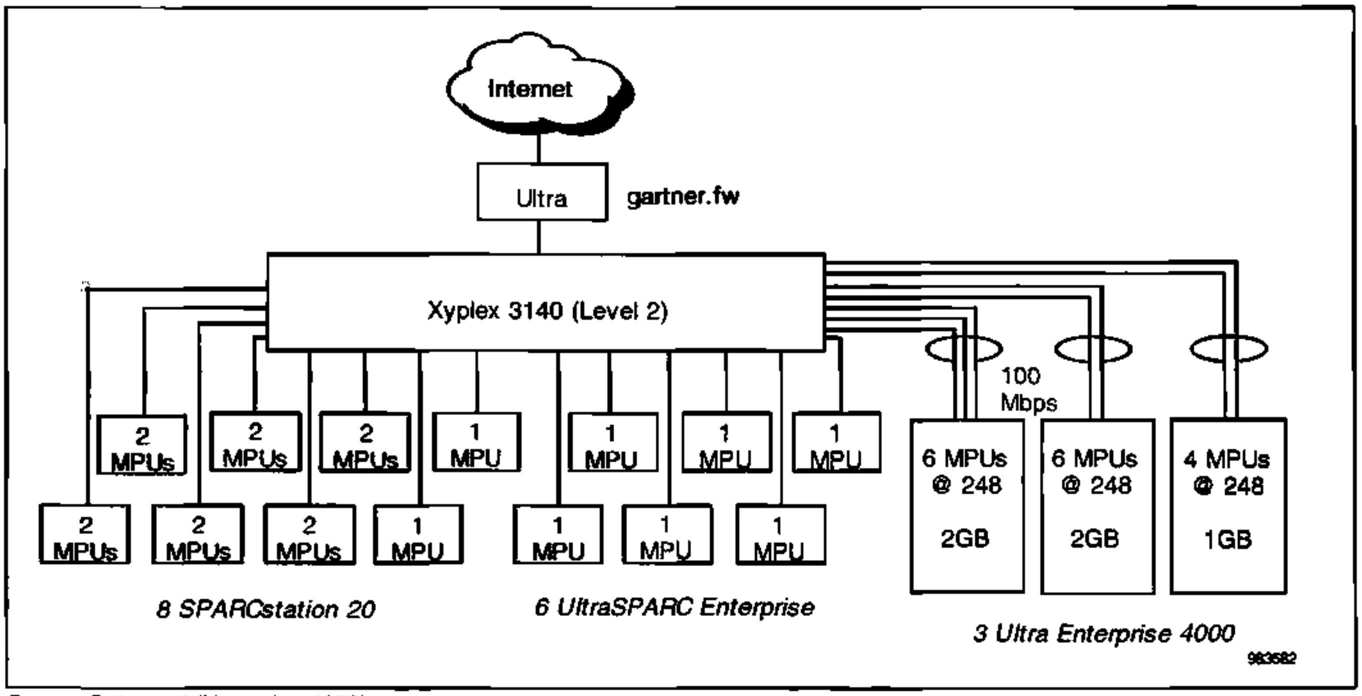


Source: Dataquest (November 1998)

Gartner.com, as illustrated in Figure 5, contains enough Sun hardware to have funded at least one sales representative's child's college education. These hosts, named Gartner1 through Gartner17, with the obvious omission of Gartner13, all run under Sun's Solaris operating system. The cadre includes eight dual-processor SPARCstation 20s, six uniprocessor UltraSPARC workstations, and three large UltraSPARC 4000 Enterprise servers. The three large servers contain a total of 16 248-MHz UltraSPARC II microprocessors, 5GB of main memory, and 213GB of redundant arrays of disk storage (RAID).

At last, the packet with the mouse click arrives at its final destination. The UltraSPARC processor channels it to a waiting program, and the system performs the action that was requested back in San Jose. The host directs its stream of data toward the browser running back in California, and the sought-for answer winds its way back. Six SPARC microprocessors at Gartner.com, along with two Motorola 68060's in the Xyplex switch, touched the packet as it traversed the site. Between the click of the mouse in San Jose and the activation of the program at Gartner.com, a total of 41 milliseconds have elapsed. Of course, the response must still travel back to California, a trip that will take it by all the same places.

Figure 5
The Systems That Constitute www.gartner.com (204.133.127.68)



Source: Dataquest (November 1998)

Another 40 or so milliseconds transpire as the packet returns to the analyst's desktop computer. The response passes through the UltraSPARC firewall, by the 68060s in the Xyplex switch, past the 960s in the Cabletron switch, past the MIPS processors in the Cisco 7500 routers that line the path between Denver and Santa Clara, back to the 68030 in the Cisco 2500 at Exodus, across the T-1 link to the Cisco 2500 at Dataquest's site, through the UltraSPARC firewall, through the Cisco 4500, through the LAN, and into the PC, where one last microcontroller transforms it from bits in the system's memory to glowing pixels on the computer's screen.

Like so many long journeys, the return covers familiar territory and seems to go by much faster than the outbound trek, but both took similar amounts of time, according to the clock on the wall. All together, 42 distinct microprocessors handled the packet along its journey, many touching it on both outbound and inbound legs of the trip.

The Microprocessor's Role in Communications Equipment

As noted throughout this travelogue, high-end routers, mostly Cisco high-end routers, play a key role in moving data within today's Internet. It was not just a coincidence that we saw so many Cisco products and so few from other vendors. As Table 5 illustrates, Cisco dominates this market segment the way Intel dominates compute microprocessors and Microsoft dominates operating systems.

The need for Internet bandwidth grows constantly, but the forecast in Table 1 indicates that sales of these powerful routers will plateau at current levels.

Table 5
Top Five Companies' Worldwide High-End Router Market Share, First Quarter 1998

	Manufacturer Revenue ($M)	Unit Shipments (K)	Revenue Market Share (%)	Unit Shipment Market Share (%)
Cisco Systems Inc.	313.9	6.7	82.9	82.4
Bay Networks Inc.	48.0	0.6	12.7	7.6
Network Systems Corporation	5.3	0.1	1.4	0.8
Cabletron Systems Inc.	3.6	0.2	0.9	2.7
Hypercom Network Systems	3.5	0.4	0.9	5.0
Others	4.2	0.1	1.1	1.5
Total	**378.5**	**8.1**	**100.0**	**100.0**

Source: Dataquest (November 1998)

The rationale behind this forecast reflects a trend that will impact this and other microprocessor applications over the next five years. The combination of increased line speeds and decreased diversity of network protocols will drive the routing function, which traditionally has been handled by powerful microprocessors and sophisticated real-time software, into special-purpose ASICs that require far less processor and software intervention. Cisco's switches—the Catalyst 5500 and the more recent Catalyst 8500—along with switches from other vendors like Bay Networks Inc., Cabletron Systems Inc., and Xyplex Networks, will absorb more and more of the traffic now handled primarily by routers.

This trend manifests itself in the dramatic 48 percent CAGR of "route switches," otherwise known as "layer 3 switches." The term "layer 3" refers to the network layer of the International Standards Organization's (ISO) networking model. In this model, traditional switching functions (such as the Kalpana switch sitting at Dataquest) operate at the physical link layer (layer 2) and network routing (such as the Internet Protocol, or IP) operates at layer 3. These ASIC-intensive route switches, although somewhat less flexible than traditional routers, provide far greater performance at the same cost as their predecessors or less, and will increasingly be deployed in lieu of high-end routers. This phenomenon first affects those routers dealing only with on-site traffic, where bandwidth requirements are greatest and interfaces to external communications facilities are least important. Later, as route switches gain increased communications flexibility and sophistication, the trend may spread to border router configurations as well. As this trend plays out, one of the last price-insensitive applications for high-end embedded processors will slowly fade from the scene.

Other attributes also differentiate the needs of the communications market from other microprocessor applications:

- Little if any need for floating-point hardware—The high-end MIPS processors used in Cisco's systems all contain powerful floating-point engines that are never used. Almost any other use of the silicon dedicated to these operations would benefit network equipment providers more than the current scheme. Even as the high-end router market transitions to more switch-like devices, midrange products and route-switch devices will need more powerful microprocessors. Vendors should consider offering versions of their high-end products without floating-point capability, especially if they can redeploy the silicon for a more beneficial purpose.
- Very long product cycles—Unlike desktop computers that often become obsolete in just a few years, many communications devices go on and on forever. Network equipment purchasers tend to be extremely conservative in their buying practices. They often pay tens or hundreds of thousands of dollars per month for the lines they rent, and they don't want some newfangled microprocessor to mess up their network. Consequently, Cisco still uses 68030s in some low-end systems, while Cabletron continues with the i960.

Dataquest Perspective

As we compare the manner in which data flowed through an early network in 1968 with the way it flows today, several important trends emerge:

- A simple transaction then took at least 200 milliseconds, even when the physical distances traveled were short. Today it takes less than half that time for a more complex message to travel a considerably greater distance. An inexpensive terminal then cost about $800 and operated at 10 characters per second. Today's inexpensive Internet devices cost a similar amount (before adjusting for inflation) and operate at speeds up to 5,600 characters per second (over ordinary phone lines, given 56K modems).
- The installed base of computers then totaled fewer than 10,000 systems. Today it totals more than 300 million systems.
- The worldwide semiconductor industry revenue in 1968 totaled approximately $1.47 billion. Thirty years later, it has grown to $147 billion, a 100-fold increase. This translates into a CAGR of 16.5 percent over the period and supports the "general wisdom" that the semiconductor industry's long-term growth is measured in the mid-teens.

At many points over the past 30 years, prophets of doom declared that the gravy days were over and growth would soon decelerate. In retrospect, it is easy to see what such observers missed. In 1968, the Internet was barely a gleam in Vinton Cerf's eye. Bill Gates had yet to write his first program or make his first million. Were representatives from the 1968 computer cognoscenti to be transported into the future (1998) and given the opportunity to review Dataquest's latest microprocessor market statistics, they would not believe that the world could find uses for so many processors. The recent slowdown of the semiconductor market has led some to once again question whether the incredible course of the modern microelectronic era is finally running out of steam. The applications and devices that will drive the continued growth of the electronics industry may not always be visible, even to its most far-sighted participants, but barring the collapse of human ingenuity, these applications too will emerge.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@gartner.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

Fourth Quarter 1998 Procurement Pulse: Order Rates Slip, Inventories Rebound, Lead Times Remain Flat, and Spot Prices Flatten (below Cost)

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

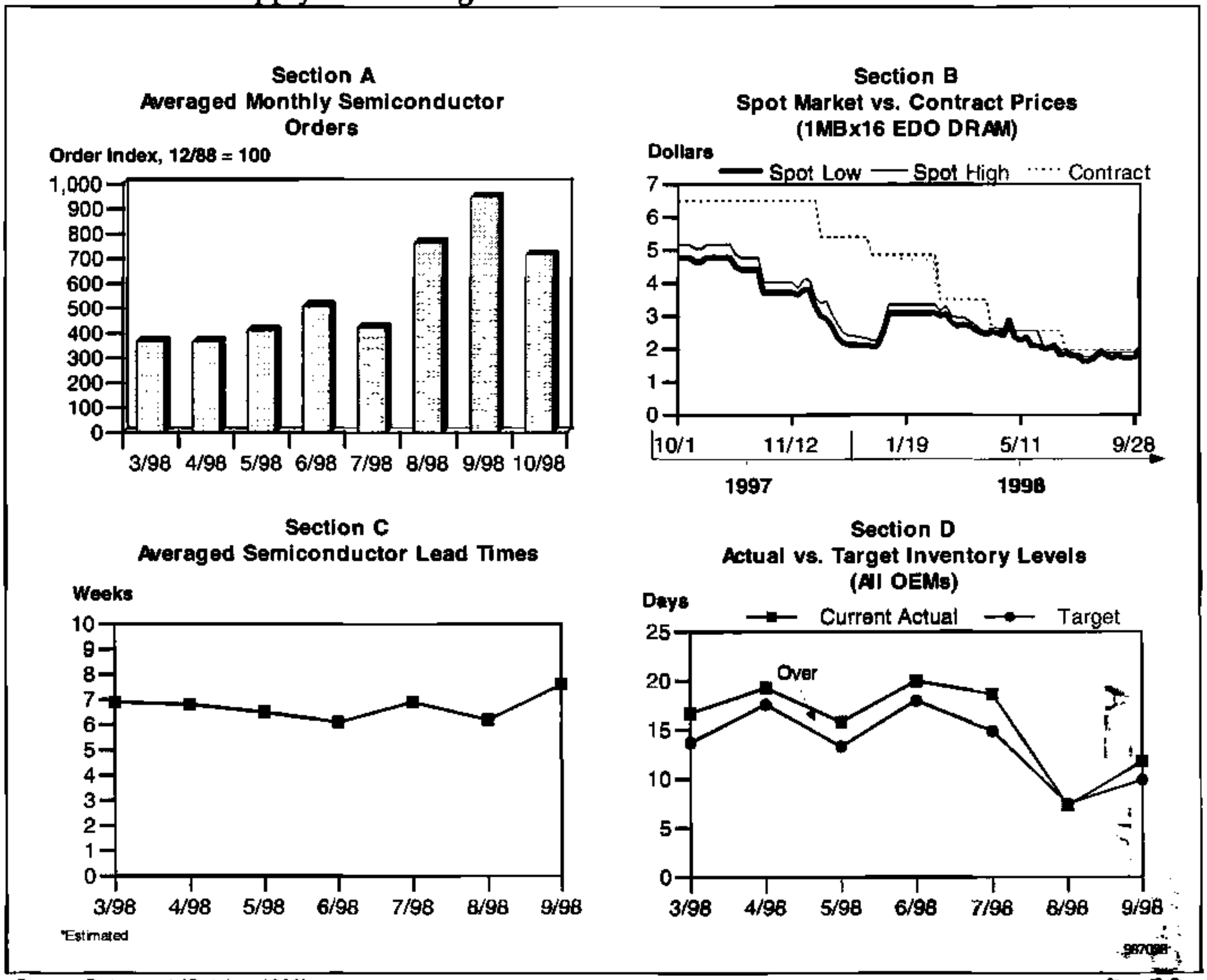
Semiconductor Orders Peak and Then Correct, Correlating with Market Demand Levels

As shown in Section A of Figure 1, the outlook for semiconductor order activity has risen and stabilized relative to the slower first half of the year. Although the outlook for October is for relatively slower buying than in September's peak end-of-quarter buying spree, the overall August-to-October outlook is much stronger than the activity of the previous six months. The combination of good inventory control and lower prices continues to keep booking activity very closely in line with end-system demand. Dataquest expects prices to remain low overall as channels stay oversupplied, a situation compounded by the Asian financial crisis. The overall sample continues to see price cuts for large-volume contracts in all areas (except for some DRAM and standard logic devices, which are flat) tracked in Dataquest's survey—MPUs, SRAM, ASICs, and flash memory. Highlighting the resumption of actual supply and demand forces in the market, DRAM pricing for the overall sample again rose ever so slightly by 0.4 percent after a

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
ProductCode: SSPS-WW-DP-9810
PublicationDate: November 9, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

relatively soft 0.8 percent decline in August. The computer subset of the respondents saw a more aggressive increase of 2.5 percent in DRAM prices after a steady 2.5 percent dip in August. Relative monthly price increases reflect the overall market situation of pricing below cost and attempts to move prices closer to cost. Aside from DRAM, the overall oversupply will continue to force prices down, most likely at slower rates than seen earlier this year. Package premiums do not exist for any given device, according to this month's respondents—another indication of overall oversupply.

Figure 1
Semiconductor Supply and Pricing



Source: Dataquest (October 1998)

Spot Market Pricing: And the 16Mb Low Point Was ... August 1998

DRAM spot pricing has turned the corner and now is on the incline relative to contract pricing, which is still declining, as shown in Section B. Although oversupply, in particular, memory oversupply, continues, there are some pockets of demand where suppliers can actually realize an increase in price. On the issue of increases in prices that are still below costs: Even if the end price is raised, if it remains below cost, the supplier still loses money, albeit less money. Demand remains steady, except for some Asian countries getting their financial houses in order. Notice by some suppliers leaving the embattled 16Mb DRAM market has caused some spot price increases, but the oversupply flood has not yet crested.

For now, contract prices remain low, and Dataquest expects them to go slightly lower before they start to rise. As suppliers try to shift production to the 64Mb DRAM device, prices for the 64Mb are also falling fast. In July, the 8Mbx8 EDO part sold for a low of $7.31 on the spot market! This part has now risen to an average of $8.35, but it is still way below its estimated average manufacturing cost of $10.50! Prices for the 64Mb have fallen so sharply that there is little hope of profit relief from this next-generation device. At the time of this writing, contract prices appeared to be undershooting spot pricing as the short-term balancing act of supply and demand sorts itself out. As noted over the past year, Dataquest expects continued volatility of spot market prices, which will vacillate around declining contract prices, causing uncertainty for buyers. The overall trend for contract buyers, however, is for continued good or excellent availability, consistently declining contract prices, and low lead times (four to six weeks) for the next six to nine months.

Lead Times for Semiconductors Remain Manageable at under Eight Weeks

Section C of Figure 1 shows that the average lead times reported by survey respondents in September have remained relatively constant over the past seven months, ranging from six to eight weeks. The most recent average, 7.6 weeks, compares unfavorably with August's 6.2-week average, but the overall trend still equals good availability. The current rise of lead times stems in part from the rumors of selective DRAM price increases and of uncertainty about the availability of next-generation DRAM architecture (that is, P100 SDRAM). As the spot market begins to rebound from this summer's pricing nadir, buyers are ensuring that contract prices and terms are kept. Good service levels and slowly declining and predictable prices continue to cement many long-term supplier relationships. Although once again there were no supply problems noted in this month's survey, good communication with suppliers cannot be viewed as a passing fad. With general availability good, this quarter's respondents had no supply problem complaints.

Semiconductor Inventories Slide Down to 10 to 18 Days

Third quarter 1998 inventories have vacillated within an eight-day span, as shown in Section D of Figure 1, compared to the relative stability of the past nine months. Respondents forecast semiconductor order rates to modulate, and there is a corresponding slight decrease or increase in inventory levels in line with historic levels. Easy replacement had caused many buyers to reassess the spot market as a way to lower the overall cost of goods on hand. With pricing on the rise in the spot market, this strategy may change by next quarter's update. The overall targeted and actual semiconductor inventory levels for September were 9.9 days and 11.1 days, respectively, compared with August's 7.5-day and 7.3-day levels. Although not shown, the computer subset is once again more aggressive because of seasonal sales, with current target and actual inventory levels of 7.5 days and 10.0 days. We expect to see inventory levels stabilize in line with steady system sales levels.

Dataquest Perspective

The story of good semiconductor availability continues, and Dataquest expects this availability to remain good into the next year. As noted over a year ago, contract prices continue to decline despite the efforts of some memory suppliers to curtail output. Lead times have stabilized to meet customer demand, in line with the moderated price declines. Dataquest continues to forecast steady unit growth rates for PCs and other electronics relative to 1997, with the overall growth trend in units following an upward slope. User semiconductor inventory levels are now in line with demand, and we expect to see continuing balance in these indexes in the near future. Allocation has not become a problem, and the shift of memory suppliers to the 64Mb SDRAM density has caused prices to fall to cost levels for the 16Mb part as well as the 64Mb EDO devices. Crossover is still not the issue—the issue is which device will cover costs. Dataquest expects to see excellent semiconductor availability at least through the first quarter of 1999. DRAM and MPU price elasticity have not propped up contract prices to date. The good news for users is that the overall decline in contract prices will continue for the third quarter and most likely through the first quarter of 1999.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

1998 Fourth Quarter Price Forecast Highlights: The Skinny on the Slump

Abstract: *Dataquest has completed the fourth quarter 1998 North American contract pricing survey for the semiconductors tracked. This Perspective analyzes the main signals seen, both overall and by some key family types, and their impact on contract buyers worldwide.*
By Evelyn Cronin

Overview

As years go, this is one that most suppliers wish would end. Not only have device prices continued to nose-dive, but end-user application demand has begun to show signs of softening.

The economic instability of the Asian region and growing problems in Russia are not helping consumers; the result is an end user-driven slowdown. When consumers are forced to tighten their belts, things like buying a new PC or upgrading to a digital cell phone tend to be put off.

In the United States, the situation is potentially more volatile, as the futures of consumers are tied up in the stock market. If it continues to perform, then people should continue to keep spending. If it fails to live up to expectations, then a lot of disappointed people will be walking about with dark clouds over their heads!

But back to the price forecast: Suppliers are sending many a mixed message. Some are trying to convince their customers that price rises are necessary for DRAM devices because the market is bottoming out—a ploy, no doubt, that these suppliers will also try with respect to other semiconductor families.

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
ProductCode: SSPS-WW-DP-9809
PublicationDate: September 21, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

Others just want to find enough customer orders to take the extra proc c produced with every design shrink.

Of late, the spot market has exhibited pricing volatility to some degree. Across the board DRAM spot market prices started to creep up despite continued lack of customer demand. Although both extended data out (EDO) 16Mb and EDO 64Mb devices have started to drop in price again (what goes up must come down), the price of the 64Mb SDRAM device is still up there.

Many spot market watchers are agog, eager to interpret this price behavior as a sign of pending undersupply. Unfortunately, the reality is far more mundane. All that is signified is production imbalance, as demand switches between 66 MHz and 100 MHz within the 64Mb SDRAM niche.

In fact, to add insult to injury, many buyers were left with a bloated feeling after misjudging third quarter 1998 demand and are even more reluctant to stomach long-term order placements for fear of a similar problem in the fourth quarter. Suppliers have been feeling buyers' pain: A bloated customer doesn't want to consume more inventory. And to think these suppliers still had the nerve to try to raise prices ...

Price Forecast Highlights

Dataquest has recently completed its fourth quarter 1998 semiconductor price forecast. The results clearly demonstrate continued marketplace uncertainty.

Although without exception buyers were optimistic about continued price declines on current and newer technologies of the semiconductors tracked, some suppliers were hoping to paint a different picture.

At the time of the survey certain suppliers were hoping to convince their customers that the recent spot market trend of price rises on the 64Mb SDRAM device was proof of arriving capacity undersupply in the DRAM arena. Unfortunately, the reality is quite different, and suppliers will have a tough time trying to convince buyers otherwise.

Dataquest continues to maintain that the DRAM oversupply will remain a reality until next year. And whenever generic multisourced produce is in oversupply, a price drop occurs. Dataquest does expect to see DRAM price declines to continue, albeit at a less dramatic pace than before.

While many wild cards are floating about, the main ones vis-à-vis semiconductor capacity are as follows:

- Economic and political instability affecting both semiconductor suppliers' ability to spend and semiconductor end-market application customers' willingness to spend (thus slowing down growth)
- Closure of or production cutbacks at leading-edge high-volume fabs, which would have a significant adverse impact on 64Mb availability
- An antidumping ruling against LG Semicon and Hyundai

- The Micron Technology-spearheaded clause to disallow U.S. moneys from being deployed by the International Monetary Fund for use in the Korean semiconductor segment

Now, let us look at the main highlights of the fourth quarter 1998 forecast by device family.

DRAM Devices

Highlights of the forecast for DRAM are as follows:

- Mixed signals are coming from suppliers, with some hoping to stabilize prices while others are resolved to continue with price declines. The bottom line is that excess capacity remains a reality, which will lead to continued price instability.
- The 64Mb SDRAM will come down further in price terms for the duration of the forecast and will be more cost-competitive than its EDO equivalent over time.
- Pricing at the 16Mb density remains largely flat but will begin to rise by the end of 1999 and beginning of 2000 as worldwide production volumes continue to decrease.
- The 16Mb SDRAM is experiencing very aggressive price declines and will be cheaper on a price per megabyte (PPM) basis than the 8Mb equivalent from the third quarter 1998 on.
- The availability of 4Mb and below devices continues to rapidly evaporate, and consequently the pricing outlook is for increasing prices from top-tier DRAM suppliers.
- No adder exists between DRAM DIMMs and DRAM SIMMs at the same density and technology. If anything, the lower-density modules have become more expensive on a PPM basis as the market has shifted to higher-density solutions.

Flash Memory

Highlights for the forecast for flash memory are as follows:

- The worldwide flash capacity excess lingers, and as a result price declines continue to be the flavor of the quarter for current and new flash technologies. This trend is expected to remain a reality for the duration of the forecast, especially for higher-density devices.
- The trend remains that for devices of the same density, the lower the voltage, the lower the device price. This relationship holds true for surveyed devices from 1Mb through 16Mb.
- The largest price declines are forecast for the 16Mb-plus densities through 2002; however, the 8Mb is still managing to come down further in price.

SRAM Devices

Highlights for the forecast for SRAM memory are as follows:

- These parts remain overshadowed by capacity excesses in the flash and DRAM, but SRAMs remain a volatile memory family.

- The sub-1Mb devices are largely flat from the last quarter and are seemingly immune to outside forces.
- However, the traditional cache SRAMs (of 256Kb, 1Mb, and 2Mb densities) still manage to muster a price drop, but look for these to start increasing by 2000, as supply continues to dry up and the market migrates to other devices.
- The 4Mb devices continue to come down in price rapidly but are only beginning to ramp up in terms of volume.

Microprocessors

Highlights for the forecast for microprocessors are as follows:

- Intel Corporation's dominance of the computer processor arena basically determines the pricing scenario for all comparable devices. However, the company's competitors are beginning to change matters.
- Intel has begun to focus aggressively on the entry-level PC market by launching a new cost-conscious family of processors. This approach is attacking the company's competitors in their core market.
- The shift to shorter-lived, more differentiated products is forcing users to adapt quickly to changes in pricing schemes.
- Apple Computer's success with the iMac is showing the market that companies can move ahead without Intel.

Dataquest Predicts

For the first time in a long while, customer demand in the major semiconductor end application markets is showing signs of slowing down. Worldwide economic instability is a major factor playing into the slowdown of customer demand.

Actual semiconductor production capacity remains in oversupply, despite all the recent announcements of fab closures, manufacturing production cutbacks, mergers, and so on. And whenever something is in excess from multiple supply sources, its market worth drops.

Therefore, despite talk to the contrary, semiconductor prices will continue to drop in general for the foreseeable future on generic products (both new and current designs). The rate of price decrease will obviously vary from device to device and from supplier to supplier, and it is doubtful that it will be as aggressive as before. Also, given the profitability issues many vendors face, some will have to make tough decisions and may be forced to walk away from certain sales situations.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

Semiconductor Inventory Holding Analysis

Abstract: *Dataquest conducts a monthly survey of the North American semiconductor procurement community, the "Procurement Pulse," to examine key measures of inventory, price, lead time, and order backlog. This Perspective presents nearly four years' worth of information on these measures and challenges the following assumptions: Does a link exist between lead time and inventory holding goals? Do market supply-and-demand dynamics impact inventory holding objectives? Can the changes in lead time and inventory holding goals be explained by knowledge of the related market conditions?*
By Evelyn Cronin

Introduction and Objectives

Dataquest surveys the North American semiconductor procurement community on a monthly basis to gauge key metrics, such as inventory, price, lead time, and order backlog. Generally, once a quarter, the Semiconductor Supply and Pricing Worldwide program publishes this information in a Dataquest Perspective titled "Procurement Pulse" (most recently, "Third Quarter 1998 Procurement Pulse: Order Rates Seesaw, Inventories React, Lead Times Remain Flat, and Spot Prices Bounce at/below Cost" [SSPS-WW-DP-9807], dated July 20, 1998). The present Perspective contains a rolling four years' worth of information on all metrics.

Dataquest

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9808
Publication Date: September 7, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

Given the depth of historical data available to Dataquest from the "Procurement Pulse" surveys, we decided to examine inventory holding objectives and lead time. We were curious to test and challenge a few procurement principles or assumptions, as follows:

- Does a link exist between lead time and inventory holding goals?
- Do market supply-and-demand dynamics impact inventory holding objectives?
- Can the changes in lead time and inventory holding goals be explained by knowledge of the related market conditions?

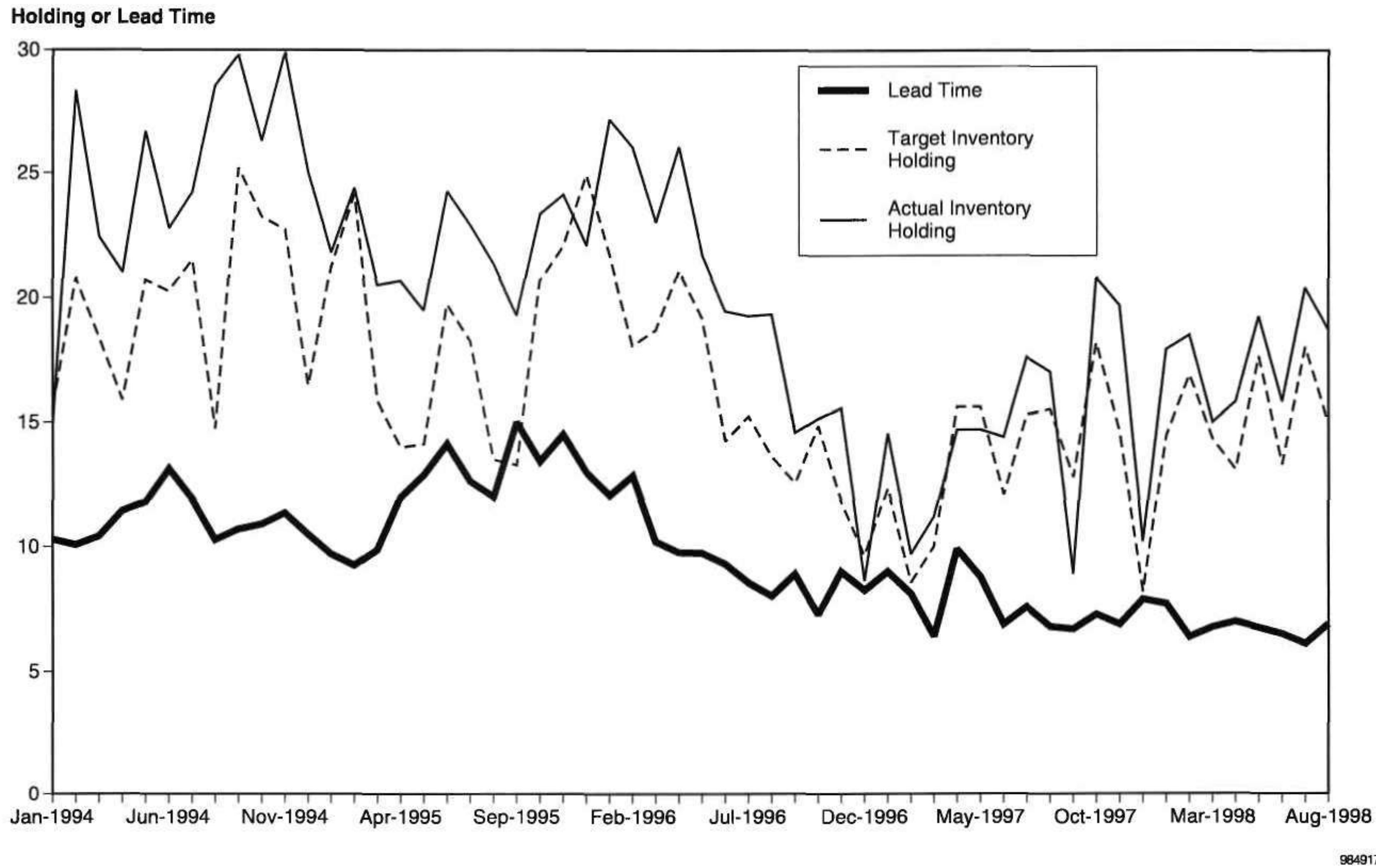
With these questions in mind, we collected the "Procurement Pulse" data for target inventory holding, actual inventory holding, and lead times. We obtained the average score, in days, for each of the three based on the overall sample of buyers who responded to Dataquest's survey. The results are plotted in Figure 1.

Observations

The following observations may be made from Figure 1.

- At first glance, Figure 1 shows major oscillations on all three curves: lead time, target inventory holding period, and finally actual inventory holding period. The time between the high and low points is very short—typically a few months.
- Second, the cyclic nature of the two inventory holding curves is very clear. Generally, target and actual inventory holding levels are lowest at year-end and at the end of selected quarters.
- The cyclic or seasonal nature of the inventory holding curves appears to be independent of lead times. For example, the target and actual inventory holding levels decreased at calendar year-end 1997 even though the lead time increased.
- Over the nearly four years covered by the data, a clear downward shift in inventory holding target and actual times is apparent. For example, in February 1994, the average actual inventory holding period was 28.4 days, whereas in February 1998, the average actual inventory holding period was 18.5 days. This difference works out to a 35 percent decline from February 1994 to February 1998.
- There is a significant delta between target and actual inventory holding times from January 1994 to mid-1996. From Figure 1, it is clear that in some cases the difference between the ideal and reality was as high as 13.8 days in August 1994.
- From mid-1996 to present, actual inventory holding levels are very close to targets. During this time, both curves appear very harmonious and track each other closely. For example, from September 1996 to the present, the largest delta between actual and target inventory holding is 5.1 days (in November 1997).

Figure 1
Inventory Holding and Lead Times, January 1994 to July 1998 (Days)



Source: Dataquest (August 1998)

Year-by-Year Analysis

Calendar Year 1994

Figure 2 sets out inventory holding times for calendar year 1994. From the figure, the following observations may be drawn:

- Lead times were largely flat.
- Actual inventory holding levels increased rapidly.
- Target inventory holding levels were slowly increasing.

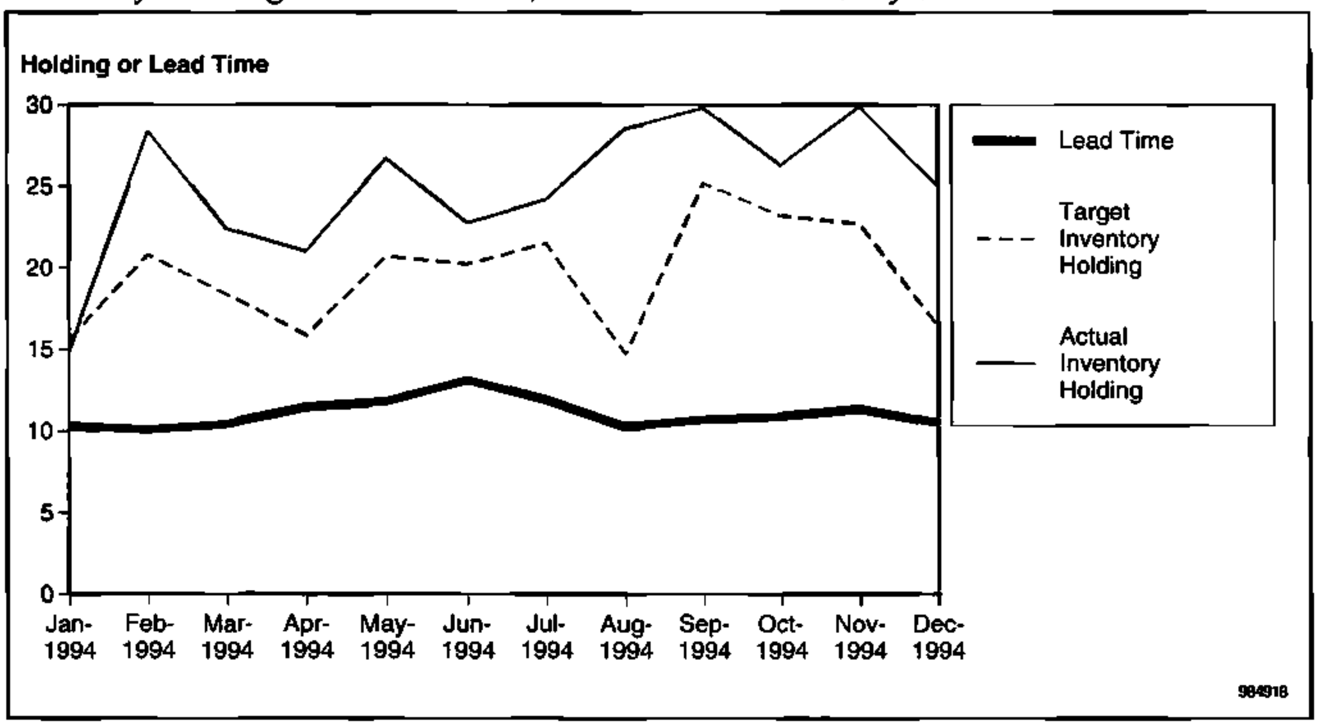
Market characteristics were as follows:

- Supply/demand: semiconductor undersupply
- Short-term historical pricing trend: stable pricing
- Pricing: flat to increasing

In 1994 the semiconductor market was in undersupply, largely driven by the major limitations in DRAM production capacity. As there had been a history of stable DRAM prices and very limited allocation of devices, DRAM was largely regarded as an investment device by many buyers. That is to say, often buyers would purchase all availability allocation regardless of immediate production requirements. They knew that the product could be resold on the spot market for a tidy profit if necessary.

The clear message from Figure 2 is that buyers did not prioritize inventory holding in 1994. Long lead times caused by production undercapacity and the resulting severe allocation problems helped produce a siege mentality. Avoiding a production stoppage was more important than meeting inventory holding targets.

Figure 2
Inventory Holding and Lead Times, Calendar Year 1994 (Days)



Source: Dataquest (August 1998)

Calendar Year 1995

Figure 3 sets out inventory holding times for calendar year 1995. From the figure, the following observations may be made:

- Lead times were sharply increasing.
- Actual inventory holding levels were increasing overall.
- Target inventory holding levels were also increasing overall.

Market characteristics were as follows:

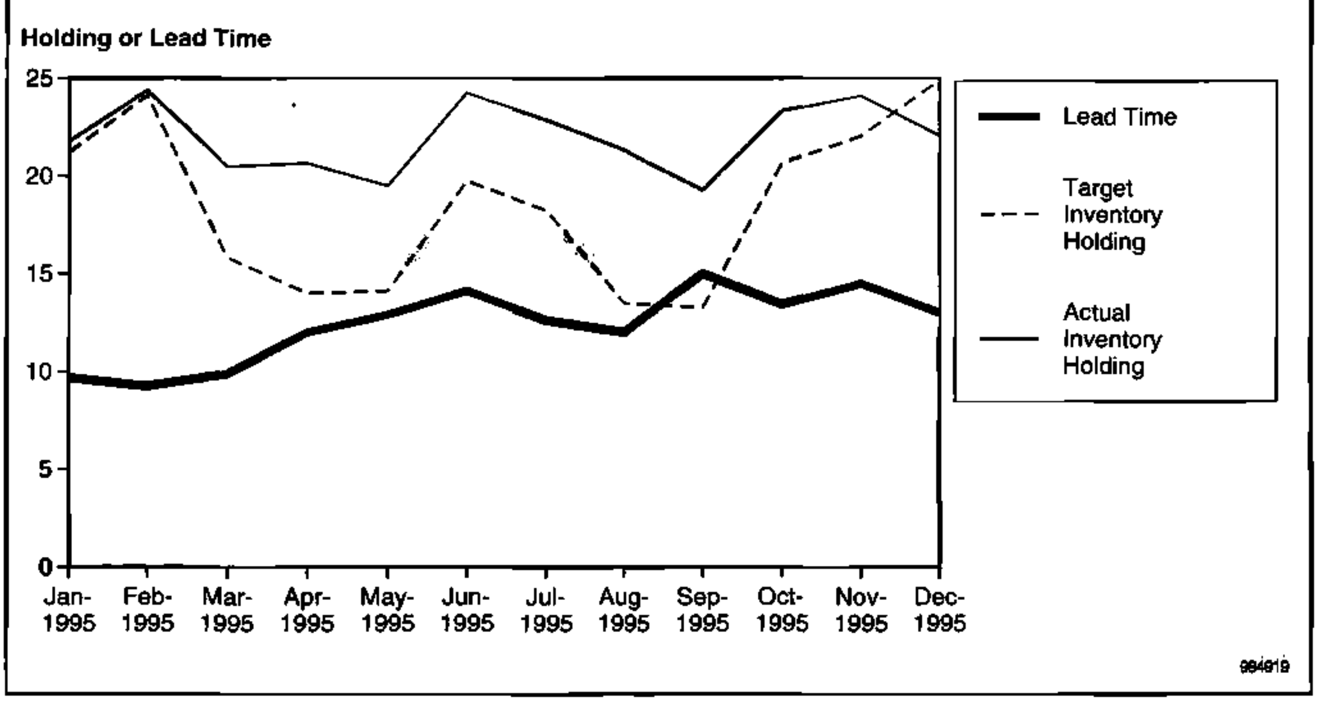
- Supply/demand: semiconductor undersupply
- Short-term historical pricing trend: very stable pricing
- Pricing: flat to increasing

In 1995 lead times began to increase very sharply as semiconductor undercapacity hit an all-time low. Buyers were able to reduce inventory holding times often by pure dumb luck; production requirements were increasing sharply while allocation levels failed to grow correspondingly, resulting in higher inventory turn rates in-house.

Toward the end of 1995, buyers perceived the undersupply to be never-ending and started to buy up any extra allocation. Figure 3 is interesting as it shows that inventory holding targets rose sharply for the fourth quarter 1995. Buyers closed the year with average actual levels below target because they were unable to buy enough!

However, unbeknownst to the buyers, substantial additional capacity was being brought online by many different DRAM suppliers. The long run of undersupply was being replaced by an oversupply. However, no one had told the buyers.

Figure 3
Inventory Holding and Lead Times, Calendar Year 1995 (Days)



Source: Dataquest (August 1998)

Calendar Year 1996

Figure 4 sets out inventory holding times for calendar year 1996. The following observations may be drawn from the figure:

- Lead times were sharply decreasing (nose-diving).
- Actual inventory holding levels were sharply decreasing (nose-diving).
- Target inventory holding levels were steadily decreasing.

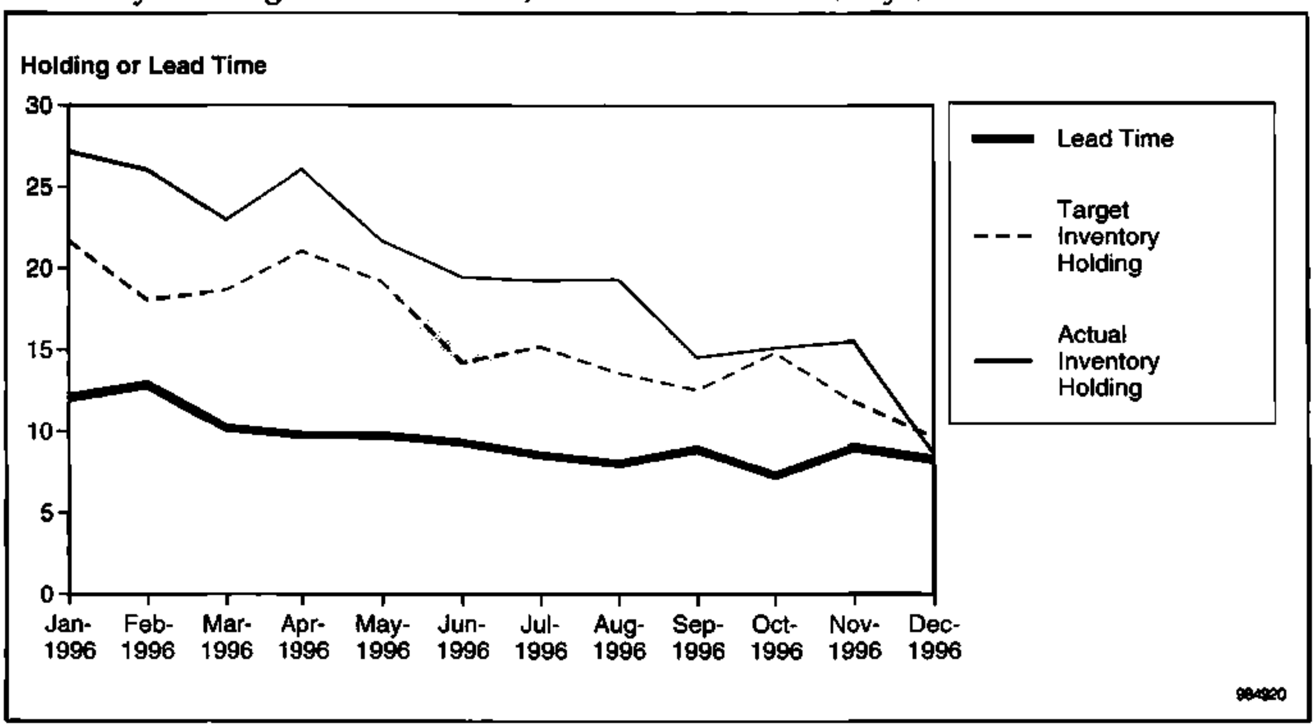
Market characteristics were as follows:

- Supply/demand: extra capacity online causing overcapacity
- Short-term historical pricing trend: stable pricing
- Pricing: steep downward descent

The year 1996 began with a large legacy of extra product. Many believed it was a carryover from year-end 1995 inventory redistribution. Likewise, prices for many semiconductor commodities began to decrease in the spot market. The gap between the spot market and the contract market opened up, and for the first time DRAM was cheaper in the spot market. Needless to say, chaotic conditions ensued.

Figure 4 shows that lead times came tumbling down—like a ton of bricks. Likewise, targeted and actual semiconductor inventory levels were nose-diving. Many thought Armageddon was approaching and were awaiting the arrival of the four horsemen.

Figure 4
Inventory Holding and Lead Times, Calendar Year 1996 (Days)



Source: Dataquest (August 1998)

Calendar Year 1997

Figure 5 sets out inventory holding times for calendar year 1997. From the figure, the following observations may be made:

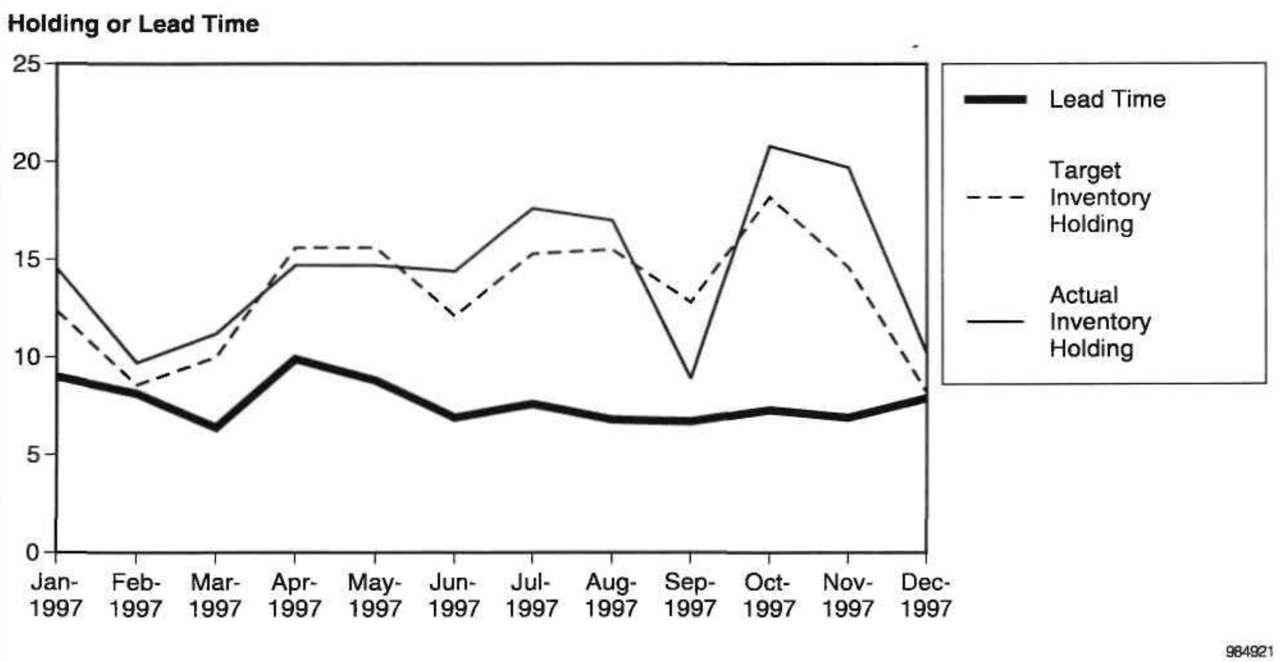
- Lead times increased slightly.
- Actual inventory holding levels increased slightly.
- Target inventory holding levels decreased slowly.

Market characteristics were as follows:

- Supply/demand: semiconductor oversupply
- Short-term historical pricing trend: extremely volatile downturn
- Pricing: declining

The year opened badly. Pricing was extremely volatile, and lead times were seemingly at an all-time low. Although the price declines in 1997 were not as severe as in the previous year, they were nevertheless significant, and the semiconductor product excesses continued to gush out of suppliers, flooding the already saturated market. Buyers had to be extremely focused on inventory holding levels. As is evident in Figure 5, both actual and target inventory holding levels track each other closely throughout 1997, and the fourth quarter/year-end 1997 was handled with a military precision.

Figure 5
Inventory Holding and Lead Times, Calendar Year 1997 (Days)



Source: Dataquest (August 1998)

January to August 1998

Figure 6 sets out inventory holding times for the current year to August. The following observations may be drawn from the figure:

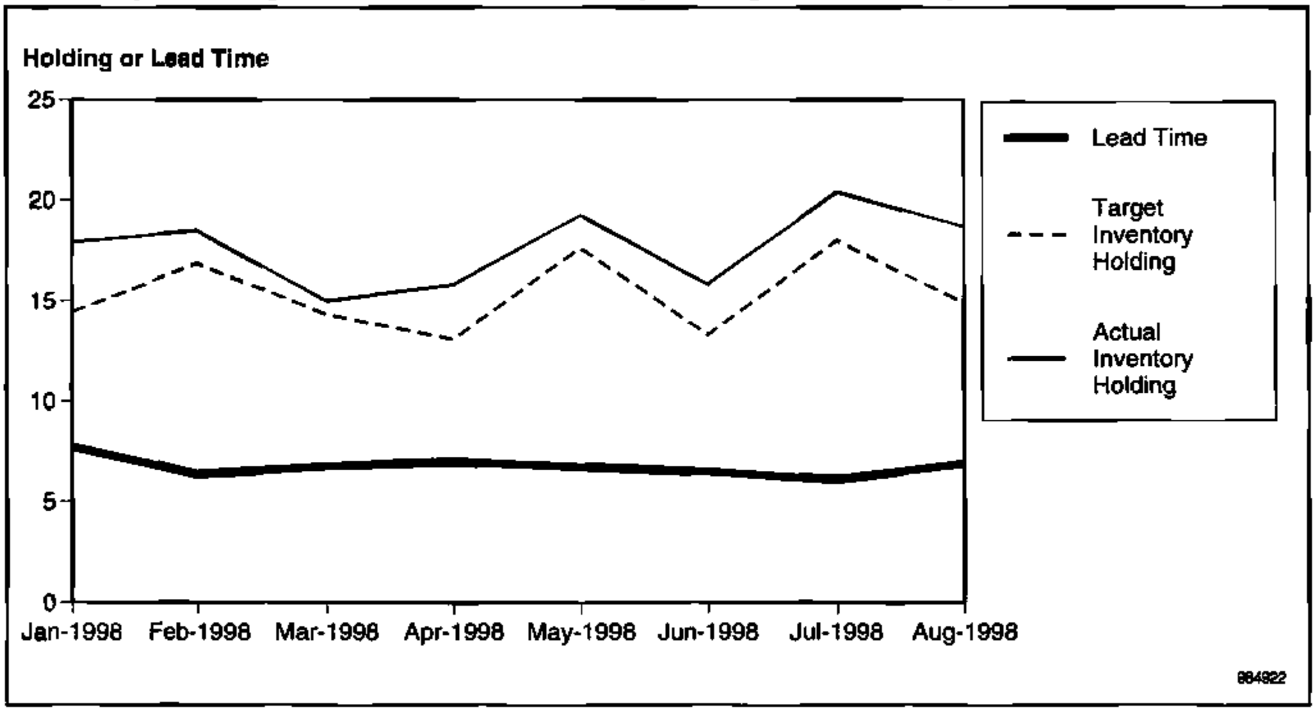
- Lead times have been largely flat.
- Actual inventory holding levels have been largely flat.
- Target inventory holding levels have been largely flat.

Market characteristics have been as follows:

- Supply/demand: semiconductor undersupply
- Short-term historical pricing trend: declining
- Pricing: measured decreases

Coming into 1998, the mind-set of buyers was in stark contrast to 1994. The buyers were now used to working in these warlike conditions and had learned through hands-on combat experience that the only consistency in the semiconductor market was instability. In comparison to 1996 and 1997, this year has been relatively calm. As of August 1998, lead times appear largely flat, as do inventory holding targets. Figure 6 shows that actual inventory levels exactly match target levels. Clearly buyers are taking no chances; the stakes are too high.

Figure 6
Inventory Holding and Lead Times, January to August 1998 (Days)



Source: Dataquest (August 1998)

Dataquest Perspective

As the outset we stated that our objectives were to test three procurement principles or assumptions:

- Does a link exist between lead time and inventory holding goals?
- Do market supply-and-demand dynamics impact inventory holding objectives?
- Can the changes in lead time and inventory holding goals be explained by knowledge of the related market conditions?

In conclusion, the answer to each of these three hypotheses is a resounding yes. The "Procurement Pulse" data does show a link between inventory holding goals and lead times. However, this link is very much related to supply-and-demand dynamics and semiconductor market characteristics.

In other words, lead times and inventory holding cannot be viewed in a vacuum, but rather in the context of overall semiconductor market characteristics. Looking to the future, Dataquest forecasts that oversupply will continue, albeit at a less dramatic level than before. As the semiconductor market approaches a balance between supply and demand, inventory holding and lead times will remain hot topics.

Currently, we forecast that pricing will decline further before it begins to increase. This decline will be more controlled in nature than has been seen previously and should continue until year-end 1999-early 2000. A period of undersupply will follow as customer demand exceeds supplier availability. However, after the tough lesson of the late 1990s, buyers will continue to focus on minimizing inventory holding levels irrespective of lead times.

For More Information...

Inquiry Hotline +1-408-468-8423
Internet address scndinquiry@dataquest.com
Via fax +1-408-954-1780
Dataquest Interactive http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

Third Quarter 1998 Procurement Pulse: Order Rates Seesaw, Inventories React, Lead Times Remain Flat, and Spot Prices Bounce at/below Cost

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

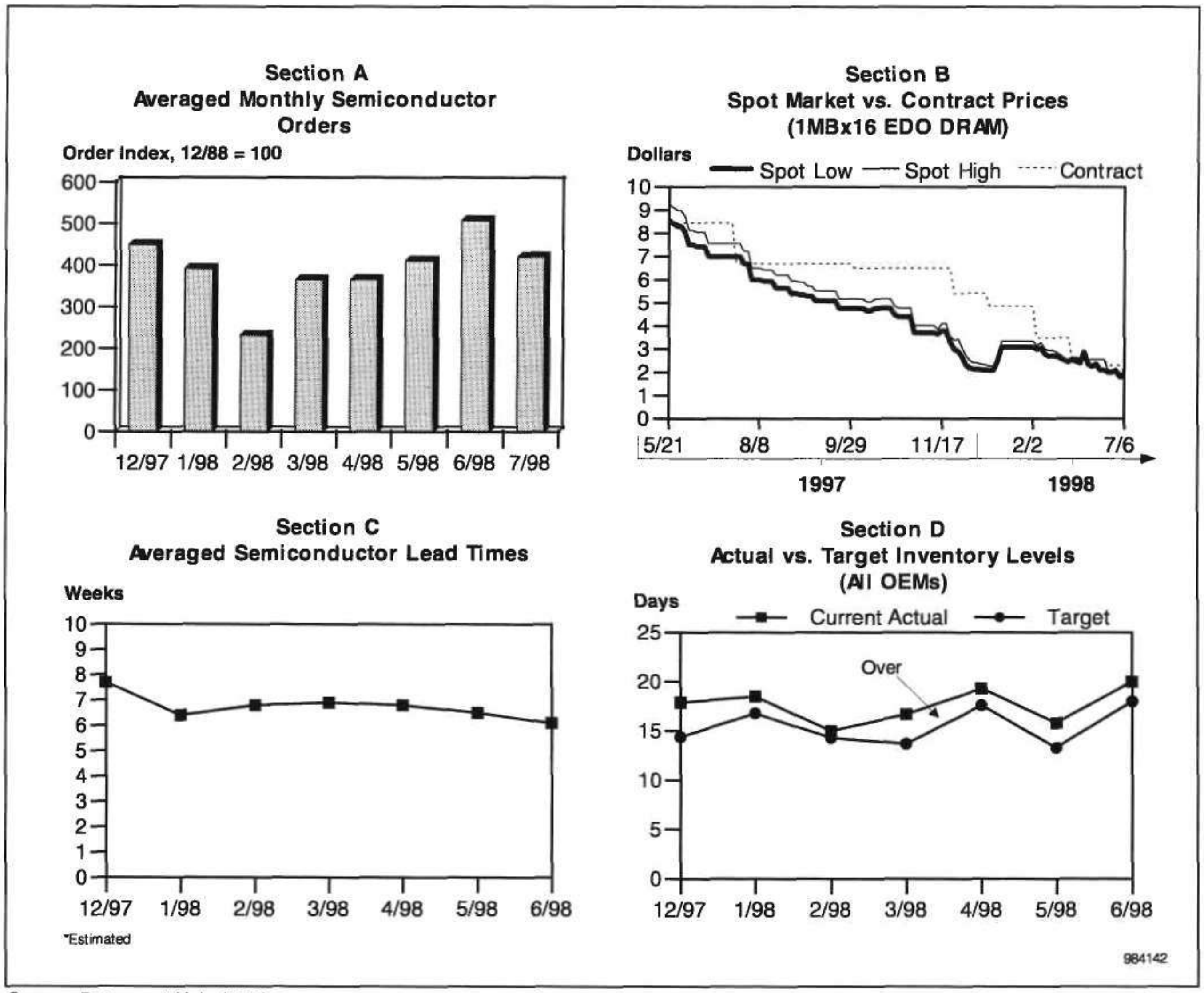
Semiconductor Orders Rise and Fall Back, Reflecting End-Market Demand Changes

As seen in Section A of Figure 1, the outlook for semiconductor order activity has improved since the traumatic first quarter, and the market is poised to continue the trend in line with end-system growth. While the outlook for July is slightly lower than June's forecast index, the July index is roughly at the level of December 1997—a good year-end booking month. The combination of good inventory control and continued lower prices is keeping booking activity very closely in line with end-system demand. Dataquest expects prices to remain low overall as channels stay oversupplied, a situation compounded more deeply now by the Asian financial crisis. The overall sample continues to see price cuts for large-volume contracts in all areas (except ASICs) tracked in Dataquest's survey—MPUs, SRAM, and, especially DRAM and flash memory. Highlighting the resumption of actual supply and demand forces in the market, DRAM pricing for the overall sample again declined on average by 3.3 percent after a relatively strong 4.4

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9807
Publication Date: July 20, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

percent decline in June. The computer subset of the respondents saw a more aggressive decline of 7.5 percent in DRAM prices after a smaller, 2.5 percent dip in June. With overall prices continuing to fall, prices for thin, small-outline packages (TSOPs) and ball grid arrays (BGAs) are at parity with more standard package offerings.

Figure 1
Semiconductor Supply and Pricing



Source: Dataquest (July 1998)

Spot Market Pricing: How Low Can It Go?

DRAM spot pricing continues to nose-dive, highlighting the memory oversupply, which is fully acknowledged by suppliers (see Figure 1, Section B). Demand levels remain steady, except for some Asian countries getting their financial houses in order. Parts originally destined for Asia are being redirected into the oversupplied marketplace with the results expected—still lower prices. Notice by some suppliers leaving the embattled 16Mb DRAM market has caused some spot price stability, but the oversupply wave has yet to crash here. For now, contract prices remain low, and we expect them to go slightly lower before they start to rise. As suppliers try to shift production to the 64Mb DRAM device, prices for the 64Mb are also falling fast. In early July the 8Mbx8 EDO part sold for a low of $7.59 on the spot market! This is down from the then-unheard-of sub-$10.00 pricing seen in March. Prices for the 64Mb have fallen so aggressively that there is little hope of profit relief from this next-generation device. As noted over the past year, Dataquest expects continued volatility of spot market prices, which will vacillate between declining contract prices, causing uncertainty for buyers. The overall trend for contract buyers, however, is continued good or excellent availability, consistently declining contract prices, and low lead times (four to six weeks) for the next six to nine months.

Lead Times for Semiconductors Remain Manageable at under Seven Weeks

Section C of Figure 1 shows that the average lead times reported by survey respondents in June remained relatively constant over the past seven months, ranging from six to eight weeks. The most recent average, 6.1 weeks, compares favorably with May's 6.5-week average, and the overall trend equals good availability. The current stability of lead times stems in part from the removal of uncertainty about DRAM supplies and the perception that availability will be good for the rest of this year. Even though spot prices are at an all-time low, they appear to be bottoming out, and most buyers are satisfied with current low contract pricing and the stability and lower total costs provided by those deliveries. Good service levels and slowly declining, predictable prices continue to cement many long-term supplier relationships. Once again, no supply problems were noted in this month's survey, and good communications with suppliers cannot be seen as a passing fad. With general availability good and improving, this quarter's respondents had no supply problem complaints.

Semiconductor Inventories Bounce within 15-to-20-Day Bandwidth

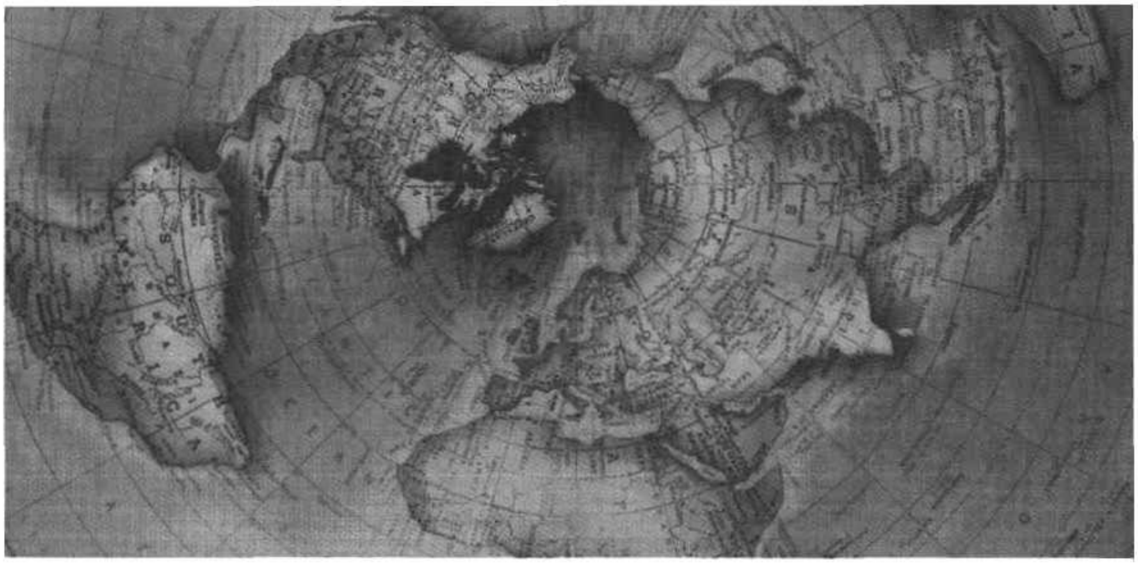
Second quarter 1998 inventories have vacillated within a five-day range, as shown in Section D, compared to the past nine months. Respondents forecast that semiconductor order rates will modulate, with a corresponding slight decrease or increase in inventory levels in line with historic levels. Easy replacement is causing many buyers to reassess the spot market as a way to lower the overall cost of goods on hand. The overall targeted and actual semiconductor inventory levels for March were 18.0 days and 20.4 days, respectively, compared with February's 13.3-day and 15.8-day levels. Although not shown, the computer subset appears to be more conservative due to seasonal sales, with current target and actual inventory levels of 25.0 days and 27.5 days, respectively. We continue to expect to see inventory levels stabilize in line with steady system sales levels.

Dataquest Perspective

Good semiconductor availability continues, and Dataquest expects this situation for the rest of this year. As noted over a year ago, contract prices continue to decline despite the efforts of some memory suppliers to curtail output. Lead times have stabilized to meet customer demand, in line with the moderate price declines. Dataquest continues to forecast steady unit growth rates for PCs and other electronics relative to 1997, with the overall growth trend following an upward slope. User semiconductor inventory levels are now in line with demand, and we expect to see continuing balance in these indexes in the near future. Allocations are still not a problem, and the shift of some memory suppliers to the 64Mb DRAM density has caused a price fall to cost levels for the 16Mb part, as well as the 64Mb device. Currently, the issue is not crossover, but rather which device will cover costs. Dataquest expects to see excellent semiconductor availability through at least the first quarter of 1999. DRAM and MPU price elasticity has not propped up contract prices to date. The good news for users is that the overall decline in contract prices will continue for the third quarter and most likely through the first quarter of next year.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com



Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

North American Semiconductor Price Outlook, Third Quarter 1998

Abstract: *The semiconductor market remains in oversupply. Dataquest's latest quarterly semiconductor price forecast shows a steep decline in prices and continued price decreases for the future. DRAM prices have been badly hit, with huge price drops. This Perspective highlights the main messages behind the latest Dataquest pricing forecast for key semiconductor device families.*
By Evelyn Cronin

Third Quarter 1998 Price Forecast Highlights: The Lowdown on the Price Drops

This has been an amazing year so far, and there are still six more months to come. Oversupply remains a fact of life virtually across the board for semiconductors, and suppliers continue to grit their teeth by lowering prices in a mad scramble for customer orders. Buyers are enjoying an unprecedented era of price reductions, especially on memory devices; there seems to be no minimum for the price bar.

Although availability remains good for most standard semiconductor devices, there may be some issues with older devices as suppliers begin scaling back production or leaving the market.

Also, for generic semiconductors, where oversupply is rampant and few manufacturers are able to make a profit, many companies will be forced to reconsider their positions within the segment and may adopt new strategies and product lines. Motorola Incorporated, for example, has just announced job and production cuts as a result of impaired profitability in the semiconductor arena. It remains to be seen how this will affect overall supply.

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9806
Publication Date: June 22, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

At the time this document was being written, DRAM spot market prices had reached record lows. Despite the low prices and excellent availability, actual customer orders remain fairly steady. The amount of DRAM traded in the spot market continues to account for only a small fraction of the overall DRAM market. So, despite the media attention given to the spot market, most trading is done in the less opportunistic contract forum.

That said, the DRAM prices in the spot market have justifiably received much attention. Many a tear of desperation has been shed by suppliers, but real action is needed to facilitate change. Antidumping rumors never really disappeared, and they are becoming louder and more forceful by the day. Will this threat or the action of another entity (for example, the European Union or the World Bank) force the price free-for-all to stop, or will suppliers continue to sacrifice price in the war for market share?

Price Forecast Highlights

Dataquest has recently completed its third quarter 1998 semiconductor price forecast. Without exception, all buyers were optimistic about continued good availability and associated price declines.

DRAM remains the most volatile product from a pricing perspective. Participants indicated very strong price declines from second quarter 1998 to third quarter 1998 on 16Mb and 64Mb densities and associated modules. They also forecast extremely good price decreases for the rest of 1998 and into 1999. The 64Mb is set to offer the best price/performance ratio of the DRAM devices over time.

SRAM, flash, ROM, and EPROM also exhibited good price reductions, particularly at the higher densities. Given that there are so many SRAM suppliers, it is not surprising that SRAM had a greatest price instability of the four segments.

Microprocessors continue to offer good price reductions, with Intel remaining in the driver's seat. That said, Intel seems to be starting to feel a bit of heat from its competitors, which are eager to gain a stronger foothold in the market.

Standard logic pricing is down from last quarter. The application-specific integrated circuits (ASICs) that were tracked have remained flat from last quarter.

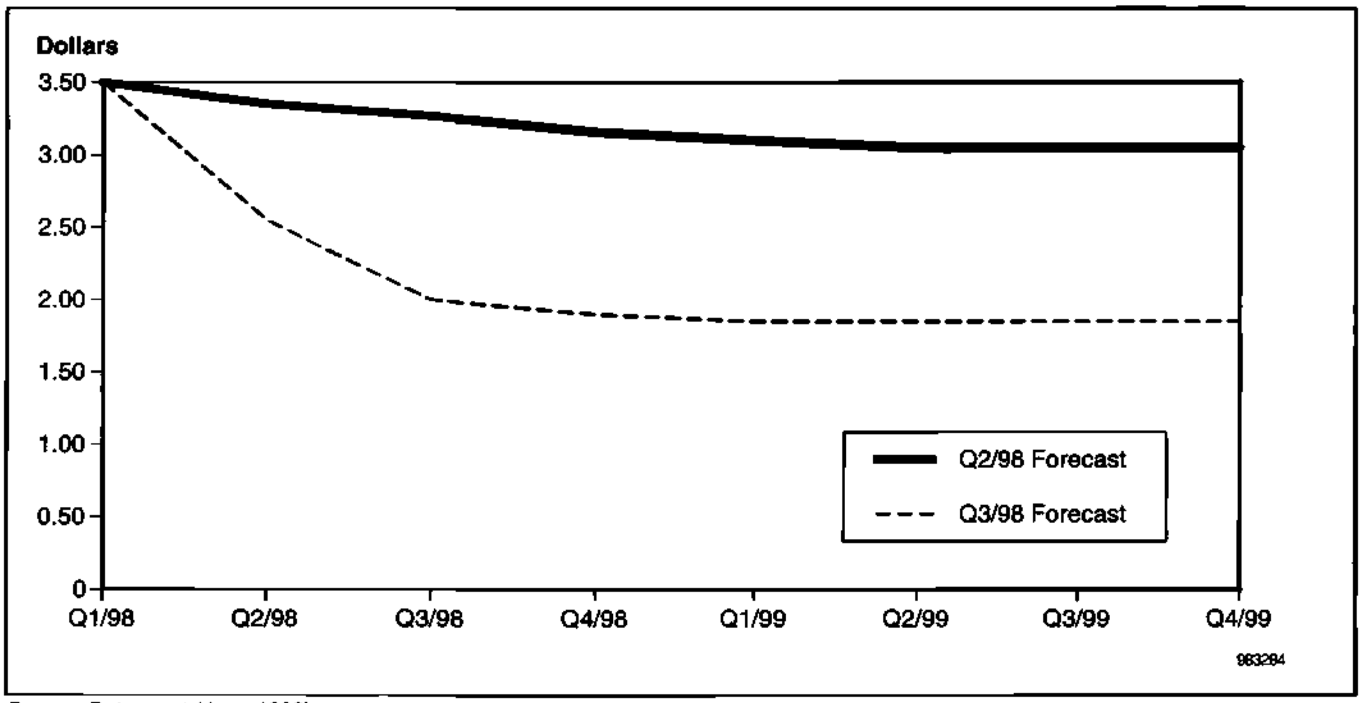
The following sections look at the highlights from the Dataquest's third quarter 1998 forecast by device family.

DRAM

Highlights of the forecast for DRAM are as follows:

- Huge price reductions were reported from the second quarter 1998 to the third quarter 1998 forecast on 16Mb and 64Mb DRAM devices. More controlled pricing is reported for the rest of the forecast for 16Mb, but good long-term price reductions are still forecast for 64Mb. Figure 1 shows the price change for 1Mbx16 EDO from the two forecasts.
- Fairly stable pricing is forecast for 1998 and 1999 on all 4Mb, discrete DRAM devices, and related modules.
- Although synchronous DRAM (SDRAM) remains more expensive than asynchronous at 16Mb, it eventually becomes cheaper than its asynchronous equivalent at 64Mb.
- Prices for the 4Mb density will begin to rise long term as the supply base shrinks. Buyers be warned!
- In general, price parity exists between DRAM dual in-line memory modules (DIMMs) and DRAM single in-line memory modules (SIMMs) at the same density and technology.
- Antidumping rumors abound for DRAM, but most suspect that if antidumping penalties are assessed, it will be at the 64Mb density only.

Figure 1
Difference between Second and Third Quarter 1998 Price Forecasts, 1Mbx16 EDO



Source: Dataquest (June 1998)

Flash Memory

Highlights of the forecast for flash memory are as follows:

- The trend remains for devices of equal density that the lower the voltage, the lower the device price. This holds true for all devices surveyed, from the 1Mb through the 16Mb.
- The continued extra flash production capacity means that price reductions are likely to occur on all devices. Although price declines will be modest on devices under 4Mb, they will be quite significant at higher densities.
- The greatest price declines are forecast for the 16Mb and higher densities through 2002.

Other Nonvolatile

Highlights of the forecast for other nonvolatile memories are as follows:

- These parts remain overshadowed by movements in the flash market and by the volatility in the SRAM and the DRAM markets.
- Some good price reductions are forecast for both ROMs and EPROMs, especially at the higher densities. However, flash will remain the dominant nonvolatile memory solution.

Microprocessors

Highlights of the forecast for microprocessors are as follows:

- Intel's dominance of the computer processor arena basically determines the pricing scenario for all comparable devices. However, its competitors are beginning to change this.
- The shift to shorter-lived, more differentiated products is forcing users to adapt quickly to changes in pricing schemes.
- Intel's competitors (AMD, Cyrix, and PowerPC devices, for example), provide good price/performance competition, and these companies are quick to reduce prices to gain business.

Dataquest Perspective

Given the continued oversupply of semiconductors and the falling revenue in the segment, it is easy to lose sight of the fact that actual customer demand remains very strong. Dataquest continues to forecast strong growth rates in all the main semiconductor end applications for the foreseeable future. Unfortunately, by comparison, the supply/demand imbalance in the semiconductor device section means that semiconductor growth rates will be less spectacular in the near term.

However, because the excess production capacity will not go away for some time, regular price reductions and good lead times have become a fact of life in the semiconductor business. Suppliers will find it tough to nearly impossible to instigate unjustified price increases on readily available, multisourced semiconductor devices.

Most semiconductor device families are expected to offer good, controlled price declines on newer devices over the entire length of the forecast. Most semiconductor families are showing good growth rates, with one notable exception—memories. Because this family is worth so much in dollar terms, it has helped cause overall semiconductor growth to slow. Also, the oversupply of SRAMs and DRAMs has destabilized the market further and led to the strong belief that some form of stabilization will have to be imposed on suppliers of these devices to avoid bankruptcy and dumping.

There is now a widely held opinion that some form of forced price stabilization may become a reality. In last quarter's highlight Perspective, Dataquest indicated that rumors were circulating about the potential for antidumping action on SRAMs. This quarter, the focus is shifting to DRAMs. There are many options for forcing steady prices on DRAMs, but they can be put into two categories: supplier initiated or third-party initiated. The main supplier-initiated options include manufacturers' ceasing to participate in the DRAM segment or cutting back production their DRAM output. The main options that could be initiated by third parties include an antidumping suit started by a particular DRAM vendor, a U.S. Department of Commerce investigation of DRAM manufacturing costs to manufacture, and instigation by financial institutions of a policy to achieve a return on investment. Time will tell.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

Central and Eastern European Semiconductor Usage Trends

Abstract: *This Perspective analyzes the developing semiconductor industries and markets of Central and Eastern Europe. Semiconductor consumption in the region in 1997 was $1.8 billion, of which Russia accounted for 43 percent. The dominant application within the Central and Eastern European semiconductor market was data processing, which accounted for 60 percent of semiconductors consumed in 1997.*
By Edmund Gemmell and Evelyn Cronin

Introduction

Much has been written about the blossoming demand for PCs, telecommunications equipment, and electronic consumer goods in the emerging electronic equipment markets of the Central and Eastern European (C&EE) region. This Perspective analyzes this blossoming demand and assesses its effects on the indigenous manufacturing infrastructure of C&EE countries and on the demand for semiconductors, both imported and locally manufactured.

Geographic Definition

For the purposes of this Perspective, the C&EE region is defined as Bulgaria, the Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, Slovenia, Ukraine, and the Rest of Central and Eastern Europe (Albania, Armenia, Azerbaijan, Belarus, Bosnia/Herzegovina, Croatia, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Serbia/Montenegro, Tajikistan, Turkmenistan, and Uzbekistan).

In addition to this top-level categorization, a subcategorization distinguishing between Central Europe and Eastern Europe is occasionally

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9805
Publication Date: June 15, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

referred to. For the purposes of this report, Central Europe refers to the former satellite states of the Soviet Union and includes the Czech Republic, Hungary, Poland, Slovakia, and Slovenia. Eastern Europe refers to the countries that made up the Soviet Union, including Russia, Ukraine, the Baltic states, and those countries now part of the Commonwealth of Independent States (CIS).

Market Overview

Total semiconductor consumption in Central and Eastern Europe in 1997 was $1.8 billion. Dataquest has calculated semiconductor consumption for the region based on the value of electronic equipment output. The major countries in terms of semiconductor consumption were Russia; which consumed 43 percent of all semiconductors used in the region; Poland, which accounted for 21 percent of all semiconductors; and the Czech Republic and Hungary, which consumed 9 percent and 8 percent, respectively.

The dominant application market within the C&EE semiconductor market was data processing, which accounted for 60 percent of all semiconductors consumed in 1997; this was a slight increase over 1996's level of 57 percent. The consumer electronics market was the next largest user of semiconductors, accounting for 17 percent of semiconductor consumption in 1996 and 1997. The communications market accounted for 11 percent of semiconductor consumption in 1997.

Direct semiconductor shipments into the region by non-C&EE semiconductor vendors accounted for 32 percent of all consumption in 1997 and 30 percent in 1996. A major contributor to these figures was PC-related semiconductors in the form of microprocessors from Intel Corporation, Advanced Micro Devices Inc., and Cyrix Corporation and DRAM from various vendors. In addition to direct shipments of semiconductors by vendors, the formal semiconductor distribution channel, mostly derived from Western Europe, accounted for a further 5 percent to 10 percent of the total market.

The C&EE region's semiconductor industry is several generations of technology behind the rest of the world, and a large proportion of indigenous semiconductor companies has ceased trading, while a substantial part survives at subsistence levels. However, there are several indigenous semiconductor companies that have found niche markets, primarily in Southeast Asia or at home, for their product ranges. Included in this category of company are Mikron JSC, Angstrem, and JSC Voronezh Semiconductor Plant (VZPP) of Russia, as well as Kvazar Micro of Ukraine, Integral of Belarus, and Tesla Sezam of the Czech Republic.

Regional Macroeconomic Trends

After seven years of continuous decline, the C&EE region as a whole witnessed the resumption of economic growth in 1997, but the projected rate for 1997 is still fragile, at less than 1 percent. Compared with 1996, average growth is likely to slow down slightly in Eastern Europe but accelerate in the Baltic states, while economic contraction seems to have finally come to an end in the CIS. This turnaround is largely the result of the improving performance of Russia and Ukraine, with Russia likely to register its first year of positive growth. Of 26 economies in the region, 11 are expected to grow at rates of 4 percent or more in 1997. Table 1 shows gross domestic product (GDP) growth rates of the major C&EE economies.

Inflation has been brought further under control in most of the C&EE region. Median inflation fell from 32 percent in 1995 to a projected 14 percent in 1997. Year-end inflation in 1997 is expected to be 40 percent or lower in 20 of the 26 countries, and there is now single-digit inflation in nine countries. Most cases of improvement have been in the CIS, although inflation performance has not been uniform; there has been slippage both in the CIS and in some Central European countries.

Table 1
Major Central and Eastern European GDP Growth Rates, 1993 to 1998 (Percent)

Country	1993	1994	1995	1996	1997	1998
Bulgaria	-2.4	1.8	2.1	-10.9	-7.0	2.5
Czech Republic	0.6	2.7	5.9	4.1	1.0	2.5
Hungary	-0.6	2.9	1.5	1.0	3.0	4.0
Poland	3.8	5.2	7.0	6.0	5.5	5.0
Romania	1.5	3.9	7.1	4.1	-1.5	1.5
Slovakia	-3.7	4.9	6.8	6.9	4.5	3.0
Slovenia	2.8	5.3	4.1	3.1	4.0	4.5
Russia	-8.7	-12.6	-4.0	-5.0	1.0	3.0
Ukraine	-14.2	-23.0	-11.8	-10.1	-3.0	2.0
Total Central Europe and Baltic States	**0.4**	**3.7**	**5.3**	**4.1**	**3.1**	**-**
Total Commonwealth of Independent States	**-9.3**	**-13.5**	**-4.9**	**-4.6**	**0.8**	**-**
Total C&EE Region	**-5.4**	**-6.6**	**-0.8**	**-1.1**	**1.7**	**-**

Source: European Bank for Reconstruction and Development Transition Report 1997

Semiconductor Market

Because of the unstructured nature of a significant proportion of semiconductor distribution channels within the C&EE region, Dataquest has calculated semiconductor consumption for the region based on the value of electronic equipment output, used in its most liberal sense. For the purposes of this report, electronic equipment output includes all activities resulting in finished electronic goods, including simple "screwdriver" manufacturing operations.

The benefit of using this definition derives from the relatively small amount of true manufacturing in the C&EE electronics and semiconductor markets. However, as the economies of C&EE develop, demand from the region's 400 million inhabitants will begin to be satisfied by developing domestic manufacturers using domestic raw materials, as opposed to the current solution: imports from other regions and final assembly of electronic product kits. This means that although current real semiconductor demand is relatively low, in future years, the C&EE electronics industry will move into value-added manufacturing, which requires the use of semiconductor components instead of board- and kit-level products. Thus, the current board-level semiconductor consumption will change to semiconductor consumption as measured in the rest of the world. Analysis of the current C&EE board-level semiconductor consumption leads to an estimate of the region's future semiconductor consumption.

An example of this type of market development can already be seen in Russia. Sistema, a holding company with companies at all levels of the production chain, has recently negotiated a deal with Ericsson to build telecommunications equipment. This equipment will not simply be the usual model of final assembly; subassemblies for the systems will be manufactured in Russia using Russian components where possible, thus ensuring real local content and local added value in the final product.

Using this definition of electronic equipment output, the semiconductor market of C&EE based on electronic equipment production totaled $1.8 billion in 1997. This makes the entire C&EE region larger in demand than Benelux and smaller than Italy. Table 2 shows total semiconductor consumption by country, based on electronic equipment production, from 1994 to 1997.

Table 2
Central and Eastern Europe—Total Semiconductor Consumption by Country, 1994 to 1997
(Millions of Dollars, Based on Electronic Equipment Production)

Country	1994	1995	1996	1997
Bulgaria	11.5	24.9	17.5	16.2
Croatia	23.0	28.7	27.5	31.1
Czech Republic	95.7	139.1	143.8	171.9
Hungary	85.7	129.1	128.3	142.3
Poland	168.5	279.6	310.4	389.0
Romania	43.7	60.3	62.3	76.3
Russia	461.3	596.1	615.8	781.0
Slovakia	30.7	43.9	45.2	55.2
Slovenia	49.0	65.3	62.1	67.8
Ukraine	52.2	57.8	53.6	69.2
Others	0	17.7	16.9	24.3
Total	**1,021.3**	**1,442.6**	1,483.5	**1,824.2**

Source: Dataquest (April 1998)

As is true elsewhere in the world, data processing is the dominant market application, accounting for 60 percent of the market in 1997. This is significantly higher than the 40 percent of the Western European semiconductor total available market (TAM) held by data processing. This segment's dominance in the C&EE region is undoubtedly the result of indigenous PC manufacturers' rapid entry into the C&EE market and their success in gaining market share over imported PCs. In 1997, indigenous PC manufacturers held a 73 percent share of the four largest PC markets (Russia, Poland, the Czech Republic, and Hungary), an increase from 69 percent in 1996. After data processing, the consumer market is the next-largest application market, followed by the communications application market and the industrial applications market.

Traditional "first point of invoice" sales into C&EE by nonindigenous semiconductor vendors were about $570 million in 1997. This represented about one-third of total semiconductor consumption in C&EE. A major contributor to this amount is the microprocessor market, whose leading participants—Intel, AMD, and Cyrix—sell directly into the C&EE PC market.

If PC manufacturing were removed from semiconductor consumption based on electronic equipment production output, the value of semiconductor consumption in 1996 would have been $635.4 million, and $731.2 million in 1997. True semiconductor sales would have been about $160 million in 1996 and $200 million in 1997.

In addition to direct sales from semiconductor vendors into the C&EE region, a significant percentage of semiconductors sold into the region originates from semiconductor distribution companies. Their business structures typically mean that their representatives in C&EE purchase semiconductors from the Western part of their organizations, which in turn purchase the semiconductors direct from the semiconductor vendors. This means that within the semiconductor vendor's reporting structure, the sale is recorded as being into Germany or the United Kingdom—whichever country the distributor manages its C&EE operations from. Through distribution reporting structures, vendors typically get some feedback concerning the final destination of their products. Dataquest estimates that the distribution channel generated revenue of about $105 million originating from the C&EE region in 1997.

Indigenous Semiconductor Industry

Until 1991, the semiconductor industry of the C&EE region was an integral part of the Warsaw Pact defense industry. Also, no part of the industry was exposed to competitive forces. These factors have had two primary effects on the C&EE semiconductor industry.

First, items produced by semiconductor companies were limited in their range. Most products were designed primarily for military purposes, which is in itself no bad thing, given that the entire U.S. semiconductor industry grew from the same need for defense technology. However, within the Warsaw Pact community, the innovation and access to technology that would have developed these military products for nonmilitary applications and spawned new industries were stifled in an atmosphere of mistrust and secrecy. Nonmilitary applications were largely ignored or were developed with second-rate technology regarded as safe enough to release to the general public.

Second, because semiconductor companies faced no competition or commercial pressures, manufacturing technologies developed only enough to ensure sufficient supply for the defense industry and paid scant regard to manufacturing costs. The lack of competition meant no single company needed to innovate manufacturing technology in order to maintain any competitive advantage. Once a level of manufacturing technology was reached that was sufficient to meet demand, innovation tended to plateau at a less-than-optimal level. This led to wafer fabrication plants with similar levels of technology and capabilities, which, although more than sufficient for military needs, were, in comparison with non-C&EE technologies, several generations behind. This applied to both semiconductor manufacturing and factory efficiency technologies.

Unfortunately, once exposed to free market economics and the almost overnight demise of their traditional markets and loss of governmental support in 1991 and 1992, the structural weaknesses that characterized the region's semiconductor industry left it completely unable to compete with the rest of the world's semiconductor industries. Exposed to market forces, C&EE semiconductor and electronic equipment manufacturers could only offer products with less advanced technology and lower quality assurance levels than available elsewhere, and so were denied access to new markets that could have replaced the rapidly shrinking home markets.

In 1989 there were more than 100 semiconductor wafer fabrication plants throughout the Soviet Union; about six years after exposure to world market dynamics, Dataquest estimates that between 30 and 40 enterprises still maintain any sort of manufacturing capabilities. These companies range from plants surviving on tens of thousands of dollars annual revenue to several companies with tens of millions of dollars in revenue.

Among the most commercially active C&EE semiconductor vendors are Tesla Sezam in the Czech Republic; Baneasa SA in Romania; Angstrem, Mikron, VZPP of Russia; Integral from Belarus, and Kvazar Micro from Ukraine, all of which have revenue measured in millions of dollars. Table 3 lists the semiconductor enterprises in the C&EE region that Dataquest believes to be economically active.

Data Processing Market

The PC market of C&EE is small when compared with that in the rest of Europe. In 1997, 3.5 million PCs were shipped into the C&EE marketplace, compared with the 19.1 million units shipped in Western Europe. Within the C&EE marketplace, indigenous PC manufacturers hold the majority of market share. In 1995, C&EE PC manufacturers held 62 percent of the region's market; by 1997, this had grown to 73 percent of all shipments. Table 4 shows the market split between indigenous manufacturers and importers.

Table 3
Central and Eastern Europe—Economically Active Semiconductor Enterprises

Company	Location	Country
Integral	Minsk	Belarus
Transistor	Minsk	Belarus
Microelectronica	Botevgrad	Bulgaria
Info Semiconductor	Sofia	Bulgaria
DZU	Stara Zagora	Bulgaria
Tesla Sezam	Roznov	Czech Republic
Estel Semiconductor	Tallin	Estonia
Melcom	Budapest	Hungary
Intermos Microelectronics	Budapest	Hungary
Alfa Semiconductor	Riga	Latvia
Venta	Vilnius	Lithuania
ITE	Warsaw	Poland
Lamina Semiconductor International	Plaseczno	Poland
Baneasa SA	Bucharest	Romania
Microelectronica SA	Bucharest	Romania
Romes SA	Bucharest	Romania
Angstrem	Zelenograd	Russia
Electronica R&D Institute	Voronezh	Russia
Elex	Alexandrov	Russia
JSC Voronezh	Voronezh	Russia
Komponent Plant	Zelenograd	Russia
Kremniy Group JSC	Bryansk	Russia
Mikron JSC	Zelenograd	Russia
Pulsar	Zelenograd	Russia
R&PA Electronic Device Manufacturer	Voronezh	Russia
Eliz	Fryazino	Russia
Exiton	Pavlov Pasad	Russia
Iskra	Ylyanovsk	Russia
Soyuz	Novosibirsk	Russia
Vostok	Novosibirsk	Russia

Table 3 (Continued)
Central and Eastern Europe—Economically Active Semiconductor Enterprises

Company	Location	Country
Ei Semi	Nis	Serbia
IHTM	Belgrade	Serbia
Diotec	Radosina	Slovakia
Tesla Piestany	Piestany	Slovakia
JSC Kwazar	Kiev	Ukraine
Kvazar Micro	Kiev	Ukraine
Gamma	Zaporozhye	Ukraine
Rodon	Ivano-Frankivsk	Ukraine

Source: Dataquest (April 1998)

Table 4
Central and Eastern Europe—PC Shipments by Source, 1995 to 1997 (Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	1,384.1	1,860.9	2,565.5
Import	836.1	899.6	934.5
Total	**2,220.2**	**2,760.5**	**3,500.0**

Source: Dataquest (April 1998)

The largest single market was Russia, which accounted for 41 percent of the total market and 42 percent of all indigenously manufactured PCs. The PC markets of Poland, the Czech Republic, and Hungary are also significant in local terms.

Unlike the Western European PC market, which is more or less homogeneous, the PC market of C&EE is definitely heterogeneous: Each country has its own set of dominant manufacturers that serve their local market primarily. Very little exporting occurs within the indigenous market, because within the C&EE marketplace, indigenous manufacturing consists of little more than final assembly of PC units. Motherboards and all other major function boards are imported (primarily from Southeast Asia); assembly is completed by the cheap labor pools in each C&EE local market. Little advantage is gained if a manufacturer in one C&EE country exports to another because production costs are equal and additional transport costs will be incurred. Moreover, foreign manufacturers will have little knowledge of the market dynamics that apply in other countries; C&EE PC manufacturers have little capital to invest in setting up a brand name elsewhere and experience difficulty in setting up distribution channels.

The only true consumption of semiconductors (measured from first point of invoice) within the PC production market is the purchase of microprocessors and DRAM. In the C&EE markets, the same dynamics seen in the rest of the world apply.

Communications Market

The telecommunications manufacturing environment in C&EE is characterized by joint ventures. The principal non-C&EE participants are Alcatel, Lucent Technologies, Ericsson, and Siemens AG, all of which have joint ventures in at least two C&EE countries. For the most part, these joint ventures are final assembly plants that produce products for their local markets. This means that non-C&EE semiconductor companies with products designed in with the major telecommunications infrastructure manufacturers already have a significant presence in the region by default. However, this presence is unseen, because only board-level kits are shipped into the C&EE region by manufacturers, although there are signs that this is gradually changing.

The following lists which companies are present in which countries:

- Russia: Alcatel, Siemens
- Poland: Alcatel, AT&T
- Hungary: Siemens, Alcatel
- Czech Republic: AT&T, Marconi
- Romania: Alcatel, Gold Star
- Bulgaria: Siemens
- Slovakia: Alcatel

Dataquest Perspective

As can be seen, most elements of the electronics industry and semiconductor industry are still in their infancy in Central and Eastern Europe. Indigenous manufacturing capabilities were significantly reduced after the collapse of the command-led economy as their traditional customers disappeared and their products were revealed as unable to compete against imports from the rest of the world. The recovery process is under way, however. Inward investment in manufacturing locations is occurring in most Central European countries, although it is lagging behind in Russia, whose economic development is several years behind the countries of Central Europe.

Most current inward investment in the manufacturing industry adds little value to the manufacturing process and consists primarily of final assembly plants. These plants produce no real demand for semiconductors because all their manufacturing inputs are in the form of kit- and board-level products. Over time, however, the manufacturing industries of Central and Eastern Europe will begin to add value in the manufacturing process and create additional demand for semiconductor products. This is beginning to happen with the presence of major contract electronics manufacturers in the region such as Elcoteq, SCI, and Flextronix, all of which have or plan to locate major manufacturing facilities in the region.

Opportunities for semiconductor vendors are sparse at the moment. Vendors that wish to increase their sales in the C&EE region will need a more in-depth business model. Appointing a sales team to the region will simply result in the current market's becoming more competitive. What is required is action to enlarge the market and encourage a quantum leap in the size of the available market. This will not be a short-term activity. It will be at least 10 years before the region as a whole fulfills its potential as an interesting market for semiconductor vendors.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

Second Quarter 1998 Procurement Pulse: Order Rates Plateau, Lead Times Flatten, Inventories Moderate, and Spot Prices Slip into Darkness

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

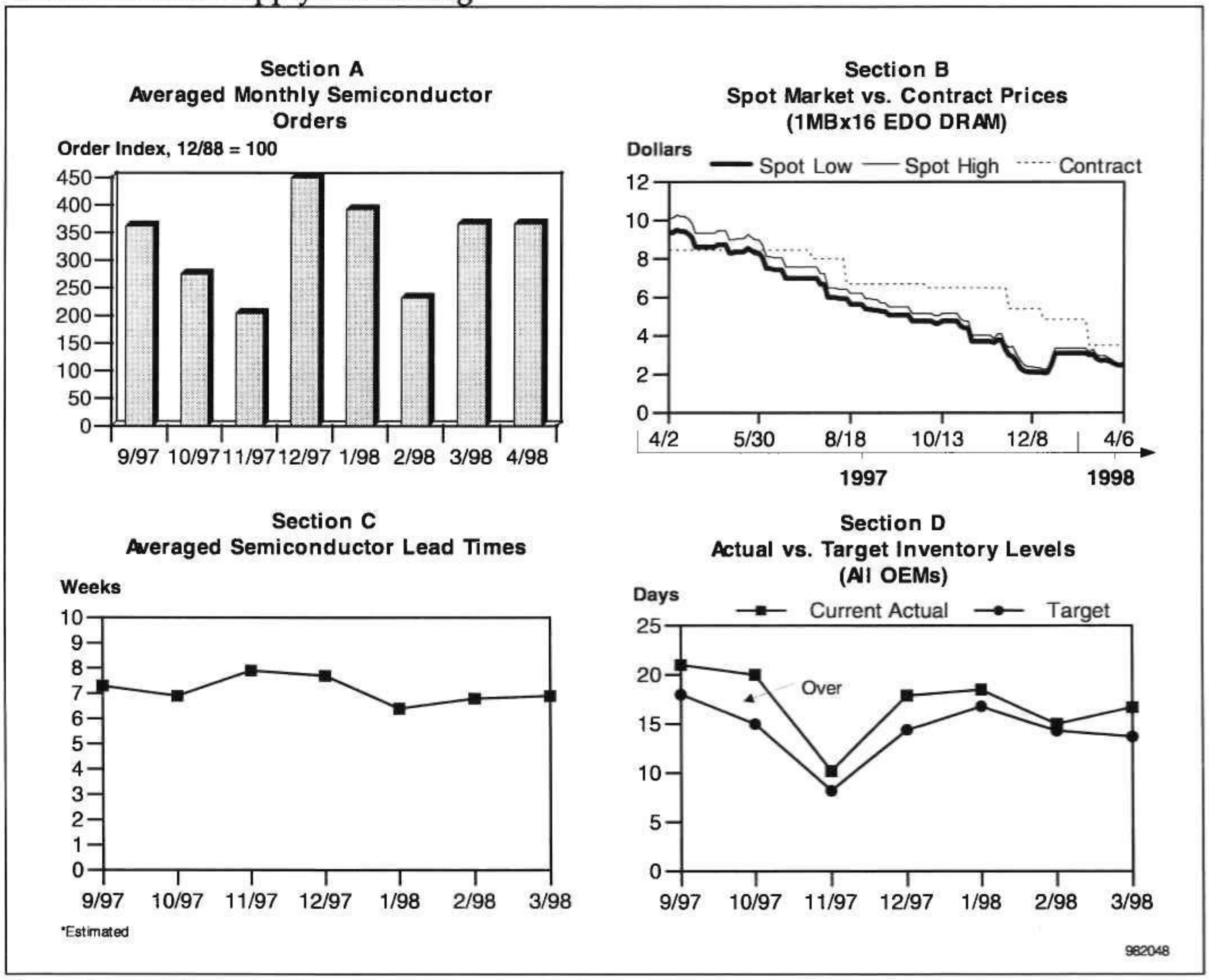
Semiconductor Orders Stabilize after First Quarter Roller Coaster

As seen in Section A of Figure 1, the outlook for semiconductor order activity has now stabilized after an up and down period from November through March. Although the outlook for April is slightly lower than January's forecast index, April has historically shown an upward trend. It appears that the dollar-based order activity index picked up slightly at the end of the year and then dropped off in January and February because of a combination of good inventory control and continued lower prices. Dataquest expects prices to remain low overall because channels continue to be oversupplied, a situation compounded somewhat by the Asian financial crisis. The overall sample continues to see price cuts for larger-volume contracts in all areas tracked in Dataquest's survey—MPUs, DRAM, application-specific ICs (ASICs), and, especially, SRAM and flash memory. Highlighting the resumption of actual supply and demand forces in the market, DRAM pricing for the overall sample again declined on average by 2.2 percent after a relatively soft 0.6 percent decline in March. The computer subset of the respondents saw a more aggressive decline of 3.3 percent in DRAM prices

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9804
Publication Date: April 20, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

after a small 1.7 percent dip in March. With overall prices continuing to fall, prices for thin, small-outline packages (TSOPs) and ball grid arrays (BGAs) are even with more standard package offerings, on average.

Figure 1
Semiconductor Supply and Pricing



Source: Dataquest (January 1998)

Spot Market Pricing: How Low Will It Go?

DRAM spot pricing continues to nosedive, highlighting the now nearly boring memory oversupply, as shown in Section B. Demand levels remain steady, with the exception of some Asian countries getting their financial houses in order. Parts originally destined for Asia are being redirected into the oversupplied marketplace with the results expected—lower prices. Rumblings are being heard of suppliers leaving the embattled 16Mb DRAM market because of the relentless price erosion illustrated in Figure 1, which may slow the decline in the upcoming quarters. For now, however, prices are low and are expected to go lower before they start to rise. As suppliers try to shift production to the 64Mb DRAM device, prices for the 64Mb are also falling fast. In late March the 8Mbx8 EDO part sold for a low of $9.20 on the spot market! Spot pricing has since risen to more than $10.00, but prices for the 64Mb have fallen so aggressively that there is little hope of profit relief from this next-generation device. As noted over the past year, Dataquest expects continued volatility of spot market prices, which will vacillate around declining contract prices, causing uncertainty for buyers. The overall trend for contract buyers, however, is for continued good or excellent availability, consistently declining contract prices, and low lead times (four to six weeks) for the next six to nine months.

Lead Times for Semiconductors Remain Manageable at under Seven Weeks

Section C shows that the average lead times reported by survey respondents in March have remained relatively constant over the past seven months, ranging from seven to eight weeks. The most recent average, 6.9 weeks, compares favorably with February's 6.8-week average, and the overall trend equals good availability. The current stability of lead times stems in part from the removal of uncertainty about DRAM supplies and the perception that availability will be good for the rest of this year. Even though spot prices are at an all-time low, most buyers are satisfied with current low contract pricing and the stability and lower total costs those deliveries provide. Good service levels and slowly declining prices continue to cement many long-term supplier relationships. Although once again there were no supply problems noted in this month's survey, good communications with suppliers cannot be seen as a passing fad. With general availability good and improving, this month's respondents had no supply problems to complain about.

Semiconductor Inventories Are Back to Historical Levels

First quarter 1998 inventories have generally declined or stabilized, as shown in Section D, compared to the past nine months (with the exception of November 1997). Respondents forecast semiconductor order rates to modulate, and there is a corresponding slight decrease or increase in inventory levels in line with historical levels. Easy replacement may cause inventory variability to continue. The overall targeted and actual semiconductor inventory levels for March were 13.7 days and 16.7 days, respectively, compared with February's 14.3-day and 15.0-day levels. Although it is not shown, the computer subset appears to be more aggressive than the average, with current target and actual inventory levels of 12.7 days and 14.0 days. We continue to expect to see inventory levels stabilize in line with steady system sales levels.

Dataquest Perspective

The story of good semiconductor availability continues, and Dataquest expects this availability to remain good for the rest of this year. As noted a year ago, contract prices continue to decline despite the efforts of some memory suppliers to curtail output. Lead times have stabilized to meet customer demand, in line with the moderate price declines. Dataquest continues to forecast steady growth rates for PCs and other electronics relative to 1997, with the overall growth trend following an upward slope. User semiconductor inventory levels are now in line with demand, and we expect to see continuing balance in these indexes in the near future. Allocations are not a problem, but the shift of some suppliers to the 64Mb DRAM density appears to be causing those without 64Mb but with abundant capacity to lower prices faster, pushing out crossover times. Dataquest expects to see excellent semiconductor availability from the fourth quarter of 1998 through the first quarter of 1999. DRAM and MPU price elasticity have not propped up contract prices to date. The good news for users is that the overall decline in contract prices will continue for the second and third quarters and most likely for the rest of the year.

For More Information...

Inquiry Hotline:	+1-408-468-8423
Via e-mail:	scndinquiry@dataquest.com
Via fax:	+1-408-954-1780
Dataquest Interactive:	http://www.dataquest.com

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

1998 Second Quarter Price Forecast Highlights: Continued Oversupplies Keep Prices on a Downward Slope

Abstract: *The semiconductor market remains in oversupply. As a result, Dataquest's latest Quarterly Semiconductor Price Forecast continues to show declining prices and good availability for all semiconductors tracked. The question of how low prices can legally go continues to keep the market on edge. This Perspective highlights the latest price forecast and notes what the findings mean to both suppliers and buyers.*
By Mark Giudici

Overview

Overall pricing during the first quarter of this year picked up where the final quarter of 1997 left off—down. The Asian financial crisis has rippled through the market and, like a stone tossed into a pond, the ripples appear to be getting larger as time passes.

The spot market still leads the price-decline parade, and contract prices continue to follow this relatively small market channel down. Some devices are more prone to dramatic declines (selected 4Mb and 16Mb DRAM), yet the overall pricing situation this year still reflects the large amounts of manufacturing capacity that were put in place during 1995, 1996, and, based on our latest findings, even during the oversupplied 1997. The oversupply is expected to continue into 1999.

Dataquest has recently completed its second quarter 1998 semiconductor price forecast. Looking forward into this year and beyond, most buyers feel confident that prices will continue to fall. How far is now the main question as the antidumping drums get louder every month. At this writing, the government is looking into the practices of selected SRAM and DRAM

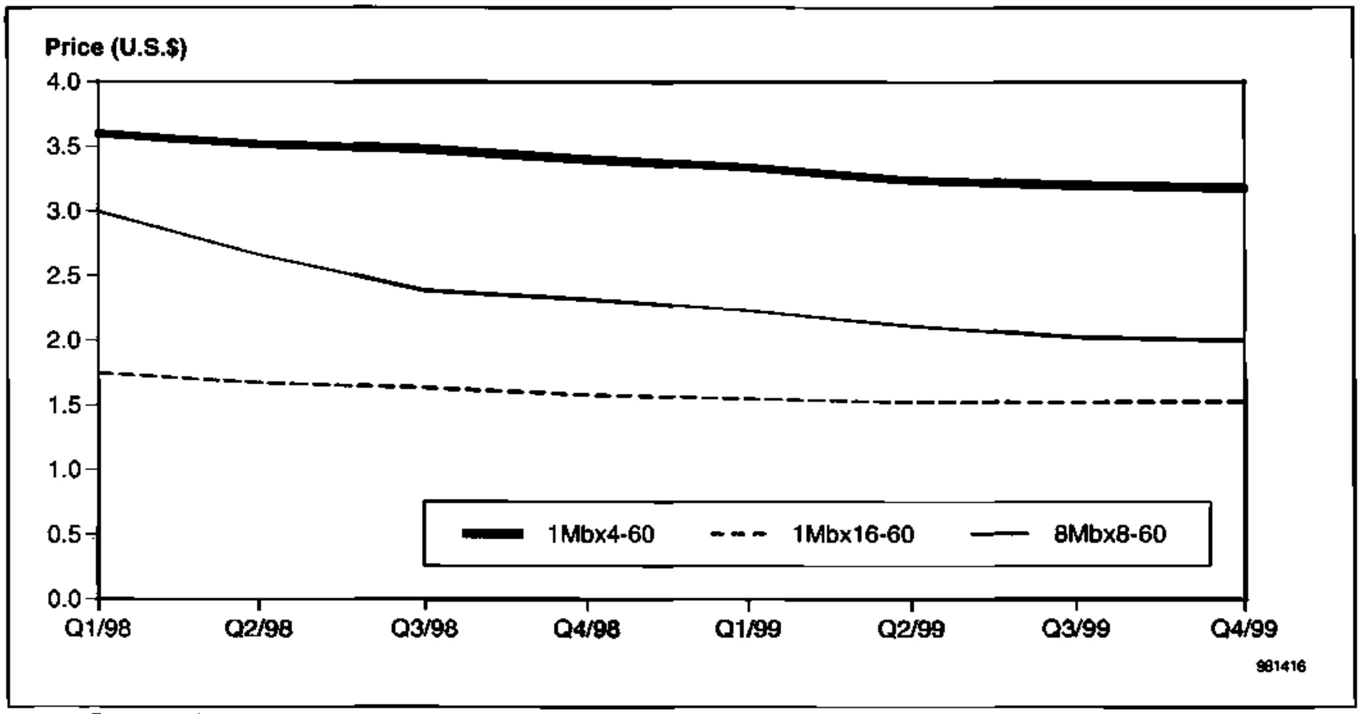
Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9803
Publication Date: April 6, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

companies to see if they should be charged punitive duties for dumping their products in the United States.

Price Forecast Highlights

As in the past 12-plus months, semiconductor prices continue to decline despite healthy end demand for electronic systems. Dataquest expects end-system demand to remain strong but for semiconductor prices to continue falling for the next 18 months or longer. Pricing for the volatile DRAM and some SRAM products is now being examined by users on a cost-plus basis, with buyers acknowledging that prices cannot decline to zero. That said, buyers are seeking the best available prices and expect lower prices and expect to spend fewer dollars per megabyte. Figure 1 plots the price per megabyte for contract price DRAM by quarter for 1998 and 1999. Using the 1Mbx4, 1Mbx16, and 8Mbx8 EDO parts as the current examples of each density, one sees that the 16Mb density clearly has the price-per-megabyte advantage for the near future and that the next-generation 64Mb part needs to come down some in order for a clear crossover to occur. Figure 2 shows the latest price forecast for the different voltage 512Kx8 (4Mb) flash memory devices by quarter for 1998 and 1999. As noted last year, since more suppliers are competing to provide products for low-voltage, portable applications, the lower the voltage, the lower the price for this growing product family.

Figure 1
DRAM Price per EDO Megabyte



Source: Dataquest (March 1998)

DRAM

Highlights of the forecast for DRAM are:

- The Asian financial crisis has caused some very large short-term price cuts for selected 4Mb and 16Mb DRAM on the spot market, which has affected some contractual pricing for these densities. The enactment of antidumping policies or even rumors of such a move may help stabilize prices near — perhaps even below — cost. Our forecast reflects this stabilizing trend.
- Controlled price reductions are forecast for all 4Mb, 16Mb, and 64Mb discrete DRAM devices for the next three years.
- Synchronous pricing will still be higher for the 16Mb density for the next two years, while the 64Mb density will hover near parity with EDO parts throughout 1998 and 1999.
- Prices for the 4Mb density will begin to rise in 2000 as the supply base shrinks.
- Pricing for EDO DIMMs continues to show a premium over like-density SIMMs through 1999.

SRAM

Highlights for the forecast for SRAM are:

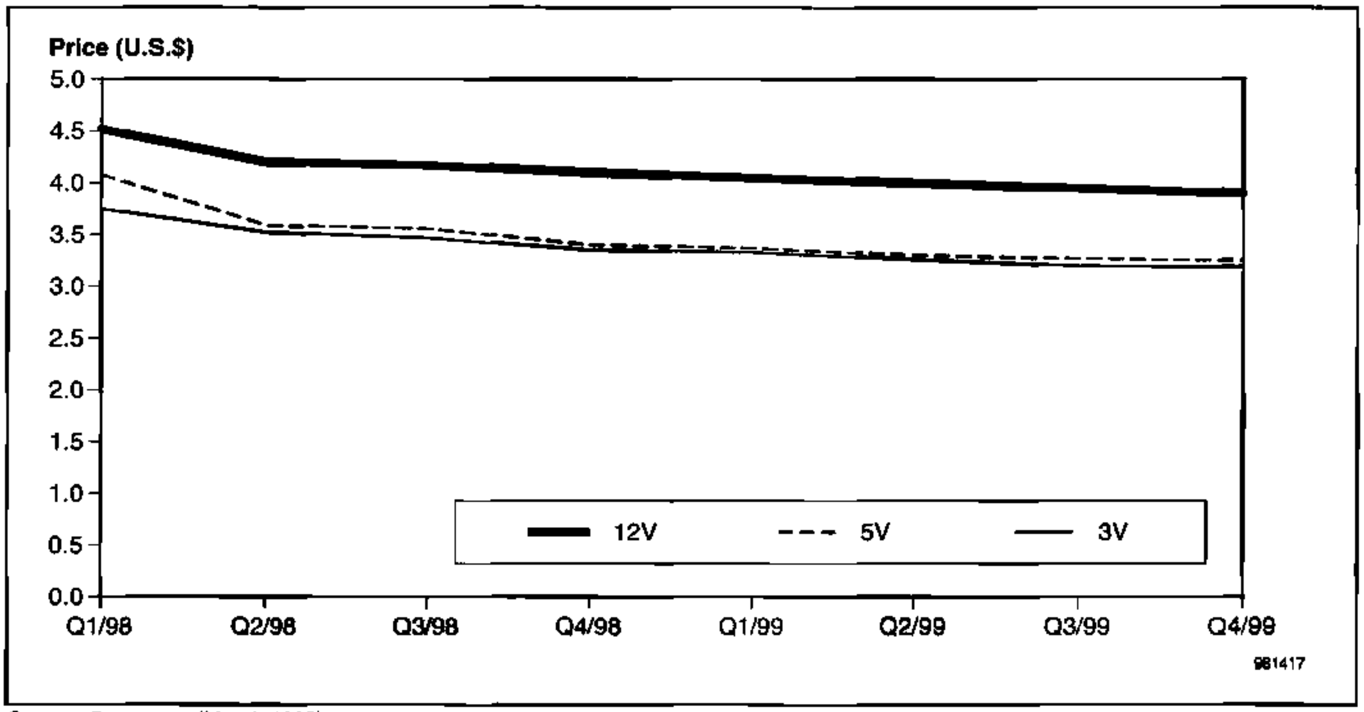
- Cutthroat SRAM pricing remains at cost-plus levels for the majority of devices.
- Sub-15ns high-density (4Mb-plus) devices still garner premiums owing to lower specialized application demand and a relatively low number of suppliers.
- Antidumping penalties for all SRAMs ranging from 10 percent to 100 percent, depending on the supplier, may force some suppliers from the market with the result of near-term flat to rising prices for some products.

Flash Memory

Highlights for the forecast for flash memory are:

- The trend toward lower cost by voltage (especially in the higher densities) continues as suppliers of low-voltage devices scramble for a share of the market for portable, power-sensitive applications.
- The oversupply syndrome affects all flash pricing, with continued price reductions expected for the next two years.
- Price declines will moderate for sub-4Mb devices as the prices fall close to production costs and suppliers focus on higher-density devices.
- The largest price declines are forecast for the 16Mb and higher densities through 2002.

Figure 2
Flash Memory Price Differences by Voltage



Source: Dataquest (March 1998)

Other Nonvolatile

Highlights for the forecast for other nonvolatile devices are:

- These parts remain overshadowed by movements in the flash market.
- Steady, but smaller price declines are expected in the ROM and EPROM arenas as flash becomes the dominant nonvolatile memory solution.

Microprocessor

Highlights for the forecast for microprocessors are:

- Intel's dominance of the computer processor arena basically determines the pricing scenario for all comparable devices.
- The shift to shorter-lived, more differentiated products is forcing users to quickly adapt to changes in pricing schemes.
- Intel's competitors (Advanced Micro Devices, Cyrix, and PowerPC, among others) provide good price/performance competition that keeps these prices falling faster than they have in the past.

Dataquest Predicts

Dataquest continues to see strong demand for electronic devices for the next two to three years, combined with an overabundance of semiconductors that go into these devices. The bottom line is good availability, declining prices, and a supply base that is willing to better accommodate customer needs. The Asian financial crisis may have a near-term effect of lower system demand in

Asia, but lower semiconductor prices based on exchange rates could offset any of these negative effects.

Depending on how specific suppliers are affected by the Asian financial crisis and antidumping actions, there will be short- and long-term market effects (especially in the DRAM and SRAM markets):

- Initial lower prices may be offset by dumping penalties.
- Affected suppliers may not keep pace with R&D costs because of cash flow issues—a long-term supply base issue.
- The spot market will continue to be the first signal regarding product availability— using a six- to 12-week trend as a guide for following contracts.

Price reductions are forecast across the board. This holds for almost every semiconductor device tracked by Dataquest. For devices in the growth phase of their life cycles, price cuts will be the largest, while more mature products will have smaller price declines.

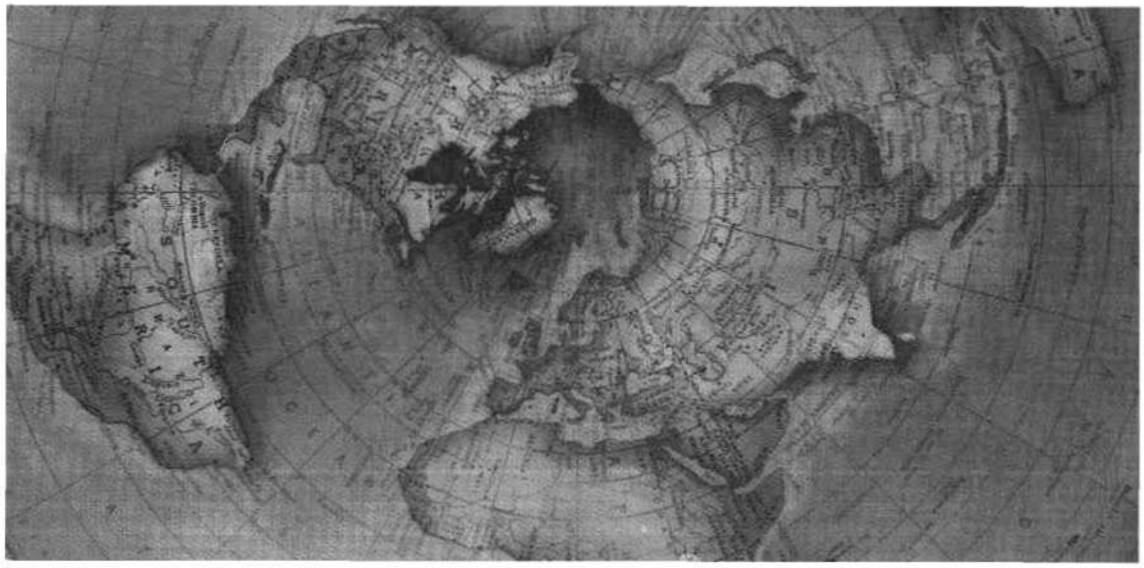
The ever-visible, ever-volatile DRAM market will continue to be the focus of the spot market, governmental trade reviewers, and suppliers pushing for a definite crossover to the 64Mb density. The bottom line is that DRAM and flash memory will see the greatest near-term price declines, with other product families also remaining in the price-cut camp.

For More Information...

Inquiry Hotline: +1-408-468-8423
Via e-mail: scndinquiry@dataquest.com
Via fax: +1-408-954-1780
Dataquest Interactive: http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective



Semiconductor Supply and Pricing Worldwide

Technology Analysis

1998 Semiconductor Cost Model Update

Abstract: *This Perspective updates the Dataquest semiconductor cost model and IC package cost table. Detailed examples of the 16Mb and next-generation 64Mb DRAM cost models that use the latest cost variables follow a brief review of the model's description.*
By Mark Giudici

DRAM Cost Update 1998: Cost-Based Pricing Returns Big Time!

Procurement departments often use cost model analysis in two ways: near-term cost/price optimization and in aiding long-range system cost analysis. Also, using semiconductor cost models during years of technology transition (for example, DRAM density crossover) often is useful in positioning procurement strategies in line with a company's system offering. The current buyer's market resulted from last year's shift in availability from an undersupply to an oversupply (relative to steady demand) for many semiconductor products.

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 that have the most influence over cost are the following: semiconductor process, wafer size, die size, sort yield, package type, and final test yield. Improvements have been made to the model this year that take into account process maturity and its effect on yield.

Dataquest

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9802
Publication Date: February 23, 1998
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

Cost Model Applications

Semiconductor cost models are predominantly used to compile costs for use in near-term contract negotiations. By identifying cost reduction areas, price negotiation results often benefit the parts buyer. Applying experience-curve theory to cost model applications can give both short- and long-term cost/price scenarios that can be a basis for strategic planning.

Strategic use of cost models in long-range planning has been underutilized 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 alternate 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.

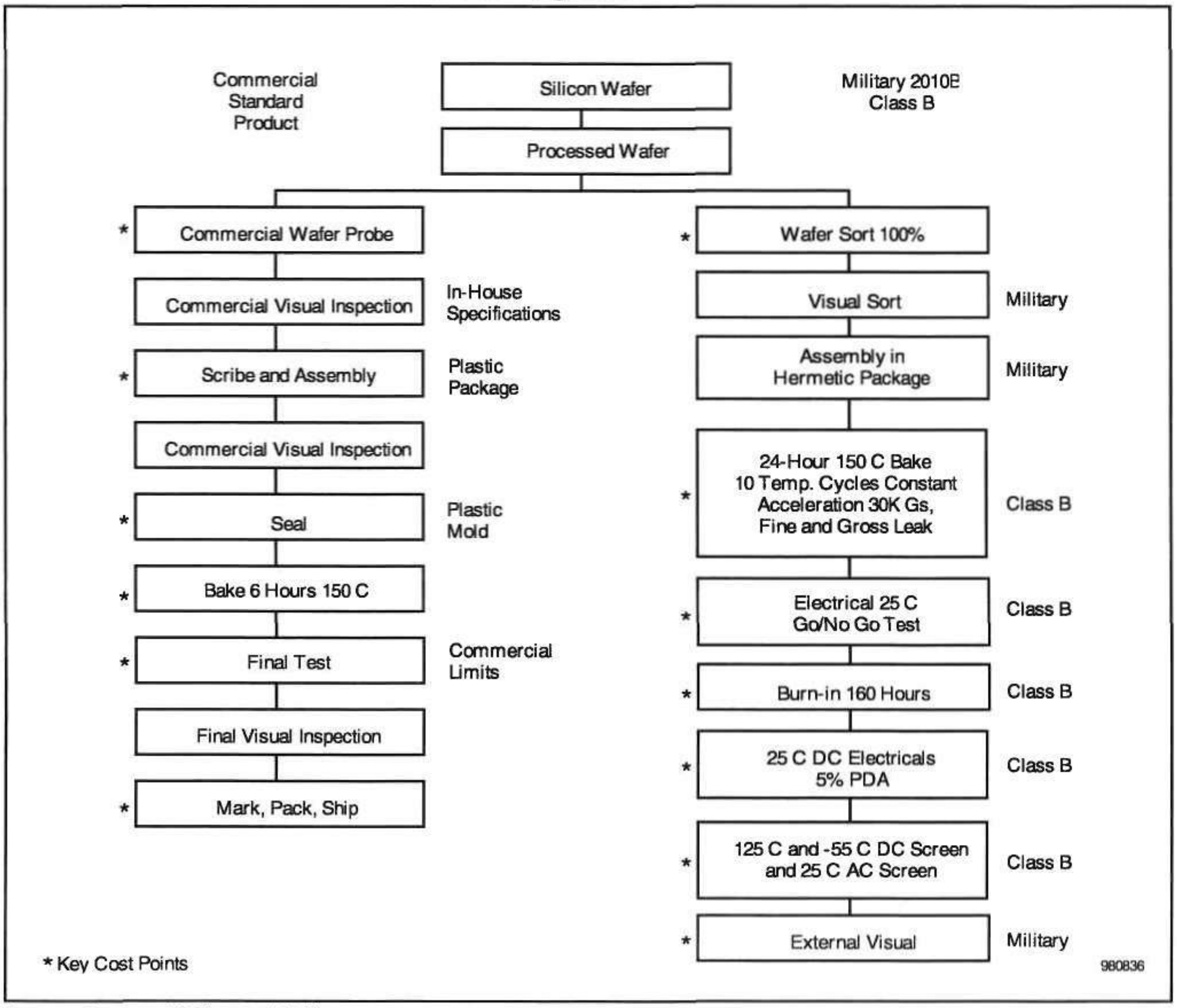
The cost/price relationship for semiconductor products varies from: product to product, company to company, and with time, as a function of business conditions. One way to perform cost/price to analysis is to monitor prices and costs over a period of several years for selected product types and identify 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

Figure 1
Commercial and MIL-STD Manufacturing Flow



Source: Dataquest (February 1998)

The manufacturing process begins with a raw, unprocessed silicon wafer that costs from under $15 (100 mm wafer) to approximately $120 (200mm 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 relative complexity and maturity of the IC process/lithography
- The number of masks
- The photolithographic requirements of the process used
- The clean room environment required by the process

A complex relationship exists for each of these elements with the end cost of the product. Some of these interacting relationships involve the depreciation schedule of a fabrication plant (that is, $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 die. 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 because of the increased density often will be lower.

The class of fab or clean room 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 the particles in the fab environment (that is, a 0.3-micron particle would not be a major problem in a 0.8-micron fab line, while the same particle would be catastrophic in a 0.25-micron line).

Table 1
Number of IC Process Mask Layer

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 1998)

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 often will reduce the manufacturing cost and related price by a factor of 2. Table 2 shows the latest cost estimates for semiconductor packaging in 1998. 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 depending on many of the key variables noted earlier (that is, die size, wafer size, process, package, among others).

Table 2
Total (Die-Free) Assembled Package Cost, 1998 (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 (Stamped)	TSOP Type II	SSOP	Plastic QUAD	TQFP 1.4mm Body	TQFP 1mm Body	Ceramic QUAD	Metal QUAD	TAB Tape/Site	Ceramic BGA	Plastic BGA One- and Two-Layer	Plastic BGA Multilayer
8	0.06	0.20	1.25							0.06												
14	0.10	0.22	1.65					1.15		0.08	0.18											
16	0.11	0.25	1.70				0.88	1.20		0.09	0.18											
18	0.12	0.30	1.80			0.19	1.00	1.30		0.12												
20	0.14	0.30	2.08			0.19	1.10	1.45	0.19	0.14	0.27	0.45	0.21									
22	0.17	0.32	2.44				1.18		0.28	0.20	0.36											
24	0.20	0.42	2.78				1.30	1.75	0.29	0.20	0.43	0.47										
28	0.23	4.60	3.27			0.22	1.51	2.05	0.30	0.22	0.49	0.54	0.32									
32	0.28	0.66	3.88			0.24	1.70	2.40	0.35	0.35	0.50	0.63	0.33	0.42	0.39							
40	0.32	0.94	4.85			0.29	2.28	2.90	0.38	0.42	0.58	0.66		0.43								
44	0.36					0.34	2.44	4.50	0.46		0.68			0.47	0.46	0.55						
48	0.44		6.12				2.70						0.35	0.50	0.47							
52						0.43	3.05							0.57								
56													0.41									
64	0.54			4.90	1.20		3.60	5.10						0.60	0.55	0.72			0.90	1.12		
68		3.20		5.10	2.45	0.55	3.90	5.50						0.62			5.10		0.90	2.11		
84		3.95		6.20	2.84	0.76	4.60							0.64	0.64		5.88		1.20	4.54		
100				7.90	3.26		5.15							0.67	0.78	0.98	9.20	2.50	1.20			
128				9.50	4.16									0.93	1.38		11.35	3.10	1.80	8.06		
132				11.10	4.36									1.20	1.60		13.60		1.80			
144				11.00	4.88			22.10						1.34	1.65		15.10	3.20	1.80	11.09	2.16	4.05
160				12.00	5.77			51.60						1.45	1.68		16.90	3.35	4.40	12.80		
164																			4.40			
169				12.50	5.92																2.70	5.08
184					6.89									1.95					4.40	16.56		
196				11.50										1.82	2.30				4.40			
208				17.85	7.65			51.25						1.85	2.35		21.10	3.77	4.40	20.38	2.85	
225				18.70				52.75													3.10	6.76
232					8.35									2.55				5.10	4.40			
240																		6.05	4.40	24.00		
244				26.54	8.60									2.95			27.70		4.40	25.38		
256					9.26			40.50						3.35	2.80		31.20	7.20	9.20	27.14	2.82	7.95
276								41.60														
296				35.16	11.15														9.20			
299					16.54																	
304														4.08				8.44	9.20	33.44	4.10	9.13

Table 2 (Continued)
Total (Die-Free) Assembled Package Cost, 1998 (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 (Stamped)	TSOP Type II	SSOP	Plastic QUAD	TQFP 1.4mm Body	TQFP 1mm Body	Ceramic QUAD	Metal QUAD	TAB Tape/Site	Ceramic BGA	Plastic BGA One- and Two-Layer	Plastic BGA Multilayer
308																			9.20			
313																					4.28	
324				38.66																36.12	4.98	10.44
340								132.00													5.00	
352																					5.05	10.66
361																			16.40	40.61		
368				43.40																		
376				45.10				362.00											16.40			
387				47.25	18.33															48.60	5.32	
420								422.00														
442																						
448				52.82																		
475																			18.80	55.82		
480																					8.13	13.24
504				68.74	19.80													42.20	22.50	59.88	9.35	13.74
625																			28.80	76.25		
672																			28.80			
Package Materials																						
Lead Frame	C194	A42	A42	A42	Cu	C151	A42/LDCC		C194	C194	A42/Cu	A42/Cu	Cu	Cu	Cu	Cu	A42	Cu	Cu with Sn plate	Cu vias	PCB	PCB
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	Epoxy	Epoxy
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 1998)

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 ($)	=K
Wafers Tested per Hour	=L =1/((#*I)/3,600)
Wafer Sort Cost per Gross Die ($)	=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 (Sec.)	=U
Cost per Hour of Testing	=V
Test Cost per Die ($)	=W =U*V/3,600
Final Test Yield (%)	=X
Cost per Final Tested Unit ($)	=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
S,G&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 1998)

Understanding Yields

Only a portion of die on a given wafer will meet the electrical test specifications to which the die was designed. The percentage of good die per wafer is known as yield. As a silicon wafer is processed, each step decreases the final yield of good parts that meet specification and are shippable.

Calculating Yield

There are several methods to calculate electrical test yields of semiconductor wafers. Dataquest uses a variant of the exponential equation called Murphy's formula to approximate yield:

Yield = $e^{(-DA)}$;

where e is the constant 2.72, D is the defect density in defects per square inch, and A is the area of the chip in square inches. This mathematical formula is useful for analyzing the key factors that affect semiconductor yields: the number of defects on the wafer and the number of chips on the wafer. The number of die per wafer is determined by the area of each chip. Defects on a wafer are caused by particles in the air falling on the wafer or process irregularities made during semiconductor manufacture. An increase in mask levels requires more time in the fab area, thus increasing the chance of defects occurring either from the air or processing error.

Yield Trade-Offs

By taking a typical 16Mb DRAM with two different die sizes (approximately 112,000 square mils and 142,000 square mils) in two different manufacturing areas, one with five defects per square inch and the other with one defect per square inch, one can easily see in Table 4 the advantages of using a clean room with fewer particulates. This points out why it is more economical to ship larger die if the fabrication area is cleaner, because more die per wafer are shippable.

Yield and Related Costs

Semiconductor chips are electrically tested several times to separate die that meet specifications from those that do not. Wafer sort, assembly, and final test are the three areas in semiconductor manufacturing where related testing occurs.

Table 4
16Mb DRAM Yield Loss to Defects (Percentage Good Die/Number of Good Chips per 8-Inch Wafer)

Chip Size (Mils^2)	Yield with Five Defects/Inch^2 (%)	Good Die	Yield with One Defect/Inch^2 (%)	Good Die
127,000	52.9	163	87.8	272
110,000	56.9	203	89.4	320

Note: A cleaner fabrication area allows for more shippable product even if the die size is larger than in a "dirtier" area.
Source: Dataquest (February 1998)

Electrical Wafer Sort

The first test, electrical wafer sort, is done on processed wafers by a computer-based tester at a test station specifically designed for that IC. The tester automatically tests each die on the wafer by contacting each pad on each chip and marking with an ink dot those die that do not pass the test. Test costs consist of equipment operating costs, direct operator costs, and the amount of time required to test each die. Equipment operating costs are dominated by the depreciation of the test equipment. Semiconductor test equipment is generally depreciated over three to five years and can range in price from $350,000 to over $1 million, depending on test/product requirements. Dataquest uses estimates of test costs per hour ranging from $25 to $125 per hour. The most complex integrated circuit test costs range from $65 to $125 per hour.

Dataquest assumes that a test operator supports each piece of test equipment and estimates the labor cost per hour to be $20. The total test cost then, including labor, ranges from $45 to $145 per hour.

The time to test a wafer is determined by the circuit complexity, the number of chips per wafer, and the yield. Good die take about five times as long to test as bad die. Test programs are formulated and used to minimize test time by testing functions of the device statistically proven to most likely fail first. Test times for good die are kept to a minimum by performing only those tests that assure 85 to 90 percent test yield when packaged. Wafer sort times for full-production VLSI chips take no longer than nine seconds for each chip.

Assembly and Packaging

Semiconductor chips in the form of processed and tested wafers are electrically functional and could be used as they are. Functional die in wafer form, although theoretically functional, are too fragile unpackaged for practical use. In order to have a protective container for a device, various packages are available to provide different devices with different degrees of ruggedness. Ranging from ceramic packages with gold contacts to blobs of epoxy covering chips on PC boards, the encapsulation method for electrically good die is determined by the end use of the system that the part goes into.

Packaging technology has continuously improved, but the basic assembly steps have not changed significantly during the past 25 years. The three main areas of assembly are the following:

- Die separation
- Die attach and lead/ball bond
- Encapsulation

Die Separation

This step refers to the method of separating the individual die on a wafer. One technique is very similar to the method of cutting glass. A plastic film is attached to the back of the wafer after which a diamond stylus automatically scratches the wafer between each die, both horizontal and vertical. Once the total wafer is scribed on these "scribe lines," the wafer is placed on a machine that fractures it along these lines. Some manufacturers use laser scribe machines to etch a line along the scribe line. Thick wafers require diamond sawing (and commensurately wider scribe lines) to prevent die loss because of uncontrolled fractures.

After the wafer is completely broken into individual die, each chip is visually inspected under a microscope to ensure removal of any that were physically damaged during the "slice and dice" procedure. Chips are also eliminated at this point if they do not conform to dimensional design rules. Good die are separated and moved to the next step of manufacture, die attach, and lead bond.

Die Attach and Lead Bond

Assuming the use of a standard plastic small outline J-lead (SOJ) package, good die are attached to metal lead frames with a small amount of molten gold or low-cost epoxy. It is imperative that a die be securely attached to the lead frame in order for it to withstand later testing requirements made of the finished device. The next step is bonding the pads of the chip to individual leads of the package with either gold (becoming more rare) or aluminum wire that is less than 1 thousandth of an inch in diameter. Thermocompression bonding involves heating the lead frame and attached die to about 340^0 C. The bonding wire is automatically pressed against the bonding pad on the heated die, fusing the wire to the die. The wire is then drawn to its respective bonding pad on the lead frame, which is also then fused. Automated bonding machines are capable of bonding more than 1,500 packages per hour. Once the die is attached with bonded leads, another visual inspection is performed to eliminate devices that were damaged or bonded incorrectly.

Encapsulation

Assembled lead frames for plastic SOJs are placed in molds into which molten epoxy plastic is injected, thus forming the body of the semiconductor device. Between 20 and 50 packages are encapsulated at once, resulting in low production costs. The molded packages are then cured in a 200^0 C oven for 40 hours. Excess metal is then removed from the devices and the leads are formed to the finished product configuration. The parts are tested for open or shorted circuits that might have resulted during encapsulation. The surviving packaged parts are now ready for final test.

Final Test

After the die have been packaged, they undergo one final test. Packaged parts are transferred from assembly to the final test area in static-free plastic tubes or trays that are inserted into automated package handlers. The handler releases one packaged part at a time into a test socket or head that is wired to an automated test system. Most manufacturers use multiple-head test systems to increase the throughput of a test system.

Each unit is stringently tested at this step, across "worst case" conditions. The circuits are tested for maximum and minimum speeds, for power dissipation, and for many combinations of inputs and outputs in order to meet all guaranteed device specifications. The automated test system performs thousands of separate tests in seconds. A typical final test by the manufacturer runs from less than one second for a TTL logic device to up to 15 seconds for some 64Mb DRAMs.

The final test must be stringent enough to ensure that the device performs over its guaranteed temperature range. The environmental conditions are usually ensured in one of the following two ways:

- All devices are tested at the high temperature end of the specifications.
- The devices are tested at room temperature over sufficiently wide tolerances (guard bands) so that operation at the temperature extremes is ensured.

The first approach is obviously the safer (more conservative) method, but it is also much more expensive. As a result, most semiconductor suppliers will correlate the room temperature characteristics with the characteristics at temperature extremes, add a safety guard band to the room temperature test parameters, and then test at room temperature. Samples are regularly taken from the production lots and tested across the full range of environmental conditions to ensure that the correlation parameters are accurate.

The functions of wafer sort and the final test correlate very closely. Often both tests are performed in the same room and/or on the same test machine; the chief difference is the test program. One of the main functions of the wafer sort program is to minimize the amount of additional labor and materials that would be assigned in producing bad ICs.

Wafer sort cannot eliminate all potentially defective die, however, because:

- Most sophisticated circuits cannot completely be tested in wafer form because of parasitic effects resulting from probes and wiring, incident room light, and other factors involved with physically sorting the die.
- Some of the die may be damaged during the assembly process.
- The die cannot be tested across the temperature range in wafer form because the wafer and probes cannot be easily maintained at temperatures below ambient.

The objective of wafer sort is to ensure that enough of the potentially rejectable chips are discarded so that final test yields will be high enough to support a desired level of profitability. Excessively high final test yields are not necessarily acceptable. This may mean that potentially good devices are being thrown away at wafer sort. As a result, many manufacturers will adjust the tightness of their internal wafer sort test to allow the final test yields to fall in the range of 80 to 90 percent good units.

Cost Model Examples

Tables 5 and 6 illustrate how cost models can highlight cost differentials of different DRAM densities. These models use best-case variables from information gathered in press and trade articles and forecasts yield/cost improvements based on historical trends from previous products.

Table 5
16Mb DRAM Cost Model (Three Metal Levels), 1998

	1997	1998	2000
Die Size (Sq. mm)	42	30	26
Wafer Sort			
Wafer Size (Diameter in Inches)	8	8	8
Geometry (Microns)	0.35	0.25	0.25
Processed Wafer Cost ($)	1,450	1,400	1,400
Die Area (Square Mils)	65,487	46,887	39,854
Active Area Factor	1.00	1.00	1.00
Number of Masks	18	18	18
Defect Density per Square Inch	0.028	0.028	0.028
Gross Die per Wafer	614	858	1,009
Processed Wafer Cost per Gross Die ($)	2.36	1.63	1.39
Test Cost per Hour ($)	110.00	110.00	110.00
Wafers Tested per Hour	0.13	0.14	0.18
Wafer Sort Cost per Gross Die ($)	1.38	0.92	0.61
Cost per Gross Die at Wafer Sort ($)	3.74	2.55	2.00
Wafer Sort Yield (%)	97	98	98
Cost per Sorted Die ($)	3.86	2.61	2.04
Assembly			
Material Cost/Sorted Die—SOJ Pkg. ($)	0.34	0.30	0.30
Number of Pins	28	28	28
Assembly Yield (%)	99	99	99
Cost per Assembled Die ($)	4.24	2.94	2.36
Final Test			
Test Time per Die (Sec.)	10.00	10.00	10.00
Cost per Hour of Testing ($)	90.00	90.00	90.00
Test Cost per Die ($)	0.25	0.25	0.25
Final Test Yield (%)	98	98	98
Cost per Final Tested Unit ($)	4.58	3.25	2.67
"Mark, Pack, and Ship"			
Cost at 99% Yield (%)	0.05	0.03	0.03
Total Fabricated Cost per Net Unit ($)	**4.63**	**3.29**	**2.69**

Source: Dataquest (February 1998)

Table 6
64Mb Cost Model, 1998

	1997	1998	1999	2000
Wafer Sort				
Wafer Size (Diameter in Inches)	8	8	8	8
Capacity Utilization (%)	100.00	100.00	100.00	100.00
Geometry (Microns)	0.40	0.25	0.25	0.25
Processed Wafer Cost ($)	1,550	1,500	1,450	1,450
Die Area (Square Mils)	303,700	212,590	148,813	119,050
Active Area Factor	1.00	1.00	1.00	1.00
Number of Masks	16	18	18	18
Defect Density per Square Inch	0.063	0.056	0.028	0.028
Gross Die per Wafer	124	177	253	317
Processed Wafer Cost per Gross Die ($)	12.49	8.46	5.72	4.58
Test Cost per Hour ($)	160.00	140.00	120.00	120.00
Wafers Tested per Hour	0.32	0.45	0.32	0.38
Wafer Sort Cost per Gross Die ($)	4.00	1.75	1.50	1.00
Cost per Gross Die at Wafer Sort ($)	16.49	10.21	7.22	5.58
Wafer Sort Yield (%)	74	81	93	94
Cost per Sorted Die ($)	22.34	12.63	7.78	5.92
Assembly				
Material Cost/Sorted Die—PQFP Pkg. ($)	0.48	0.50	0.50	0.50
Number of Pins	44	44	44	44
Assembly Yield (%)	95	95	95	95
Cost per Assembled Die ($)	24.02	13.82	8.72	6.76
Final Test				
Test Time per Die (Sec.)	90.00	80.00	60.00	60.00
Cost per Hour of Testing ($)	160.00	140.00	120.00	120.00
Test Cost per Die ($)	4.00	3.11	2.00	2.00
Final Test Yield (%)	90	90	90	90
Cost per Final Tested Unit ($)	31.13	18.81	11.91	9.73
"Mark, Pack, and Ship"				
Cost at 99% Yield (%)	0.31	0.19	0.12	0.10
Total Fabricated Cost per Net Unit ($)	**31.44**	**19.00**	**12.03**	**9.83**

Source: Dataquest (February 1998)

These 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 time period is useful in learning where a given supplier stands concerning technology and production efficiency.

Dataquest Perspective

The individual unit cost of a semiconductor forms 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 allocations 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 initially considered important. Many different "what if" scenarios are often required to best utilize cost modeling in long-range system analysis. As different suppliers improve yields and lower costs, individual company price points can often 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 better match reality should only be made when basic changes occur, not for perturbations that deviate from the norm. As improvements are made to this model in the upcoming months, clients will be notified.

Those in procurement use cost modeling and experience curve analysis for both short- 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 communications with suppliers regarding yield improvements or other cost savings in combination with cost model use potentially can allow for price reductions for astute procurement groups. Periodic "reality checks" of the model assures planners that they used the best information available at the time. Using cost modeling in this way provides a tangible benchmark for procurement to use with their suppliers in terms of cost and price reduction for critical semiconductor parts.

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@dataquest.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

Dataquest
A Gartner Group Company

Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

First Quarter 1998 Procurement Pulse and 1997 in Review: As Order Rates Stabilize, Lead Times Flatten and Inventories Bounce, while Spot Prices Dive

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 A. Giudici

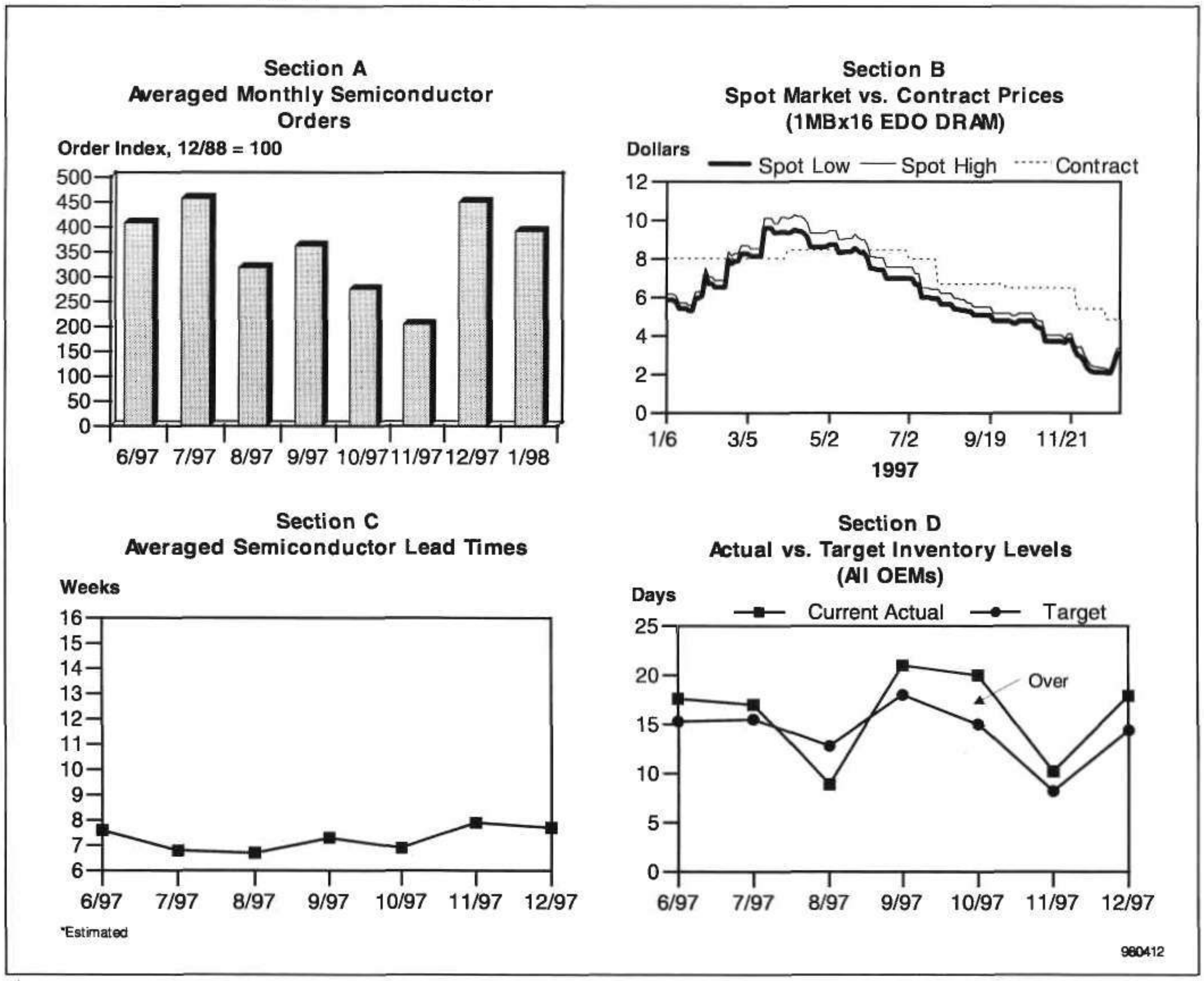
1997 in Review

The past year started much as this year did, on the heels of continued excellent availability, lead times, and prices. Some memory suppliers, smarting from a harsh 1996, attempted to stay the flow of red ink and curtailed shipments (not production). Although spot prices did rise in the memory market and contracts temporarily stabilized in the second quarter, the continued cost of holding inventory forced suppliers to exhale pent-up product, and third quarter 1997 pricing dropped precipitously. Intel Corporation, in the meanwhile, was experiencing real product competition from Advanced Micro Devices Inc.'s K6 part and began an accelerated price reduction program aimed at keeping AMD (and anybody else) happy with the profit crumbs from the Wintel table. Availability throughout the year (even during the second quarter "shortage") remained good to very good, with lead times no longer than 8.5 weeks. Inventories, both targeted and actual, reflected the combination of systems sales and short-term supplier sales pushes—generally within an on-hand level of three to four weeks. In

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-DP-9801
Publication Date: January 19, 1997
Filing: Perspective
(Final hard copy to follow for filing in binder)

sum, 1997 was a buyer's year, where selected suppliers took stock of market dynamics and relative worth. The recent financial crisis in Asia has only exacerbated some of these companies' woes. Dataquest expects 1998 to settle down to good semiconductor supply and some supplier rationalization, with a more sober forecast for Asian growth. Figure 1 shows supply and pricing.

Figure 1
Semiconductor Supply and Pricing



Source: Dataquest (January 1998)

Semiconductor Order Rate Expected to Stabilize after a Year-End Uptick

As shown in Section A of the figure, semiconductor order activity has gone down over the past six months, with a quick rise in December and now back to a level even with July 1997. Although slightly lower than December's forecast index, January has historically been up a cleanup month in activity. Last year definitely had the "summer slows," but it appears that order activity picked up slightly at the end of the year and that this will continue because of continued low pricing at the component level—especially in light of the Asian financial situation. The overall sample continues to see price cuts for larger-volume contracts in all areas tracked in this survey—MPUs, DRAM, ASICs, and especially SRAM and flash memory. Highlighting the resumption of actual supply versus demand, DRAM pricing for the overall sample again declined on average by 2.6 percent after a relatively soft 2.9 percent decline noted in December. The computer subset of the respondents saw a slower decline of 1.7 percent in DRAM prices after a strange 0.5 percent rise noted in December. While overall prices continue to fall, TSOPs and BGAs continue to earn (albeit smaller) premiums of 1 to 2 percent over more standard package offerings.

Spot Market Pricing: How Low *Will* It Go?

DRAM spot pricing continues to nose-dive, highlighting the past memory oversupply, as shown in Section B. The second quarter scheme to control prices did so only in the volatile and low-volume spot market, as shown in the figure. While suppliers vainly have tried to shift the market to the 64Mb DRAM device, prices for the 16Mb are so low that overall market crossover may not occur in calendar year 1998! As noted over the past year, Dataquest expects continued volatility, with spot market prices vacillating around declining contract prices, causing uncertainty for some buyers. The overall trend, however, is for continued good or excellent availability, consistently declining contract prices, and low lead times (four to eight weeks) for the next six to nine months for contract buyers.

Lead Times for Semiconductors Remain Manageable at under Eight Weeks

Section C of the figure highlights that the average lead time given by December respondents has remained relatively constant over the past seven months, ranging from seven to eight weeks. The last input, 7.7 weeks, compares favorably with November's 7.9-week average, but the overall trend equals good availability. The current stability of lead times is in part due to the removal of uncertainty over DRAM supplies and the perception of good availability for the near future. Even though spot prices are at an all-time low, most buyers are satisfied with the current low contract pricing and the stability those deliveries provide. Good service levels and slowly declining prices are cementing many long-term supplier relations. Although there were no supply problems again noted in this month's survey, good communications with suppliers cannot be seen as a passing fad. With general availability good and improving, there are few (any?) supply problems to complain about.

Semiconductor Inventories Back to Historical Levels

Section D shows that second half 1997 inventories had an early quarterly rise and later fell in response to good availability and the opportunity to run down quarter-end inventories, knowing that operating run rate inventories are easily replaceable. As respondents forecast semiconductor order rates to modulate, Dataquest sees a corresponding slight increase in inventory levels in line with historical levels, with the possible continuation of inventory variability because of easy replacement. The overall targeted and actual semiconductor inventory levels for December were 14.4 days and 17.9 days, respectively, compared with November's 8.2-day and 10.2-day inventory levels. Although not shown, the computer subset appears aggressive relative to the average, with current target and actual inventory levels of 9.0 days and 12.0 days. We continue to expect to see stabilized inventory levels in the future, in line with steady systems sales levels.

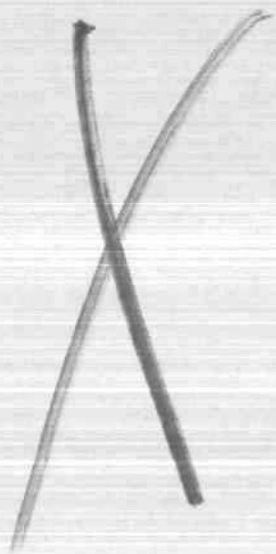
Dataquest Perspective

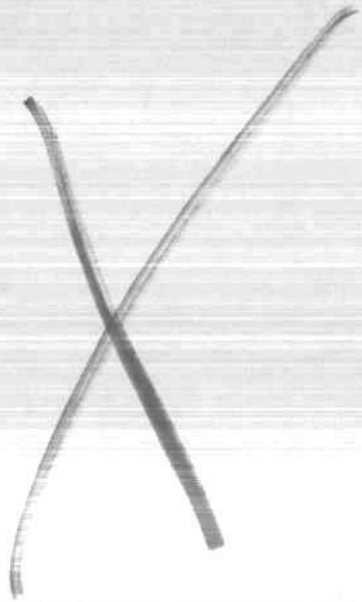
Availability of semiconductors remains very good, and we expect it to remain this way well into mid- to late 1998. As mentioned, since last March, Dataquest has continued to see contract prices decline, despite the efforts of some memory suppliers to curtail output noted early in 1997. Lead times have stabilized to meet customer demand, in line with the moderate price declines. Dataquest continues to forecast steady growth rates for PCs and other electronics relative to 1997, with the overall trend following an upward growth slope. User semiconductor inventory levels are now in line with demand, and we expect to see continuing balance in these indexes in the near future. Real allocations are not a problem, but the attempted quick shift of some suppliers to the 64Mb DRAM density appears to be causing those that do not supply 64Mb but that have abundant capacity to lower prices faster, resulting in a pushing out of planned crossover times. Dataquest expects to see excellent semiconductor availability on through the second and third quarters of 1998. DRAM and MPU price elasticity to date has not propped up contract prices. The good news for users is that overall declining contract prices will continue to be with us for the first and second quarters, and most likely for the rest of the year.

For More Information...

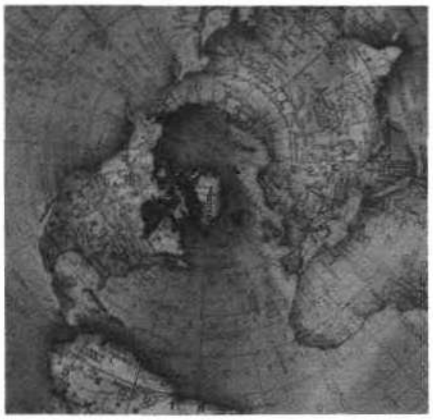
Mark Giudici, Director and Principal Analyst .... (408) 468-8258
Internet address .... mark.giudici@dataquest.com
Via fax .... (408) 954-1780
Dataquest Interactive .... http://www.dataquest.com

Market Trends





Market Statistics



Dataquest

Worldwide Semiconductor Forecast and Trends: Spring 1998

Market Trends

Program: Semiconductors—Top Views
Product Code: SCND-WW-MT-9801
Publication Date: June 1, 1998
Filing: Top Views

Worldwide Semiconductor Forecast and Trends: Spring 1998

Market Trends

Program: Semiconductors—Top Views
Product Code: SCND-WW-MT-9801
Publication Date: June 1, 1998
Filing: Top Views

Table of Contents

Table of Contents (Continued)

List of Figures

List of Tables

Chapter 1
Executive Summary

Dataquest forecasts that worldwide semiconductor revenue will grow 8.2 percent in 1998, reaching $159 billion. The world market should grow at a 14.4 percent compound average growth rate (CAGR) from 1997 through 2002, reaching $288 billion in 2002.

Objectives

This forecast and market trends information serves the following objectives:

- Near-term planning for worldwide and regional semiconductor manufacturing, sales, and procurement tactics
- Long-term strategic planning for semiconductor product strategy and supply-base management
- Capital formation process decision-making in debt and equities markets

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- Worldwide semiconductor revenue should increase by just over 8 percent in 1998 to a total of $159 billion. This modest recovery—which is a slower 1998 growth rate than originally expected—follows the slight 3.5 percent growth of 1997. The industry faces its third year of lackluster performance. The Asian financial crisis and low dynamic RAM (DRAM) pricing will hamper semiconductor revenue growth this year, although some product segments will achieve robust double-digit growth rates. In 1999, the market should grow by 18 percent to $188 billion. Long-term growth will be somewhat slower than in the previous forecast. By 2002, worldwide semiconductor revenue should total nearly $290 billion, which marks a 14.4 percent CAGR for the five-year period from 1997 through 2002.
- Worldwide PC unit shipments will increase by just over 15 percent in 1998 and exceed 90 million units. PC revenue will grow by just 6.4 percent this year, however, in part because of the emergence of the "sub-$1,000 PC." In the long term, the semiconductor forecast assumes that worldwide PC unit shipments will grow at a 16 percent CAGR for the five-year period and total nearly 170 million units in 2002. PC revenue, however, should grow at a slower 9 percent CAGR because of the decline in PC pricing.
- The semiconductor industry should retain long-term vitality. PCs, communications, and consumer electronics will continue to rank as the most important application markets. The trend toward system-level integration (SLI) bodes well for the industry. The impact of information technology (IT) market challenges such as the year 2000 (Y2K) problem and the European Monetary Union (EMU) remain uncertain. However, the effect of these on the semiconductor market will likely "filter" through their impact on the PC, communications, and related equipment sectors.

- The Asian crisis means somewhat lower near-term and long-term expectations for Japan and Asia/Pacific. Japan will remain behind the Americas region as the world's second-largest semiconductor consumption market until 2000, when Asia/Pacific should surpass Japan.
- The x86 architecture, as the central processor in the PC, serves as the major driving force for the PC and microprocessor (MPU) markets. As expected, MPU revenue growth will start to moderate following the extremely high growth of the 1992-to-1997 period. For 1998, worldwide MPU revenue should increase by just over 15 percent—and at a 16 percent CAGR for the 1997-to-2002 time frame.
- Microprocessors in embedded applications will continue to fuel the growth of MPUs for a wider array of vendors. For example, growth in video games, communications, and Internet appliances continues to drive the embedded RISC market.
- Digital signal processors (DSPs) rank among the highest-growth semiconductor products. These devices are the centerpiece of communications electronics such as cell phones, modems, and the emerging consumer digital electronics. DSP technology is vital in speeding up the information highway. Worldwide DSP revenue should grow at a 25 percent CAGR for the 1997-to-2002 period.
- Memory IC trends, especially DRAM pricing, serve as a key swing factor in both the near-term and long-term forecasts. In 1998, worldwide memory revenue should grow by a scant 1.4 percent; DRAM revenue will increase by just 1 percent this year.
- There will be a continuing oversupply of DRAM capacity through most of 1999. The long-term forecast, however, explicitly assumes a DRAM capacity shortage by year 2000 and a DRAM revenue surge for 2001. Associated assumptions are excess DRAM capacity by 2002 and a cyclical DRAM revenue downturn that year.
- Cell-based ICs (CBICs) will continue to be a fast-growing logic product and will be the product of choice for system-level integration. By contrast, gate arrays are entering the decline phase of the product life cycle.

Key Growth Metrics

Table 1-1 provides growth by product for the period from 1997 to 2002, including the CAGRs.

Semiconductor Forecast: With and without DRAM

Figure 1-1 provides a different forecast view.

The figure shows the worldwide semiconductor growth rates and revenue totals for 1997 through 2002 for the total semiconductor market, the DRAM market, and the non-DRAM semiconductor market (that is, total semiconductors, excluding DRAM).

Flatter, more stable semiconductor growth is seen when DRAMs are excluded. The figure also highlights the higher, more volatile growth expected for DRAM.

Table 1-1
Worldwide Semiconductor Growth by Product Type, 1997 and 2002 (Revenue in Millions of Dollars)

	1997 Revenue	1997 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)	1997-2002 CAGR (%)
Total Semiconductor	**147,165**	**3.5**	**287,895**	**4.7**	**17.7**	**14.4**
Total Integrated Circuit	**127,571**	**3.1**	**257,154**	**4.1**	**18.6**	**15.1**
Bipolar Digital	1,239	-33.0	604	-14.6	-17.2	-13.4
MOS Memory	30,978	-18.6	61,202	-20.1	15.1	14.6
Dynamic RAM	20,744	-20.3	40,920	-29.4	18.8	14.6
Static RAM	4,008	-20.2	9,761	3.8	5.7	19.5
Nonvolatile Memory	5,571	-13.7	9,432	15.1	10.9	11.1
EPROM	785	-37.1	225.9	-16.0	-8.9	-22.0
EEPROM	967	-7.9	1,922.9	15.3	17.8	14.7
Flash Memory	2,775	-3.2	6,378.1	19.2	63.3	18.1
Mask ROM	1,044	-19.1	905.1	-0.1	-5.7	-2.8
Other MOS Memory	655	13.5	1,089	10.7	28.2	10.7
MOS Microcomponent	48,945	18.0	103,130	14.9	27.8	16.1
Microprocessor	23,659	26.1	49,650	14.5	33.9	16.0
Microcontroller	10,896	6.4	22,230	14.2	18.8	15.3
Microperipheral	10,736	6.5	19,990	12.2	23.1	13.2
Digital Signal Processor	3,654	53.0	11,260	23.7	52.4	25.2
MOS Digital Logic	24,757	9.2	50,818	18.8	19.8	15.5
ASICs	16,527	11.7	39,789	21.8	24.9	19.2
Custom IC	1,514	-12.2	205	-41.4	-5.5	-33.0
MOS Standard Logic	2,266	13.7	2,805	1.1	13.7	4.4
Total Other MOS Logic	4,450	7.0	8,019	14.7	26.0	12.5
Analog-Monolithic	21,652	18.7	41,400	11.2	16.3	13.8
Total Discrete	14,255	5.8	23,300	10.4	11.8	10.3
Total Optical Semiconductor	5,339	8.6	7,441	8.2	14.7	6.9

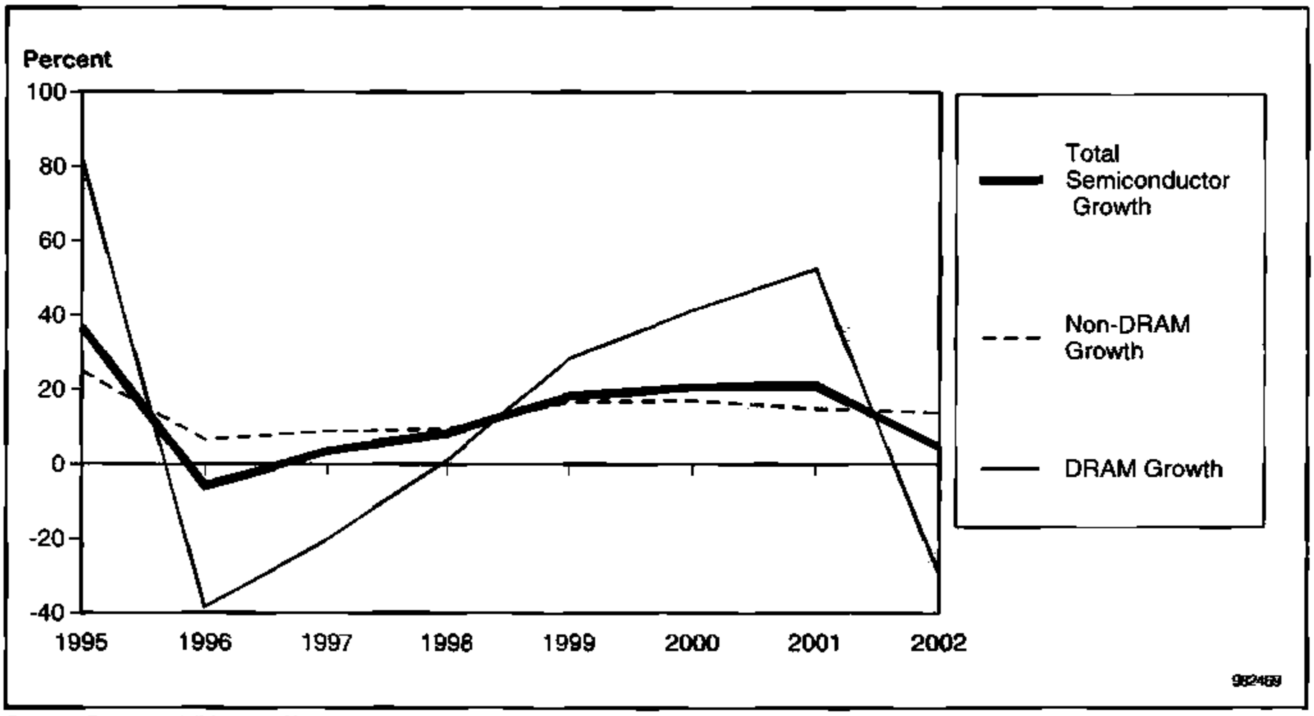
Source: Dataquest (May 1998)

Electronic Production Forecast Analysis

As a first step in the forecast process, Dataquest combined worldwide electronic equipment production from 1997 to 2002 with semiconductor input/output (I/O) analysis. This process generated the following worldwide semiconductor forecast (with the final forecast shown in parentheses):

- 1998—$164 billion for the production-based estimate of semiconductor consumption (versus the final forecast of $159 billion)
- 2002—$262 billion for the production-based estimate (versus a $288 billion final forecast)

Figure 1-1
Worldwide Semiconductor Forecast



Source: Dataquest (May 1998)

The forecast methodology process uses this information as a central input and "sanity check" for generating the final semiconductor forecast.

Forecast Methodology

The worldwide semiconductor revenue forecast consists of an interlinked set of regional product consumption forecasts. A team of product and regional experts generate regional product forecasts. The experts are chosen on the basis of their expertise, including knowledge of key application trends, unit growth rates, and local economic factors.

Each regional product forecast (for example, the Asia/Pacific DSP forecast) rolls into a single, worldwide product forecast. Also, the totality of regional product forecasts (for example, Japanese consumption of DSP and DRAM, among others) roll into a single regional forecast. As noted, the interlinked forecasts ultimately roll into the worldwide product forecast.

The basic methodology is as follows:

- Under the aegis of the worldwide product director, a regional product expert provides a "first-pass" regional product consumption forecast to the worldwide product director. For example, the microcontroller (MCU) expert in Japan provides a five-year forecast of MCU consumption in Japan to the worldwide MCU director. The worldwide director compiles the full set of MCU regional forecasts and then reviews the resultant worldwide MCU revenue totals and growth rates.

- Concomitantly, under the aegis of a regional forecast director, the "first-pass" regional product forecasts are also sent by the regional product experts to the regional forecast director. For example, the MCU expert in Japan and the DRAM expert, among others, send their Japanese consumption market forecasts to the Japan regional forecast director. The regional forecast director compiles the regional product forecasts into a regional forecast and then reviews the resultant regional revenue totals and growth rates.
- The process remains interactive as the regional product forecasts get fine tuned. When agreement has been reached on these regional product forecasts, a "proposed" worldwide forecast is reviewed by a team of worldwide and regional product analysts. This process typically requires selective modification to worldwide product forecasts, including regional forecasts. This process includes scrutiny of worldwide growth rates, product growth, regional growth, upside/downside potential, and related factors.
- By consensus, the final worldwide and regional semiconductor product forecasts are then generated and published from the forecast database.

The Forecast Range

Market uncertainty means a forecast's results will be either higher or lower than the forecast. For this reason, this section provides a forecast range. Although the Asian crisis certainly tempers semiconductor market expectations, DRAM pricing predominates as the foremost swing factor affecting the semiconductor forecast range.

For the forecast range analysis, Dataquest assumes a set of low-side and high-side DRAM pricing assumptions. We also assume that DRAM bit growth will be quite predictable, despite pricing volatility.

For the low-side scenario, we assume low DRAM pricing. The market price is assumed to be at a "bottom-level," cost-based price, below which antidumping measures would be taken.

By contrast, under the high-side scenario, we assume very high DRAM pricing. Using historic patterns, we assume high markups for the market price, at as much as 1.7 times the cost.

The following summarizes the worldwide semiconductor forecast range for the 1999-through-2002 period, based on the DRAM price low/high assumptions (with the official forecast in parentheses).

Total Worldwide Semiconductor Forecast Range

The worldwide semiconductor forecast range is as follows:

- 1999—$186 billion to $201 billion ($188 billion forecast)
- 2000—$217 billion to $252 billion ($227 billion forecast)
- 2001—$249 billion to $291 billion ($275 billion forecast)
- 2002—$281 billion to $325 billion ($288 billion forecast)

Perspective

The worldwide IT market totaled $1 trillion for 1997. Inclusion of all telecom services and companies' internal information system (IS) spending would increase the 1997 total to more than $2 trillion. Either way, the IT market is bigger than most countries' gross domestic product.

GartnerGroup has identified the megatrends that will shape the worldwide IT industry for the next five years. The global semiconductor industry, as a key enabling technology for the IT marketplace, will directly benefit from several IT megatrends. These IT megatrends signal long-term vitality for the worldwide semiconductor market:

- Rise of the Internet:
  - 300 million active Internet seats are expected by 2002.
  - Semiconductors will build the infrastructure as well as equip and connect the users.
- Network computing happens—although "network computers" do not:
  - The network computer will fizzle; although it has stimulated interested in fully equipped sub-$1,000 PCs.
  - Networked computing, however, will continue to expand and use semiconductors in that process.
- Bandwidth demand explodes:
  - Bandwidth demand will grow 30 to 40 percent per year.
  - Networking functions will become integrated into semiconductors—although software solutions will be just as important.

Meanwhile, some IT market trends do not favor the semiconductor outlook. For the medium term, concern exists that solutions for the Y2K and EMU problems could divert business spending from PCs and other semiconductor-based products.

In the long term, worldwide IT spending should grow at an 11 to 12 percent CAGR for the 1997-to-2002 period. There will be a dramatic shift toward the added-value software and services segments—meaning lower revenue growth for hardware segments.

To put everything in perspective, however, the worldwide semiconductor forecast looks realistic. The services and emerging software segments will grow at CAGRs of 16 percent or higher over the next five years. By contrast, system hardware revenue will grow at a sub-10 percent CAGR. Driven by the trend toward system-level integration, the semiconductor market should grow at a "sort of intermediate" CAGR of 14 percent.

Project Analysts: Joseph Grenier, Kevin McClure, Mary A. Olsson, and Ronald Bohn

Contributors: Geoff Ballew, Bruce Bonner, Nathan Brookwood, Joe D'Elia (Europe), Jon Cassell, Jeremy Donovan, Dale Ford, Clark Fuhs, Mark Giudici, Richard Gordon (Europe), Jim Handy, Chang Soo Kim (Korea), Bryan Lewis, Jim Liang, Greg Sheppard, George Shiffler, Yoshihiro Shimada (Japan), Tom Starnes, Masahiro Suzuki (Japan), Yoshihisa Toyosaki (Japan), and Jim Tully (Europe)

Chapter 2
Worldwide Forecast by Product

The tables of this chapter provide the complete five-year forecast by product type and by region for the worldwide semiconductor market.

Worldwide Semiconductor Product Forecast and History

The following tables show semiconductor product growth, both historic and forecast. Table 2-1 provides the five-year forecast through 2002 by product type for the worldwide semiconductor market. Table 2-2 presents the history of product growth for 1992 through 1997.

As noted in the tables, the worldwide semiconductor market should grow at a 14 percent-plus CAGR during the five-year period from 1997 to 2002. This is a realistic growth expectation when compared to the 18 percent CAGR from 1992 to 1997.

Forecast Summary: No Strong Recovery Yet

For many semiconductor companies, 1997 marked a year of modest revenue recovery following the 1996 revenue downturn. Memory segments like DRAM, however, did not recover in terms of revenue growth.

The forecast calls for modest worldwide semiconductor growth in 1998 and stronger growth over the long term. As noted, Dataquest expects the worldwide semiconductor market as measured in revenue to grow at a sub-10 percent rate this year. Our prior expectation for 1998 had been a more robust growth rate.

DRAM and the Asian crisis explain much of this change. For example, worldwide DRAM revenue should remain flat in 1998 at the 1997 level. The prior expectation was for a rebound in DRAM revenue growth this year. DRAM bit growth remains impressive, but excess capacity and low pricing combined with the Asian crisis mean scant DRAM revenue growth for 1998.

1998 Forecast Range

As noted, the worldwide semiconductor forecast calls for just over 8 percent this year. Applications market analysis, however, reveals that the 1998 forecast ranges from a low-side estimate of 3 percent growth to a high-side estimate of slightly over 10 percent growth.

Key Application Markets

PCs, communications, and consumer electronics will account for about 70 percent of semiconductor consumption. Trends in these application markets will determine near-term results and fuel long-term growth in semiconductor revenue. In the long term, the PC remains the paramount application for compute MPU and DRAM. Servers will eventually emerge as a key application for compute MPUs. Mobile communications, data communications, and digital consumer electronics, among other applications, should drive DSP, MCU, embedded MPU, and digital application-specific IC (ASIC) growth. Flash memory and EEPROM should also benefit from these trends.

Table 2-1
Worldwide Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**147,165**	**3.5**	**159,249**	**8.2**	**188,256**	**18.2**	**227,054**	**20.6**	**275,028**	**21.1**	**287,895**	**4.7**	**14.4**
Total Integrated Circuit	**127,571**	**3.1**	**138,617**	**8.7**	**165,531**	**19.4**	**201,014**	**21.4**	**247,052**	**22.9**	**257,154**	**4.1**	**15.1**
Bipolar Digital	1,239	-33.0	1,112	-10.3	946	-14.9	835	-11.7	707	-15.3	604	-14.6	-13.4
MOS Memory	30,978	-18.6	31,401	1.4	39,743	26.6	53,572	34.8	76,573	42.9	61,202	-20.1	14.6
Dynamic RAM	20,744	-20.3	20,960	1.0	26,897	28.3	38,043	41.4	57,994	52.4	40,920	-29.4	14.6
Static RAM	4,008	-20.2	4,182	4.3	5,694	36.2	7,378	29.6	9,402	27.4	9,761	3.8	19.5
Nonvolatile Memory	5,571	-13.7	5,533	-0.7	6,343	14.6	7,262	14.5	8,193	12.8	9,432	15.1	11.1
EPROM	785	-37.1	527	-32.8	406	-23.0	328	-19.3	269	-17.9	226	-16.0	-22.0
EEPROM	967	-7.9	1,121	15.9	1,305	16.4	1,472	12.8	1,668	13.3	1,923	15.3	14.7
Flash Memory	2,775	-3.2	3,057	10.2	3,710	21.4	4,506	21.5	5,350	18.7	6,378	19.2	18.1
Mask ROM	1,044	-19.1	828	-20.7	922	11.4	956	3.6	906	-5.2	905	-0.1	-2.8
Other MOS Memory	655	13.5	726	10.9	809	11.4	889	9.9	984	10.7	1,089	10.7	10.7
MOS Microcomponent	48,945	18.0	55,530	13.5	65,980	18.8	76,970	16.7	89,750	16.6	103,130	14.9	16.1
Microprocessor	23,659	26.1	27,300	15.4	32,250	18.1	37,440	16.1	43,380	15.9	49,650	14.5	16.0
Microcontroller	10,896	6.4	12,320	13.1	14,270	15.8	16,720	17.2	19,460	16.4	22,230	14.2	15.3
Microperipheral	10,736	6.5	11,300	5.3	13,660	20.9	15,580	14.1	17,810	14.3	19,990	12.2	13.2
Digital Signal Processor	3,654	53.0	4,610	26.2	5,800	25.8	7,230	24.7	9,100	25.9	11,260	23.7	25.2
MOS Digital Logic	24,757	9.2	26,573	7.3	31,084	17.0	37,061	19.2	42,793	15.5	50,818	18.8	15.5
ASICs	16,527	11.7	18,409	11.4	22,330	21.3	27,446	22.9	32,675	19.1	39,789	21.8	19.2
Custom IC	1,514	-12.2	1,164	-23.1	823	-29.4	557	-32.3	349	-37.3	205	-41.4	-33.0
MOS Standard Logic	2,266	13.7	2,373	4.7	2,565	8.1	2,739	6.8	2,775	1.3	2,805	1.1	4.4
Total Other MOS Logic	4,450	7.0	4,626	4.0	5,366	16.0	6,318	17.7	6,993	10.7	8,019	14.7	12.5
Analog-Monolithic	21,652	18.7	24,001	10.8	27,777	15.7	32,577	17.3	37,229	14.3	41,400	11.2	13.8
Total Discrete	14,255	5.8	15,221	6.8	16,934	11.3	19,711	16.4	21,100	7.0	23,300	10.4	10.3
Total Optical Semiconductor	5,339	8.6	5,411	1.3	5,791	7.0	6,329	9.3	6,876	8.6	7,441	8.2	6.9

Source: Dataquest (May 1998)

Table 2-2
Worldwide Semiconductor Market, Revenue History, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	65,260	9.3	85,514	31.0	110,513	29.2	151,310	36.9	142,150	-6.1	147,165	3.5	17.7
Total Integrated Circuit	54,417	11.4	73,429	34.9	95,861	30.5	132,184	37.9	123,761	-6.4	127,571	3.1	18.6
Bipolar Digital	3,193	-12.0	3,079	-3.6	2,912	-5.4	2,455	-15.7	1,849	-24.7	1,239	-33.0	-17.2
MOS Memory	15,308	19.2	23,306	52.2	33,505	43.8	55,287	65.0	38,064	-31.2	30,978	-18.6	15.1
Dynamic RAM	8,765	25.5	14,581	66.4	23,266	59.6	42,249	81.6	26,012	-38.4	20,744	-20.3	18.8
Static RAM	3,038	17.9	3,908	28.6	4,514	15.5	6,265	38.8	5,020	-19.9	4,008	-20.2	5.7
Nonvolatile Memory	3,316	7.2	4,551	37.2	5,407	18.8	6,239	15.4	6,455	3.5	5,571	-13.7	10.9
EPROM	1,253	-7.7	1,460	16.5	1,561	6.9	1,437	-7.9	1,249	-13.1	785	-37.1	-8.9
EEPROM	426	0	561	31.7	746	33.0	793	6.3	1,050	32.4	967	-7.9	17.8
Flash Memory	239	0	746	212.1	884	18.5	1,942	119.7	2,866	47.6	2,775	-3.2	63.3
Mask ROM	1,398	0	1,784	27.6	2,216	24.2	2,067	-6.7	1,290	-37.6	1,044	-19.1	-5.7
Other MOS Memory	189	-1.0	266	40.7	318	19.5	534	67.9	577	8.1	655	13.5	28.2
MOS Microcomponent	14,359	22.0	19,947	38.9	26,408	32.4	34,504	30.7	41,469	20.2	48,945	18.0	27.8
Microprocessor	5,501	41.4	8,783	59.7	11,437	30.2	14,269	24.8	18,756	31.4	23,659	26.1	33.9
Microcontroller	4,613	4.2	5,904	28.0	7,517	27.3	10,250	36.4	10,244	-0.1	10,896	6.4	18.8
Microperipheral	3,801	20.4	4,581	20.5	6,424	40.2	8,316	29.5	10,081	21.2	10,736	6.5	23.1
Digital Signal Processor	444	48.5	679	52.9	1,030	51.7	1,669	62.0	2,388	43.1	3,654	53.0	52.4
MOS Digital Logic	10,042	3.5	13,121	30.7	16,108	22.8	20,667	28.3	22,676	9.7	24,757	9.2	19.8
ASICs	5,440	5.0	7,203	32.4	9,008	25.1	12,528	39.1	14,801	18.1	16,527	11.7	24.9
Custom IC	2,013	-5.3	2,367	17.6	2,502	5.7	2,143	-14.3	1,724	-19.6	1,514	-12.2	-5.5
MOS Standard Logic	1,191	19.9	1,501	26.0	1,864	24.2	2,202	18.1	1,993	-9.5	2,266	13.7	13.7
Total Other MOS Logic	1,399	-0.4	2,080	48.7	2,769	33.1	3,821	38.0	4,158	8.8	4,450	7.0	26.0
Analog-Monolithic	10,180	7.0	12,513	22.9	15,263	22.0	17,616	15.4	18,235	3.5	21,652	18.7	16.3
Total Discrete	8,155	1.5	9,083	11.4	10,763	18.5	14,314	33.0	13,474	-5.9	14,255	5.8	11.8
Total Optical Semiconductor	2,688	-4.1	3,002	11.7	3,889	29.5	4,812	23.7	4,915	2.1	5,339	8.6	14.7

Source: Dataquest (May 1998)

The following section summarizes the 1998 outlook for the three key semiconductor application markets: PCs, communications, and consumer electronics.

The High and Low of PC Semiconductors

Personal computers and workstations consume about one-third of the world's semiconductors and therefore have a tremendous impact on the market growth dynamics. Additionally, these applications consume 75 to 80 percent of all DRAM shipments and are somewhat elastic in terms of semiconductor demand as measured by revenue. This adds volatility to the overall semiconductor demand picture and particularly affects memory pricing trends.

Near-term volatility is minimal because we are already about one-third of the way through 1998, and we have a high level of confidence in our assumptions regarding PC pricing dynamics and the software application base (including operating systems) for PCs. We see minimal upside opportunities for our forecast in the near term unless system demand takes a dramatic uptick. Downside risk for 1998 is 5 percent on a revenue basis.

Long-term trends have greater volatility and hinge on four key "swing" factors. The low-side scenario would involve a 10 percent downward revision for PC semiconductor revenue in 1999 and 15 percent thereafter. Semiconductor spending as a percentage of the factory system average selling price (ASP) cannot be raised, so any dramatic upside opportunity can come only from higher-than-expected unit shipments or a stabilizing trend in factory system ASPs.

The key trends include the following:

- DRAM ASPs—The high-side scenario requires DRAM ASPs, as our memories forecast has DRAM and bit consumption according to the forecast. The low-side scenario has DRAM ASPs 20 percent lower than the target ASPs in the DRAM forecast.
- Consumer spending recovery in Asia—The high-side scenario involves a quicker recovery than Dataquest currently projects. The low-side scenario includes moderate recovery of consumer spending in Asia. The outlook is good for North America and Europe.
- The popularity of sub-$1,000 PCs in business environments—The high-side scenario includes limited acceptance of sub-$1,000 PCs in corporate environments. The low-side scenario has business acceptance of sub-$1,000 mirroring consumer excitement over that category. Falling ASPs for the PC industry cause PC makers to limit their semiconductor spending on a per-PC basis. Unit growth remains strong either way.
- Compelling new applications—The high-side scenario requires new applications to emerge that convince buyers to "buy up." Microsoft's Chrome product in the Windows 2000 operating system is an example. New versions of today's programs will only lead to the low-side scenario. Windows 98 arrives midyear, but it is unlikely to inspire dramatic changes. Windows NT 5.0 will not emerge until 1999.

The High and Low of Communications Semiconductors

The communications market accounts for about 20 percent of worldwide semiconductor consumption. In the near term, consumption for use in communications equipment on the low side could be 3 to 4 percent lower than the current forecast; on the high side, consumption could be 6 to 7 percent higher than forecast.

The following section summarizes the forecast range across different communications application segments:

- Premise telecom high and low range:
  - 1998 semiconductor consumption forecast ranges from 4 to 5 percent lower to just over 4 percent higher.
  - Downside would be mainly due to pricing pressures and Asian financial crisis.
  - Upside would be driven by 56Kbps modem "churn," acceptance of new wide area network (WAN) systems, and Y2K; the Y2K problem could cause companies to buy new premise telecom systems as their solution (versus a software rewrite).
- Public telecom high and low range:
  - 1998 forecast ranges from 3 percent lower to 3 percent higher.
  - Downside and upside both depend mainly on pricing and uncertainty.
- Mobile communications high and low range:
  - 1998 forecast ranges from 3 percent lower to more than 10 percent higher.
  - Downside would be due to lower demand resulting from the Asian crisis and European saturation.
  - Upside would be due to lack of negative impact from Asia crisis, strong subscriber growth, microcell and picocell infrastructure deployment, and possible strong code division multiple access (CDMA) ramp in the United States.

The High and Low of Consumer Semiconductors

Consumer electronics use about 10 percent of the world's semiconductors. In 1998, the forecast assumes just over a 9 percent worldwide increase of semiconductors for consumer electronics equipment. The following assumptions guide this 1998 forecast:

- Demand for next-generation consumer products will recover from the 1997 lull in demand. These products include digital set-top boxes (STB), digital TV, including high-definition television (HDTV), digital versatile disc (DVD), and 32-bit and 64-bit game players (Nintendo 64 and Sony Playstation).
- Legacy consumer product demand will increase slightly or else remain flat versus 1997. These older applications include color TVs, component stereos, analog audio/video systems, and household appliances.
- Semiconductor price erosion will moderate.
- Asian crisis will have moderate impact on consumer electronics sales.

Consumer Electronics Low-Side Scenario

For the near term, consumption for use in consumer electronics could on the low side be more than 10 percent lower than the current forecast. At worst, consumption by consumer applications could actually decline this year versus 1997. A similar result occurred in this application market during 1996.

The following assumptions would cause this negative 1998 scenario:

- The Asian crisis has major negative impact on consumer electronics sales.
- Demand for next-generation consumer products continues to fall below expectations.
- Legacy consumer product demand continues to decline.
- Semiconductor price erosion continues.

Consumer Electronics High-Side Scenario

On the high side, consumption could be 1 to 2 percent higher than forecast. The optimistic outlook says that consumer electronics applications can sustain the same near-11 percent consumption growth rate as experienced in the past several years. The following assumptions would cause this optimistic 1998 scenario:

- Fallout from the Asian crisis on consumer electronics demand is contained.
- The rate of demand for next-generation consumer products increases significantly.
- Legacy consumer demand rises slightly.
- Semiconductor price erosion moderates.

As noted, the 1998 forecast range based on applications analysis runs from a low-side estimate of 3 percent growth to a high-side estimate of slightly over 10 percent growth.

Product Forecasts

The following sections highlight trends that guide key product forecasts.

ASIC and Logic Trends and Forecast Assumptions

The worldwide MOS digital logic forecast calls for 7.3 percent growth in 1998. This is slower growth than originally expected. On a regional basis, the 1998 forecasts have been lowered in all regions to varying degrees, with the highest reduction in Japan, followed by Asia/Pacific.

The short-term forecasts on other MOS logic products have also been lowered. Supply exceeds demand for these products, which means downward pricing pressure. Standard logic remains relatively unchanged from our prior forecasts. ASIC product forecasts have been lowered only slightly.

Cell-based ICs, the system-level integration product of choice, will continue as the fastest-growing logic product. Gate arrays, however, are under serious pricing pressure and are entering the decline phase of the life cycle. CBICs are displacing gate arrays from high-end applications as programmable logic devices (PLDs) displace gate arrays on low-end applications. This translates into higher long-term growth in the CBIC and PLD segments and lower growth in gate arrays.

For 1998, the worldwide CBIC market should grow at a 22 percent rate. PLDs are suffering from rapid price erosion and slow demand, so we are forecasting only an 11 percent increase in 1998, the lowest growth rate in history. Gate array revenue will continue to decline and decrease this year by 7 percent. Full-custom ICs are on the most rapid decline, as they are being replaced by cell-based ICs and gate arrays to some degree. The mature standard logic market should increase by 5 percent. Other MOS logic products will grow 4 percent.

Long term, the CBIC market should exceed $30 billion by 2002, with an impressive CAGR of more than 27 percent for 1997 through 2002. PLDs will expand at nearly a 20 percent CAGR and exceed $5 billion by 2002. Other MOS logic products—which include some application-specific standard products—will grow at a respectable near-15 percent CAGR. The standard logic market will grow slowly, while gate arrays will decline.

Microprocessor Trends and Forecast Assumptions

The worldwide microprocessor revenue forecast remains largely consistent with prior expectations. As expected, MPU revenue should increase this year and over the long term, but at a slower rate versus the 1992-to-1997 period. The x86 architecture will continue its domination of the PC market. Business PC demand continues to drive MPU demand. The x86 MPU technology advances still stimulate PC demand from the key "early adopter" repeat buyers.

Key PC market dynamics, however, are changing as of first half 1998. For example, the "sub-$1,000" PC captured consumer market demand during late 1997. Business buyers now show growing interest in low-cost PCs, which means a long-term decline in the PC ASP. A sharp fall in the x86 MPU ASP, however, is not expected. Competition for Intel Corporation from competitors such as Advanced Micro Devices Inc. and National Semiconductor Corporation will not cause an x86 price war.

Why not? Although the price of MPUs for PC desktop applications will decline, the x86 ASP will rise somewhat as MPUs absorb other system functions. Also, Intel is creating workstation- and server-specific versions of x86 products that generate a much higher ASP (more than $500) than devices geared for PC markets. Internet appliances, communications (for example, cellular), and video games will fuel growth in the embedded RISC MPU market.

For 1998, worldwide MPU revenue should increase by 15.4 percent and reach $27 billion. Intel should lead a strong rebound in second-half 1998 in the worldwide MPU market. In 2002, worldwide MPU revenue should reach $50 billion, which represents a 16 percent CAGR for 1997 through 2002. This is a lower long-term MPU growth rate than the 30 percent-plus CAGR for the 1992-through-1997 period; this mirrors the slower long-term pace of PC revenue growth.

Microcontroller and DSP Trends and Forecast Assumptions

Our forecast continues to assume that non-PC applications such as digital cellular, digital consumer electronics, and data communications will drive demand for MCUs and DSPs, including embedded versions. The following is a summary of these product forecasts:

- DSPs should increase by more than 25 percent in 1998, exceeding $4.5 billion. By 2002, worldwide DSP revenue should surpass $11 billion, which translates into a stellar 25 percent CAGR for 1997 through 2002.
- Sharp price erosion for MCU products means lower 1998 revenue than originally expected. In 1998, worldwide MCU revenue will increase by just over 13 percent and total $12.3 billion. Long term, worldwide MCU revenue will total $22 billion by 2002. The forecast of a 15.3 percent CAGR for the 1997-to-2002 period is lower than previously expected.

Memory IC Trends and Forecast Assumptions

The DRAM market will remain volatile. The DRAM revenue forecast could swing widely for both the near term and the long term because of DRAM price fluctuations. DRAM bit consumption continues in line with our prior projections. This means that unit demand should be strong, although pricing might remain weak. As indicated, the semiconductor forecast assumes a cyclical upturn in 2001. The DRAM market peak in 2001, however, has been moderated to match similar historical peaks.

DRAM prices continue to hug a cost-based price curve, which means low pricing. This stifles the prospect for DRAM revenue growth. Dataquest expects this to remain the case through 1998 and into 1999. These prices are limited on the high side by DRAM oversupply and on the low side by antidumping regulations.

The effects of the current Asian crisis on DRAM prices will be "self-regulating" in that a temporary 1998 price downturn should shift market share to lower-cost producers. After this, the low-cost suppliers' capacity will be utilized, and DRAM prices will recover slightly.

The current overcapacity will continue through 1999 and into 2000. Capital expenditure did not slow in 1997 as we had originally anticipated. To reflect the impact, the DRAM market revenue peak originally expected for 2000 has been pushed out by one year to 2001. (Some manufacturing capacity may eventually exit the DRAM market, but this is not predicted in the current forecast.)

The DRAM high-side revenue forecast for 2002 is $78 billion. This would occur if there were a shortage in this year and bit growth followed its historical rate of 65 percent per year. Our low-side scenario, assuming as severe an overcapacity as we currently face, would be just $34 billion. By contrast, the DRAM bit growth trend has been extremely stable since the early 1980s, despite price fluctuations and the expected positive and negative influences of demand drivers.

The static RAM (SRAM) market is still oversubscribed, but conversion of cellular phones from analog to digital has dramatically increased SRAM usage in these phones. There is a big difference between this market and the

PC market, the last big SRAM stronghold. Cell phone manufacturers are much more selective about their supplier base; they use parts from top-tier suppliers and shy away from small, fabless companies. We still expect to see attrition in this market. Many companies that thrived in an open market for PC cache chips will shortly be excluded from this previously highly penetrable market and will not be able to participate in the cellular telephone market.

The nonvolatile memory market should see a continuing slow conversion from EPROM toward flash memory. Most of this conversion is happening in new designs and is therefore occurring at the higher densities. The flash memory market has moved from high profitability toward more competitive pricing as many competitors join the fold. However, unit growth remains strong. This new lower pricing has acted to enable the use of flash memory in a diverse array of new applications. Mask ROM has moved away from the "growth hump" that was characteristic of the game cartridge boom and is back on the less-dramatic, pregame growth trend.

Substantial growth should continue in the relatively small EEPROM market, fueled by this technology's use in everything from electronic commerce to microcontroller-based systems, including smart cards. New applications include Universal Serial Bus (USB) interfaces for the PC. The conversion of DRAM modules from single in-line memory modules (SIMMs) to dual in-line memory modules (DIMMs) will also help, as each new DIMM will contain one EEPROM to identify the attributes of the module.

The following summarizes memory IC product outlooks:

- DRAM revenue should increase by a scant 1 percent in 1998 and total $21 billion. By 2002, worldwide DRAM revenue should total $41 billion, which marks a 14.6 percent CAGR for 1997 through 2002.
- SRAM revenue will grow by 4.3 percent in 1998 and total $4.2 billion. In 2002, worldwide SRAM revenue will total nearly $10 billion, which means a 20 percent CAGR for 1997 through 2002.
- Flash memory revenue should increase by 10.2 percent in 1998 and reach the $3 billion level. By 2002, worldwide flash revenue will total nearly $6.4 billion, with an 18 percent CAGR for 1997 through 2002.
- EEPROM revenue will rise by 16 percent in 1998 and exceed the $1.1 billion mark. By 2002, worldwide EEPROM revenue should approach $2 billion, for a near-15 percent CAGR for 1997 through 2002.
- EPROM revenue should decrease by more than 30 percent in 1998, declining to just over $0.5 billion. By 2002, worldwide EPROM revenue will decline to only $0.22 billion.
- Mask ROM revenue will fall by more than 20 percent in 1998, declining to $0.8 billion. By 2002, however, worldwide mask ROM revenue will edge upward to the $0.9 billion level.

Analog Product Trends and Forecast Assumptions

Worldwide analog IC revenue during 1998 should grow by nearly 11 percent and total $24 billion. The Asian financial crisis should reduce consumer demand in the Asia/Pacific and Japan, which will slow the growth of analog products. By contrast, the analog market expanded by nearly 19 percent in 1997.

Analog IC revenue should grow at a CAGR of 14 percent from 1997 through 2002 and reach $41 billion by 2002. Looking at the long-term trends through 2002, mixed-signal ICs will experience solid growth, driven by application markets such as digital cellular. Also, new emerging applications in the consumer and communications market will contribute to the growth of mixed-signal ICs. In the more traditional, standard linear product area, voltage regulator products will still enjoy strong growth as the demand for smart power continues to grow, especially in the portable markets.

Discrete Product Trends and Forecast Assumptions

Worldwide discrete product revenue should rise in 1998 by nearly 7 percent to $15.2 billion. The discrete product market grew at a similar rate in 1997. The long-term forecast assumes a stable market. We forecast a CAGR of 10 percent in discrete products through 2002, reaching a total of $23 billion.

Regional vendors in the Americas, Europe, and Asia/Pacific are expected to maintain fairly strong growth and a share of the discrete market through the end of the decade. The Americas region's growth will be determined by prowess in the communications, automotive, and industrial sectors in the face of strong competition from Europe.

Optoelectronics Product Trends and Forecast Assumptions

Optoelectronic semiconductors have a number of factors that will affect overall and regional growth rates. Optoelectronic IC revenue should grow only 1.3 percent in 1998 and total $5.4 billion. This market grew by nearly 9 percent in 1997. By 2002, worldwide optoelectronics revenue will total $7.4 billion, which represents a moderate percent 7 percent CAGR for 1997 through 2002.

For the near term, the Asian economic crisis will reduce dollar growth in Japan and the Asia/Pacific region through lower demand or currency effects relative to the dollar. These effects are expected to be most severe in 1998. After this year, this region is expected to resume higher growth rates as worldwide and regional demand for new consumer electronics and personal communications products overcome the effects of the current economic conditions.

For example, long-term acceptance of DVD and multimedia disk consumer electronic products will raise growth rates of laser diodes. More expensive diodes are required for the new, high-capacity players. This long-term growth will benefit Japan and the Asia/Pacific region.

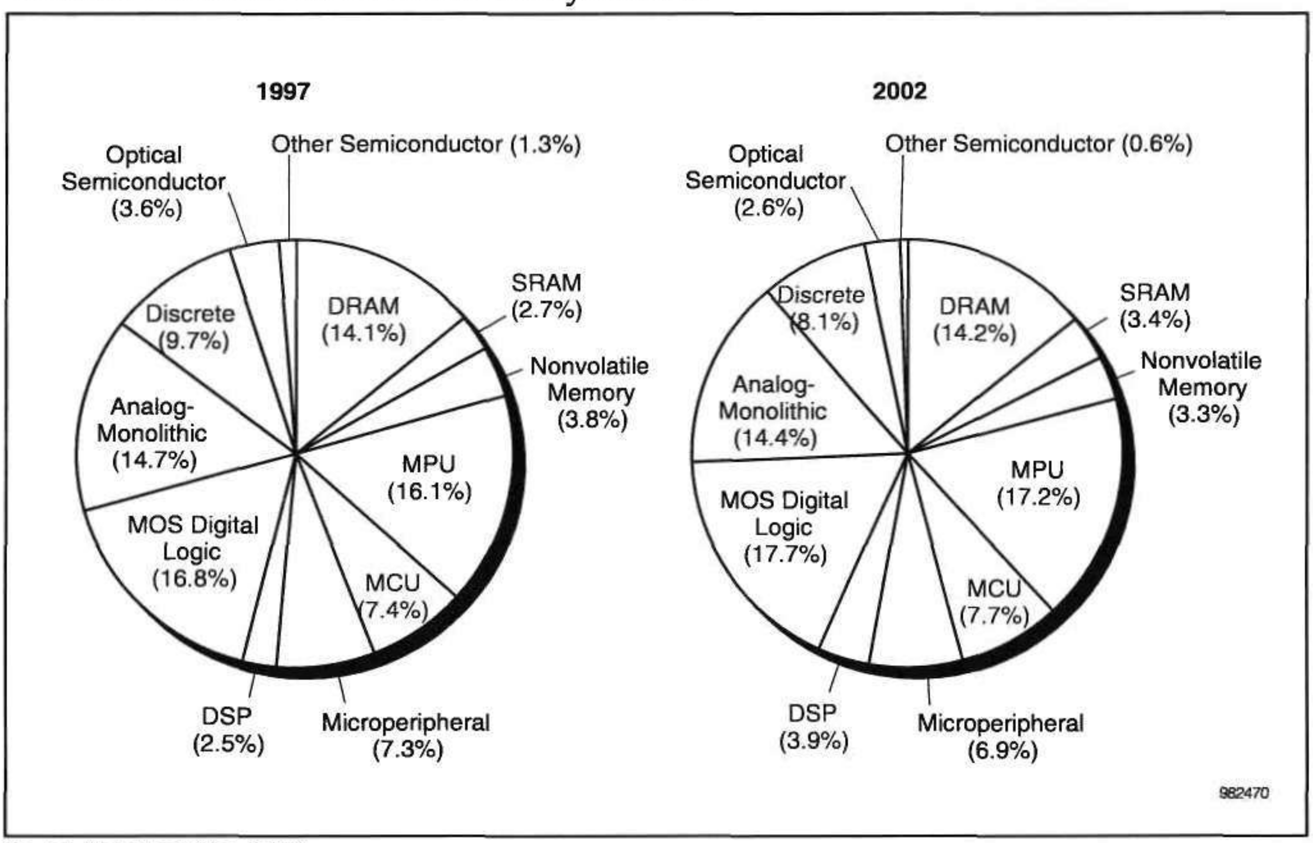
The growth in Japan will be mitigated by movement of production of consumer electronics products to the Asia/Pacific region as volumes increase and prices decrease. Digital cameras will drive demand for charge-coupled devices (CCDs). This will have a positive effect on demand for CCDs in Japan, but it will be insignificant compared to slower CCD growth in camcorder markets for the next five years until prices drop and picture quality improves. CCD demand in digital cameras will not have a large effect on the overall growth rate for CCDs or optoelectronics until the end of the forecast period.

The growth of the Internet also means positive long-term growth in this market. The Internet is creating extensive demand for high-bandwidth optical networks. This factor is particularly important in the United States. It will cause higher growth in laser diodes for fiber-optic modules for 155-Mbps through 10-Gbps fiber-optic networks. This will have a positive effect on growth in Europe as well as the Americas.

A third factor that is positively affecting demand for optoelectronics is automotive electronics. Automobile manufacturers are switching from incandescent lamps to LEDs for the rear braking lights in new car designs. This will give LEDs a positive push in all markets for the next several years as more car models adopt the new technology.

Figure 2-1 shows the impact of these varying rates of growth by product.

Figure 2-1
Worldwide Semiconductor Forecast by Product



Source: Dataquest (May 1998)

Chapter 3
Worldwide Semiconductor Product Forecasts by Region

This chapter presents the worldwide product forecasts by region.

Worldwide Semiconductor Forecast by Region

The worldwide semiconductor revenue forecast is broken into the four constituent regional forecasts in Figure 3-1. By world region, the forecast calls for the following CAGRs for 1997 to 2002 (regional revenue consumption for 2002 is shown in parentheses):

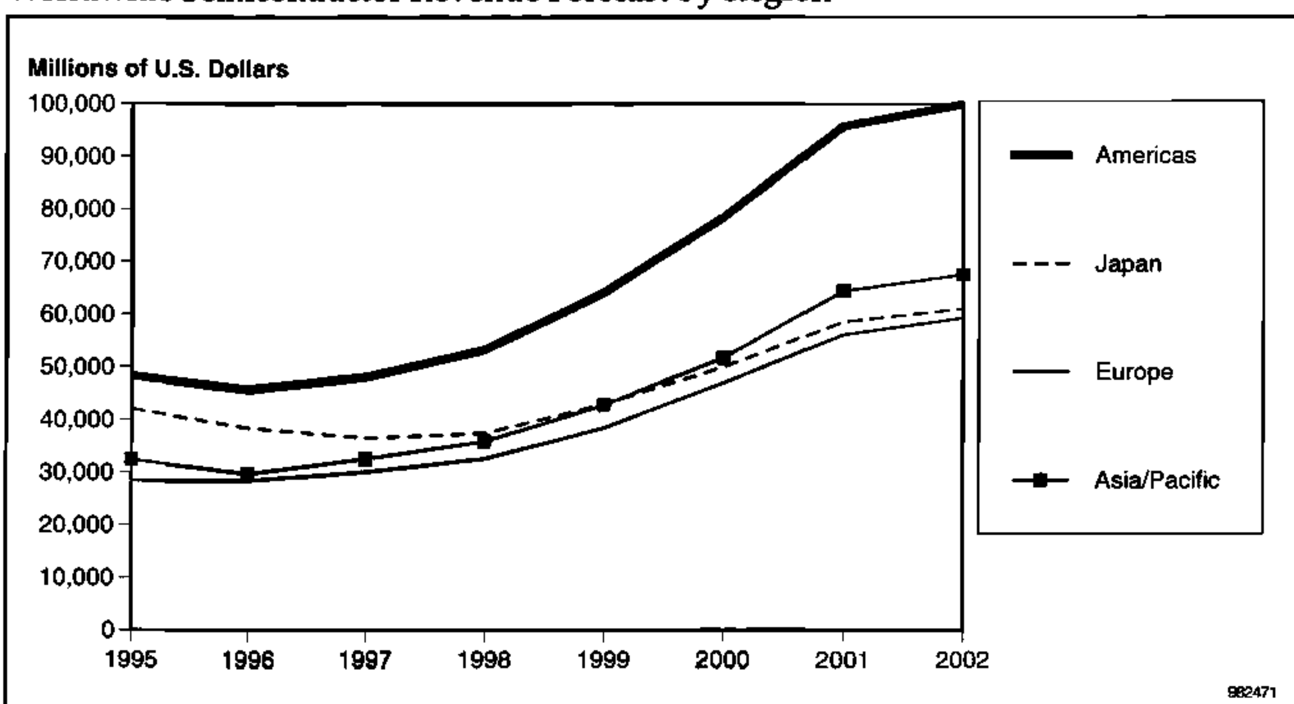
- Americas—15.7 percent CAGR ($100 billion)
- Japan—11 percent CAGR ($61 billion)
- Europe, Middle East, and Africa—14.6 percent CAGR ($59 billion)
- Asia/Pacific—15.7 percent CAGR ($68 billion)

As indicated, the long-term growth rates for Japan and Asia/Pacific have been lowered versus prior expectations.

Table 3-1 shows the regional revenue data and annual growth rates by region for the five-year semiconductor forecast.

The effect of this forecast on total market share by region is provided in Figure 3-2.

Figure 3-1
Worldwide Semiconductor Revenue Forecast by Region



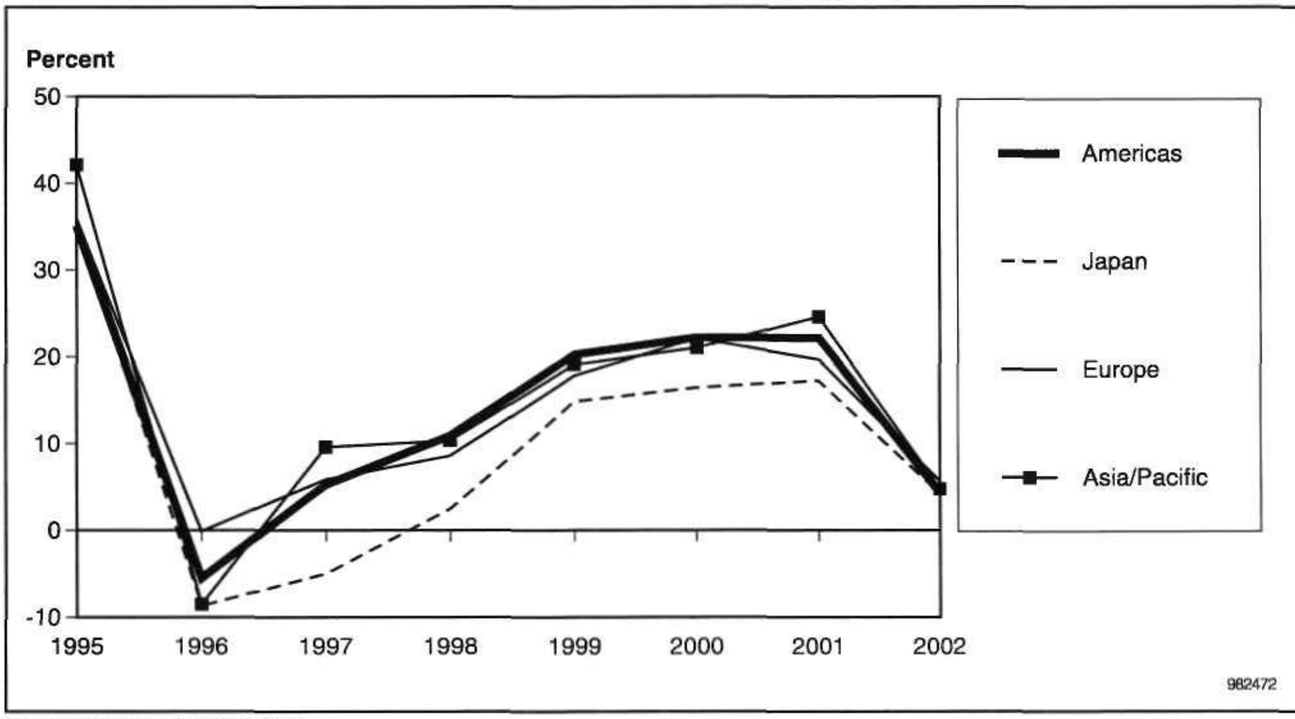
Source: Dataquest (May 1998)

Table 3-1
Total Semiconductor (Including Hybrid) Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Worldwide	**147,165**	**3.5**	**159,249**	**8.2**	**188,256**	**18.2**	**227,054**	**20.6**	**275,028**	**21.1**	**287,895**	**4.7**	**14.4**
Americas	48,086	5.3	53,326	10.9	64,133	20.3	78,388	22.2	95,782	22.2	99,906	4.3	15.7
Japan	36,499	-5.0	37,397	2.5	42,943	14.8	49,988	16.4	58,610	17.2	61,093	4.2	10.9
Europe	30,046	5.9	32,627	8.6	38,425	17.8	46,927	22.1	56,152	19.7	59,335	5.7	14.6
Asia/Pacific	32,534	9.6	35,899	10.3	42,754	19.1	51,751	21.0	64,483	24.6	67,561	4.8	15.7

Source: Dataquest (May 1998)

Figure 3-2
Worldwide Semiconductor Revenue Growth Forecast by Region



Source: Dataquest (May 1998)

Semiconductor Product Forecasts by Region

This section builds on the product and regional analysis of the prior sections by focusing on the individual products and their regional segmentation.

Microcomponent IC Forecast by Region

Table 3-2 shows microcomponent product consumption by region for 1997 to 2002. Microcomponent growth should moderate somewhat to a 16 percent CAGR for 1997 through 2002. The Americas will remain the largest market, by far. Asia/Pacific, driven by MPUs and microperipherals (MPRs), will remain the second-largest regional market. Even so, as noted, the Asian crisis throws a pall over the outlook for Asia/Pacific and Japan consumption.

The large MPU market—$27 billion in 1998 and $32 billion in 1999—will grow at a 16 percent CAGR from 1997 through 2002. For 1998, Americas and Asia/Pacific should achieve the strongest growth rates among the regions. By 2001, each regional MPU market, led by the large Americas market, will exceed $10 billion, except for Japan.

Communications and digital entertainment applications, among others, will drive the DSP market to a 25 percent CAGR for 1997 through 2002. Rapid growth means an $11 billion market by 2002, led by the European and Americas regions.

Table 3-2
Microcomponent Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Microcomponent													
Worldwide	48,945	18.0	55,530	13.5	65,980	18.8	76,970	16.7	89,750	16.6	103,130	14.9	16.1
Americas	17,785	21.9	20,543	15.5	24,270	18.1	28,000	15.4	32,540	16.2	37,070	13.9	15.8
Japan	9,336	6.1	10,040	7.5	12,040	19.9	14,010	16.4	16,010	14.3	18,470	15.4	14.6
Europe	10,939	17.1	12,296	12.4	14,310	16.4	16,700	16.7	19,490	16.7	22,420	15.0	15.4
Asia/Pacific	10,885	24.5	12,651	16.2	15,360	21.4	18,260	18.9	21,710	18.9	25,170	15.9	18.3
Microprocessor													
Worldwide	23,659	26.1	27,300	15.4	32,250	18.1	37,440	16.1	43,380	15.9	49,650	14.5	16.0
Americas	10,626	33.4	12,436	17.0	14,500	16.6	16,600	14.5	19,100	15.1	21,600	13.1	15.2
Japan	2,676	14.7	2,813	5.1	3,420	21.6	4,020	17.5	4,710	17.2	5,550	17.8	15.7
Europe	5,901	16.6	6,702	13.6	7,760	15.8	8,930	15.1	10,200	14.2	11,600	13.7	14.5
Asia/Pacific	4,456	31.4	5,349	20.1	6,570	22.8	7,890	20.1	9,370	18.8	10,900	16.3	19.6
Microcontroller													
Worldwide	10,896	6.4	12,320	13.1	14,270	15.8	16,720	17.2	19,460	16.4	22,230	14.2	15.3
Americas	2,194	0.6	2,790	27.2	3,190	14.3	3,680	15.4	4,390	19.3	5,060	15.3	18.2
Japan	4,059	3.3	4,360	7.4	5,200	19.3	6,040	16.2	6,720	11.3	7,580	12.8	13.3
Europe	2,330	11.9	2,540	9.0	2,820	11.0	3,290	16.7	3,920	19.1	4,510	15.1	14.1
Asia/Pacific	2,313	12.8	2,630	13.7	3,060	16.3	3,710	21.2	4,430	19.4	5,080	14.7	17.0
Microperipheral													
Worldwide	10,736	6.5	11,300	5.3	13,660	20.9	15,580	14.1	17,810	14.3	19,990	12.2	13.2
Americas	3,887	6.6	3,967	2.1	4,870	22.8	5,610	15.2	6,460	15.2	7,310	13.2	13.5
Japan	1,873	-9.2	1,917	2.3	2,200	14.8	2,410	9.5	2,620	8.7	2,850	8.8	8.8
Europe	1,661	8.0	1,755	5.6	2,070	18.0	2,360	14.0	2,720	15.3	3,030	11.4	12.8
Asia/Pacific	3,315	17.0	3,662	10.5	4,520	23.4	5,200	15.0	6,010	15.6	6,800	13.1	15.5
Digital Signal Processor													
Worldwide	3,654	53.0	4,610	26.2	5,800	25.8	7,230	24.7	9,100	25.9	11,260	23.7	25.2
Americas	1,078	36.1	1,350	25.2	1,710	26.7	2,110	23.4	2,590	22.7	3,100	19.7	23.5
Japan	728	54.9	950	30.5	1,220	28.4	1,540	26.2	1,960	27.3	2,490	27.0	27.9
Europe	1,047	59.1	1,300	24.2	1,660	27.7	2,120	27.7	2,650	25.0	3,280	23.8	25.7
Asia/Pacific	801	71.2	1,010	26.1	1,210	19.8	1,460	20.7	1,900	30.1	2,390	25.8	24.4

Source: Dataquest (May 1998)

MCUs continue to find new embedded homes in every conceivable electronic product, meaning stable long-term growth. The $11 billion MCU market of 1997 will double to $22 billion by 2002. The CAGR for 1997 through 2002 is expected to be 15 percent.

For 1998, Americas shows the strongest growth among the regions; all other 1998 regional forecasts have been lowered. Japan will remain the largest MCU market in the long term, with Americas and Asia/Pacific the fastest growing.

Memory IC Forecast by Region

Table 3-3 shows the memory product consumption forecast by region. Each region will show a double-digit CAGR over the forecast period. In 1998, however, each region shows negligible memory revenue growth.

The Asia/Pacific growth rate will *no longer* outpace other regions' memory growth. The Americas region will remain by far the No. 1 market for DRAM. The Americas region should also ultimately emerge as the leading consumer of nonvolatile memory. Asia/Pacific, Europe, and Japan will be important markets, however, for nonvolatile memory. For example, Europe's consumption will be driven by cellular phones that use EEPROM or flash.

Digital Logic Forecast by Region

Table 3-4 gives the digital logic forecast by region. For 1998, Americas and Europe should show the strongest regional growth. The Asian crisis means lowered expectations for Asia/Pacific and Japan. Japan will continue to rank with Americas as the two largest markets.

The worldwide digital logic markets will achieve a long-term 16 percent growth rate driven by strength in digital cell-based ICs and PLDs. The trend to system-level integration means that many formerly standalone MPUs will instead ship in the form of ASIC cores. By region, 1997-to-2002 CAGRs will range as follows:

- Japan—10 percent
- Asia/Pacific—15 percent
- Europe, Middle East, and Africa—18 percent
- Americas—19 percent

Analog, Discrete, and Optoelectronics by Region

Table 3-5 shows the regional forecasts for analog ICs, discrete semiconductors, and optoelectronic semiconductors. The products tend to be mature, as reflected in their slower, more stable growth rates. Optoelectronics consumption centers in Japan. The market for analog and discrete products has been geographically diversified.

Table 3-3
MOS Memory Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Memory													
Worldwide	30,978	-18.6	31,401	1.4	39,743	26.6	53,572	34.8	76,573	42.9	61,202	-20.1	14.6
Americas	11,898	-18.7	12,215	2.7	15,733	28.8	21,511	36.7	29,953	39.2	24,108	-19.5	15.2
Japan	6,523	-23.1	6,518	-0.1	8,192	25.7	10,870	32.7	15,224	40.1	12,439	-18.3	13.8
Europe	6,041	-12.7	6,092	0.8	7,718	26.7	10,756	39.4	14,831	37.9	12,127	-18.2	15.0
Asia/Pacific	6,516	-18.7	6,576	0.9	8,100	23.2	10,436	28.8	16,566	58.7	12,527	-24.4	14.0
Dynamic RAM													
Worldwide	20,744	-20.3	20,960	1.0	26,897	28.3	38,043	41.4	57,994	52.4	40,920	-29.4	14.6
Americas	8,233	-21.3	8,427	2.4	11,003	30.6	15,851	44.1	22,982	45.0	16,681	-27.4	15.2
Japan	3,837	-24.1	3,877	1.0	4,975	28.3	7,037	41.4	10,727	52.4	7,569	-29.4	14.6
Europe	4,032	-12.8	4,045	0.3	5,229	29.3	7,763	48.5	11,255	45.0	8,169	-27.4	15.2
Asia/Pacific	11	-21.0	4,611	-0.7	5,690	23.4	7,393	29.9	13,030	76.3	8,500	-34.8	12.9
Static RAM													
Worldwide	4,008	-20.2	4,182	4.3	5,694	36.2	7,378	29.6	9,402	27.4	9,761	3.8	19.5
Americas	1,852	-10.3	1,932	4.3	2,589	34.0	3,218	24.3	4,230	31.4	4,289	1.4	18.3
Japan	911	-26.1	950	4.3	1,294	36.2	1,677	29.6	2,137	27.4	2,219	3.8	19.5
Europe	646	-18.9	674	4.3	918	36.2	1,189	29.6	1,515	27.4	1,573	3.8	19.5
Asia/Pacific	599	-35.3	626	4.4	893	42.7	1,294	44.9	1,520	17.5	1,680	10.5	22.9
Nonvolatile Memory													
Worldwide	5,571	-13.7	5,533	-0.7	6,343	14.6	7,262	14.5	8,193	12.8	9,432	15.1	11.1
Americas	1,519	-16.5	1,527	0.5	1,780	16.5	2,055	15.5	2,309	12.4	2,646	14.6	11.7
Japan	1,612	-21.1	1,510	-6.3	1,721	14.0	1,934	12.4	2,115	9.3	2,381	12.6	8.1
Europe	1,216	-14.0	1,210	-0.5	1,390	14.9	1,604	15.4	1,839	14.6	2,140	16.4	12.0
Asia/Pacific	1,224	4.0	1,286	5.1	1,452	12.9	1,668	14.9	1,930	15.7	2,265	17.4	13.1
Other MOS Memory													
Worldwide	655	13.5	726	10.9	809	11.4	889	9.9	984	10.7	1,089	10.7	10.7
Americas	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
Japan	163	6.5	181	10.9	201	11.4	221	9.9	245	10.7	271	10.7	10.7
Europe	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
Asia/Pacific	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0

Source: Dataquest (May 1998)

Table 3-4
Digital Logic Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Digital Logic													
Worldwide	24,757	9.2	26,573	7.3	31,084	17.0	37,061	19.2	42,793	15.5	50,818	18.8	15.5
Americas	8,525	12.7	9,484	11.3	11,373	19.9	13,900	22.2	16,465	18.4	19,960	21.2	18.5
Japan	8,164	4.4	8,282	1.5	9,256	11.8	10,492	13.4	11,663	11.2	13,387	14.8	10.4
Europe	4,159	5.2	4,634	11.4	5,515	19.0	6,714	21.7	7,889	17.5	9,531	20.8	18.0
Asia/Pacific	3,909	17.2	4,172	6.7	4,940	18.4	5,955	20.5	6,776	13.8	7,939	17.2	15.2
MOS Digital ASIC													
Worldwide	16,527	11.7	18,409	11.4	22,330	21.3	27,446	22.9	32,675	19.1	39,789	21.8	19.2
Americas	7,098	18.6	8,094	14.0	9,912	22.5	12,296	24.1	14,795	20.3	18,200	23.0	20.7
Japan	4,577	4.0	4,775	4.3	5,580	16.9	6,574	17.8	7,581	15.3	8,935	17.9	14.3
Europe	3,190	12.9	3,647	14.3	4,458	22.2	5,561	24.7	6,674	20.0	8,210	23.0	20.8
Asia/Pacific	11	4.7	1,893	13.9	2,380	25.7	3,015	26.7	3,625	20.2	4,443	22.6	21.7
Custom IC													
Worldwide	1,514	-12.2	1,164	-23.1	823	-29.4	557	-32.3	349	-37.3	205	-41.4	-33.0
Americas	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
Japan	795	-5.2	630	-20.8	466	-26.0	315	-32.5	197	-37.4	116	-41.0	-31.9
Europe	71	-47.8	49	-31.0	37	-25.0	26	-30.0	17	-35.0	10	-40.0	-32.4
Asia/Pacific	425	-4.5	341	-19.8	256	-25.0	179	-30.0	116	-35.0	70	-40.0	-30.3
MOS Standard Logic													
Worldwide	2,266	13.7	2,373	4.7	2,565	8.1	2,739	6.8	2,775	1.3	2,805	1.1	4.4
Americas	684	4.9	705	3.0	761	8.0	811	6.6	823	1.5	815	-1.0	3.6
Japan	500	11.4	513	2.5	549	7.2	586	6.6	588	0.4	599	2.0	3.7
Europe	466	11.0	487	4.4	512	5.2	532	4.0	538	1.0	548	2.0	3.3
Asia/Pacific	616	30.5	670	8.7	743	11.0	810	9.0	826	2.0	843	2.0	6.5
Total Other MOS Logic													
Worldwide	4,450	7.0	4,626	4.0	5,366	16.0	6,318	17.7	6,993	10.7	8,019	14.7	12.5
Americas	520	-16.7	541	4.0	636	17.6	755	18.8	827	9.5	936	13.2	12.5
Japan	2,292	7.6	2,365	3.2	2,661	12.5	3,018	13.4	3,298	9.3	3,737	13.3	10.3
Europe	432	-24.5	451	4.5	509	12.7	595	16.9	660	11.0	763	15.5	12.0
Asia/Pacific	1,206	45.1	1,269	5.2	1,561	23.0	1,951	25.0	2,208	13.2	2,584	17.0	16.5

Source: Dataquest (May 1998)

Table 3-5
Analog-Monolithic Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Analog-Monolithic													
Worldwide	21,652	18.7	24,001	10.8	27,777	15.7	32,577	17.3	37,229	14.3	41,400	13.3	13.8
Americas	5,477	23.8	6,359	16.1	7,510	18.1	8,877	18.2	10,261	15.6	11,557	12.0	16.1
Japan	4,977	8.7	5,058	1.6	5,509	8.9	6,030	9.5	6,551	8.6	7,033	12.3	7.2
Europe	4,888	17.8	5,350	9.5	6,150	15.0	7,060	14.8	7,950	12.6	8,650	14.4	12.1
Asia/Pacific	6,310	24.1	7,234	14.6	8,608	19.0	10,610	23.3	12,467	17.5	14,160	14.0	17.5
Total Discrete													
Worldwide	14,255	5.8	15,221	6.8	16,934	11.3	19,711	16.4	21,100	7.0	23,300	19.8	10.3
Americas	3,074	5.1	3,400	10.6	3,910	15.0	4,704	20.3	5,098	8.4	5,697	19.3	13.1
Japan	4,244	-3.7	4,361	2.8	4,701	7.8	5,148	9.5	5,522	7.3	5,903	17.5	6.8
Europe	3,120	9.6	3,309	6.1	3,750	13.3	4,670	24.5	4,920	5.4	5,500	20.4	12.0
Asia/Pacific	11	15.9	4,151	8.8	4,573	10.2	5,189	13.5	5,560	7.1	6,200	22.6	10.2
Total Optical Semiconductor													
Worldwide	5,339	8.6	5,411	1.3	5,791	7.0	6,329	9.3	6,876	8.6	7,441	7.5	6.9
Americas	970	31.3	1,022	5.4	1,090	6.7	1,175	7.8	1,275	8.5	1,350	4.4	6.8
Japan	2,725	3.3	2,640	-3.1	2,820	6.8	3,050	8.2	3,305	8.4	3,560	7.8	5.5
Europe	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	8.1	7.5
Asia/Pacific	913	23.5	945	3.5	1,021	8.0	1,174	15.0	1,301	10.8	1,481	8.5	10.2

Source: Dataquest (May 1998)

Analog IC Forecast by Region

The movement to digital consumer electronics will be evolutionary, which means a stable long-term outlook for the analog IC market. As noted, the Asian crisis, among other factors, means somewhat lowered analog IC consumption expectations for Asia/Pacific and Japan in 1998 and in the long term. Even so, analog ICs historically show more equal distribution among the four regions than other products, and this stabilizes the worldwide outlook. Also, the increasing presence of analog ICs in computer and communications applications should stabilize worldwide growth.

Discrete Device Forecast by Region

Discrete semiconductors have been losing market share because of the relentless integration of components, yet the long-term outlook remains consistent with recent growth rates. For example, the discrete market had just under a 12 percent CAGR during the 1992-to-1997 period. Discrete semiconductors should grow at a somewhat slower but similar 10.3 percent CAGR for 1997 through 2002. The discrete semiconductor market remains viable because power and RF devices are not readily integrated. Power transistors represent about one-third of discrete device revenue and are expected to lead discrete device growth.

Asia/Pacific should ultimately surpass Japan as the world's largest market for discrete semiconductors. Each regional discrete device market—except Japan—should grow at a low double-digit CAGR through 2002.

The growing use of power discrete devices in power control and communications applications in the Americas and Europe indicates regional CAGRs of more than 12 percent in the next five years. The Americas and European markets for discrete semiconductors will remain at relatively the same size.

Optical Semiconductor Forecast by Region

Japan has been and should continue to be the largest regional market, by far, for optical semiconductors. Optoelectronics products are the most dependent of all semiconductor products on consumer entertainment-related applications. A major boom in the DVD application would mean stronger growth than currently projected for this product market (7 percent CAGR for 1997 to 2002). Meanwhile, computer and peripheral applications have an increasing impact on the optical semiconductor market. For example, scanners and copiers use charge-coupled devices (CCDs), CD-ROMs use laser diodes, and optical-fiber data links use semiconductor receivers and transmitters.

Chapter 4
Americas Forecast by Product Family

Semiconductor Forecast by Region

The semiconductor forecast calls for the Americas region (North America and Latin America) to grow at a 16 percent CAGR for 1997 through 2002. This growth will push the $48 billion market of 1997 to $100 billion by 2002.

The following section identifies the assumptions that guide the forecast.

Dataquest expects the Americas semiconductor market to grow by a moderate 11 percent rate in 1998. Stronger growth should occur during the 1999-to-2001 time frame. As of the first half of 1998, the major North American semiconductor vendors reported slower growth than expected in world markets, including the home region. Some have indicated slowdowns in key application segments such as desktop PCs, cellular handsets, and consumer markets. In the long term, these application markets should expand, which signals strong regional growth in the DSP, flash, and SLI product markets.

PCs will remain a kingpin application in the Americas region for both the near term and the long term. For example, MPU and DRAM product revenue represents over 40 percent of the Americas region's product revenue. For 1998, the Americas MPU market will grow by 17 percent and reach $12 billion. The Americas DRAM market will barely grow in 1998 because of low pricing, despite continuing DRAM bit growth. As indicated, Dataquest expects a rebound in the second half of 1998 in the Americas PC MPU market.

Also, Intel should successfully migrate the x86 architecture to server applications over the long term; this translates into a 15 percent CAGR for MPU revenue in the Americas region.

High-Growth Products

MPUs will remain the largest regional product market. The 1997-to-2002 CAGRs of the fastest-growing semiconductor products in the Americas region are as follows (with 2002 revenue in parentheses):

- DSPs—24 percent CAGR ($3.1 billion)
- ASICs—21 percent CAGR ($18.2 billion)
- SRAM—18 percent ($4.3 billion)
- Flash memory—17 percent ($1.9 billion)
- MPUs—15.2 percent ($21.6 billion)

Tables 4-1 and 4-2 provide details of the Americas semiconductor market.

Figure 4-1 shows the effect of the Americas forecast on the relative consumption by product. The Americas market will remain highly dependent on the health of data processing, especially PCs.

Table 4-1
Americas Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**48,086**	**5.3**	**53,326**	**10.9**	**64,133**	**20.3**	**78,388**	**22.2**	**95,782**	**22.2**	**99,906**	**4.3**	**15.7**
Total Integrated Circuit	**44,042**	**4.8**	**48,904**	**11.0**	**59,133**	**20.9**	**72,509**	**22.6**	**89,409**	**23.3**	**92,859**	**3.9**	**16.1**
Bipolar Digital	357	-40.2	303	-15.1	247	-18.5	221	-10.5	190	-14.0	164	-13.7	-14.4
MOS Memory	11,898	-18.7	12,215	2.7	15,733	28.8	21,511	36.7	29,953	39.2	24,108	-19.5	15.2
Dynamic RAM	8,233	-21.3	8,427	2.4	11,003	30.6	15,851	44.1	22,982	45.0	16,681	-27.4	15.2
Static RAM	1,852	-10.3	1,932	4.3	2,589	34.0	3,218	24.3	4,230	31.4	4,289	1.4	18.3
Nonvolatile Memory	1,519	-16.5	1,527	0.5	1,780	16.5	2,055	15.5	2,309	12.4	2,646	14.6	11.7
EPROM	220	-43.3	133	-39.3	92	-31.2	65	-28.8	46	-30.2	30	-33.6	-32.7
EEPROM	303	7.4	369	21.7	443	20.1	499	12.6	534	7.0	602	12.8	14.7
Flash Memory	11	-8.9	935	8.0	1,140	21.9	1,382	21.3	1,628	17.8	1,910	17.3	17.2
Mask ROM	309	-34.5	91	-30.9	106	16.9	109	2.7	102	-6.5	103	1.8	-4.6
Other MOS Memory	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
MOS Microcomponent	17,785	21.9	20,543	15.5	24,270	18.1	28,000	15.4	32,540	16.2	37,070	13.9	15.8
Microprocessor	10,626	33.4	12,436	17.0	14,500	16.6	16,600	14.5	19,100	15.1	21,600	13.1	15.2
Microcontroller	2,194	0.6	2,790	27.2	3,190	14.3	3,680	15.4	4,390	19.3	5,060	15.3	18.2
Microperipheral	3,887	6.6	3,967	2.1	4,870	22.8	5,610	15.2	6,460	15.2	7,310	13.2	13.5
Digital Signal Processor	1,078	36.1	1,350	25.2	1,710	26.7	2,110	23.4	2,590	22.7	3,100	19.7	23.5
MOS Digital Logic	8,525	12.7	9,484	11.3	11,373	19.9	13,900	22.2	16,465	18.4	19,960	21.2	18.5
ASICs	7,098	18.6	8,094	14.0	9,912	22.5	12,296	24.1	14,795	20.3	18,200	23.0	20.7
Custom IC	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
MOS Standard Logic	684	4.9	705	3.0	761	8.0	811	6.6	823	1.5	815	-1.0	3.6
Total Other MOS Logic	520	-16.7	541	4.0	636	17.6	755	18.8	827	9.5	936	13.2	12.5
Analog-Monolithic	5,477	23.8	6,359	16.1	7,510	18.1	8,877	18.2	10,261	15.6	11,557	12.6	16.1
Total Discrete	3,074	5.1	3,400	10.6	3,910	15.0	4,704	20.3	5,098	8.4	5,697	11.7	13.1
Total Optical Semiconductor	970	31.3	1,022	5.4	1,090	6.7	1,175	7.8	1,275	8.5	1,350	5.9	6.8

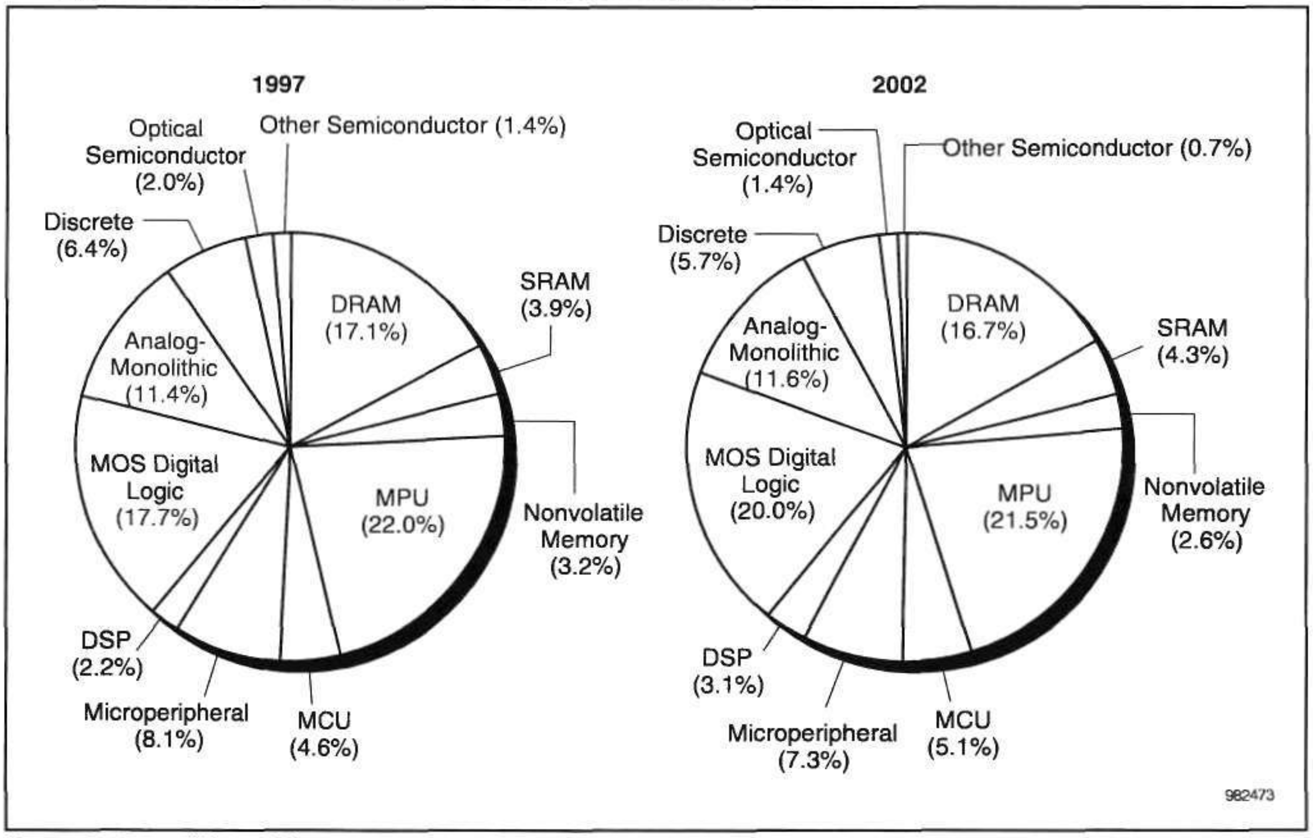
Source: Dataquest (May 1998)

Table 4-2
Americas Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	20,426	20.2	27,924	36.7	35,773	28.1	48,343	35.1	45,672	-5.5	48,086	5.3	18.7
Total Integrated Circuit	18,400	20.5	25,629	39.3	32,864	28.2	44,691	36.0	42,009	-6.0	44,042	4.8	19.1
Bipolar Digital	1,232	-7.4	1,173	-4.8	967	-17.6	760	-21.4	597	-21.4	357	-40.2	-21.9
MOS Memory	5,707	26.5	8,785	53.9	12,469	41.9	20,480	64.2	14,642	-28.5	11,898	-18.7	15.8
Dynamic RAM	3,555	36.7	5,832	64.1	9,030	54.8	15,739	74.3	10,455	-33.6	8,233	-21.3	18.3
Static RAM	1,107	24.5	1,349	21.9	1,630	20.8	2,509	53.9	2,064	-17.7	1,852	-10.3	10.8
Nonvolatile Memory	924	3.2	1,449	56.8	1,634	12.8	1,951	19.4	1,820	-6.7	1,519	-16.5	10.5
EPROM	417	-4.8	489	17.3	527	7.8	419	-20.5	388	-7.4	220	-43.3	-12.0
EEPROM	139	0	178	28.1	233	30.9	290	24.5	282	-2.8	303	7.4	16.9
Flash Memory	11	0	482	232.4	474	-1.7	852	79.7	950	11.5	865	-8.9	42.9
Mask ROM	309	0	300	34.5	400	33.3	390	-2.5	200	-48.7	131	-34.5	-10.1
Other MOS Memory	121	-3.2	155	28.1	175	12.9	281	60.6	303	7.8	294	-3.0	19.4
MOS Microcomponent	5,282	34.8	7,620	44.3	9,839	29.1	12,425	26.3	14,587	17.4	17,785	21.9	27.5
Microprocessor	2,674	53.2	4,323	61.7	5,446	26.0	6,800	24.9	7,968	17.2	10,626	33.4	31.8
Microcontroller	938	19.3	1,254	33.7	1,652	31.7	2,048	24.0	2,181	6.5	2,194	0.6	18.5
Microperipheral	1,486	17.4	1,764	18.7	2,320	31.5	2,982	28.5	3,646	22.3	3,887	6.6	21.2
Digital Signal Processor	184	54.6	279	51.6	421	50.9	595	41.3	792	33.1	1,078	36.1	42.4
MOS Digital Logic	3,179	10.8	4,459	40.3	5,422	21.6	6,801	25.4	7,566	11.2	8,525	12.7	21.8
ASICs	2,313	10.6	3,088	33.5	3,846	24.5	5,012	30.3	5,986	19.4	7,098	18.6	25.1
Custom IC	207	5.1	291	40.6	493	69.4	529	7.3	304	-42.5	223	-26.6	1.5
MOS Standard Logic	369	31.3	433	17.3	563	30.0	684	21.5	652	-4.7	684	4.9	13.1
Total Other MOS Logic	290	-3.7	652	124.8	525	-19.5	582	10.9	624	7.2	520	-16.7	12.4
Analog-Monolithic	2,691	12.3	3,304	22.8	3,820	15.6	3,994	4.6	4,425	10.8	5,477	23.8	15.3
Total Discrete	1,603	15.4	1,811	13.0	2,212	22.1	3,027	36.8	2,924	-3.4	3,074	5.1	13.9
Total Optical Semiconductor	423	27.4	484	14.4	697	44.0	625	-10.3	739	18.2	970	31.3	18.1

Source: Dataquest (May 1998)

Figure 4-1
Americas Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 5
Japanese Forecast by Product Family

Semiconductor Forecast by Region

Dataquest forecasts that the Japanese market will have an 11 percent CAGR for 1997 through 2002. The $37-billion market (in 1997) should reach $60 billion by 2002. This Japanese regional forecast of semiconductor consumption is lower than previously expected. Japan's economy both affects and is affected by the Asian crisis.

The following section identifies the assumptions that guide the forecast.

Market Weakness of Applications

On the demand side, electronic equipment production is expected to show 3 percent growth, which is lower than the fall forecast. This reduction comes from the decelerated domestic economy, as well as the decrease in demand in Asia/Pacific because of the macroeconomic crisis. PC shipments in Japan are experiencing sluggishness or even a decline in some months, and 1998 will see modest single-digit growth. Mobile communications did not slow down as expected in 1997—so the downturn is expected this year.

The CAGR of electronic equipment production for Japan in the years 1997 through 2002 is quite weak—less than 3 percent. Communications and consumer products will remain the leading applications, while industrial will see the highest CAGR over the period. Even with the introduction of all the digitized systems, the consumer category should remain the second-largest. Japan's consumer segment, however, should generate the slowest growth in semiconductor consumption for the coming five years.

Slower Semiconductor Product Growth

Japanese semiconductor consumption in 1998 will increase by just 3 percent in dollars, and at a somewhat higher rate in yen. With major applications slowing down, such as PCs, mobile communications, and audio/video equipment, as well as weak capital spending in most industries, Japanese semiconductor consumption is showing the lowest growth among all regions. In the coming five years, the weak growth in electronic equipment production will limit the growth of semiconductor consumption in Japan. As a result, Japan's 11 percent CAGR is the lowest of all the regions.

DRAM bit prices are declining faster than forecast during 1998 because of prolonged oversupply and the quick ramp-up of 64Mb supply. The shift from extended data out (EDO) to SDRAM may not contribute to DRAM price firming as much as previously expected. The current focus of interest is on the pricing premium of 100-MHz SDRAM, which remains to be secured for the first half of 1998 but will diminish in the second half as vendors increase supply.

Flash memory market will continue to be driven in both the near term and the long term by mobile equipment and IC card applications, such as cellular phones and digital still camera. As major memory suppliers emphasize flash memory in view of sluggish DRAM, the pricing of flash memories will continue to decline, and that will include 16Mb and beyond.

In the MOS microcomponent area during 1998, the MPU market growth in Japan will slow because of the sluggish Japanese PC market; the MCU market will experience somewhat stronger growth this year.

Four-bit MCUs will continue to enjoy expansion in application areas but will be replaced by 8-bit toward the end of the forecast period. MCUs with embedded flash will expand their market quickly and will lead to the introduction of embedded ferroelectric (FRAM) MCUs. Sixteen-bit MCU applications include emerging digital consumer equipment such as DVD, minidisc (MD), digital TV, and digital VCR. Both 32-bit and 64-bit products will continue to find applications in system-level integration.

DSP including media processors will continue to show the highest growth among microcomponent categories, finding applications in digital cellular, rigid disk drive (RDD), and DVD, utilizing advanced process technology of each generation.

In the ASIC area, system-level integration is becoming the norm for product development as well as applications. This trend is expediting the shift from gate arrays to CBICs and PLDs. In the Japanese market, because the domestic suppliers still put emphasis on gate arrays, this shift is taking place more slowly than in the worldwide market. CBICs in Japan are currently based on 0.35- to 0.25-micron processes, moving to 0.18-micron processes, as microcomponent, memories, and analog become embedded to offer SLI solutions.

Portable equipment applications in Japan are expected to drive low-voltage technologies as well as embedded memories and high-density packaging technologies.

Analog is expected to slow down in 1998 because of sluggish domestic markets for end products including consumer equipment. General-purpose analog such as amps and voltage regulators enjoyed proliferation as emerging new systems were introduced. However, as SLI becomes the norm for optimized system development, independent, general-purpose analog will be embedded in CBICs. RF and power products continue to enjoy sound growth in the forecast period, although 1998 should be a year of slow growth.

Similar market trends are expected for discrete semiconductors in Japan. For example, small signal products, which enjoyed an increase in volume in the past few years, will finally see slow growth as SLI products incorporate more system blocks. Here again, RF and power are the two functions that remain to be covered by independent ("discrete") discrete products, helped by mobile applications and digital consumer equipment. Steady growth is expected in optical semiconductors.

High-Growth Products

The 1997-to-2002 CAGRs of the fastest-growing semiconductor products in the Japanese region are shown here (with 2002 revenue in parentheses):

- DSPs—28 percent ($2.5 billion)
- SRAM—20 percent ($2.2 billion)

- Flash memory—18 percent ($1.5 billion)
- MPUs—16 percent ($5.6 billion)

Tables 5-1 and 5-2 provide details of the Japanese semiconductor market.

Figure 5-1 provides a product comparison for final revenue in the Japanese market.

Table 5-1
Japanese Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**36,499**	**-5.0**	**37,397**	**2.5**	**42,943**	**14.8**	**49,988**	**16.4**	**58,610**	**17.2**	**61,093**	**4.2**	**10.9**
Total Integrated Circuit	**29,530**	**-5.9**	**30,396**	**2.9**	**35,422**	**16.5**	**41,790**	**18.0**	**49,783**	**19.1**	**51,630**	**3.7**	**11.8**
Bipolar Digital	530	-31.2	498	-6.0	425	-14.7	389	-8.5	335	-13.9	300	-10.4	-10.8
MOS Memory	6,523	-23.1	6,518	-0.1	8,192	25.7	10,870	32.7	15,224	40.1	12,439	-18.3	13.8
Dynamic RAM	3,837	-24.1	3,877	1.0	4,975	28.3	7,037	41.4	10,727	52.4	7,569	-29.4	14.6
Static RAM	911	-26.1	950	4.3	1,294	36.2	1,677	29.6	2,137	27.4	2,219	3.8	19.5
Nonvolatile Memory	1,612	-21.1	1,510	-6.3	1,721	14.0	1,934	12.4	2,115	9.3	2,381	12.6	8.1
EPROM	169	-51.4	114	-32.8	87	-23.0	71	-19.3	58	-17.9	49	-16.0	-22.0
EEPROM	151	-9.6	175	15.9	204	16.4	230	12.8	260	13.3	300	15.3	14.7
Flash Memory	11	-19.0	702	10.2	852	21.4	1,034	21.5	1,228	18.7	1,464	19.2	18.1
Mask ROM	309	-11.8	520	-20.7	579	11.4	600	3.6	568	-5.2	568	-0.1	-2.8
Other MOS Memory	163	6.5	181	10.9	201	11.4	221	9.9	245	10.7	271	10.7	10.7
MOS Microcomponent	9,336	6.1	10,040	7.5	12,040	19.9	14,010	16.4	16,010	14.3	18,470	15.4	14.6
Microprocessor	2,676	14.7	2,813	5.1	3,420	21.6	4,020	17.5	4,710	17.2	5,550	17.8	15.7
Microcontroller	4,059	3.3	4,360	7.4	5,200	19.3	6,040	16.2	6,720	11.3	7,580	12.8	13.3
Microperipheral	1,873	-9.2	1,917	2.3	2,200	14.8	2,410	9.5	2,620	8.7	2,850	8.8	8.8
Digital Signal Processor	728	54.9	950	30.5	1,220	28.4	1,540	26.2	1,960	27.3	2,490	27.0	27.9
MOS Digital Logic	8,164	4.4	8,282	1.5	9,256	11.8	10,492	13.4	11,663	11.2	13,387	14.8	10.4
ASICs	4,577	4.0	4,775	4.3	5,580	16.9	6,574	17.8	7,581	15.3	8,935	17.9	14.3
Custom IC	795	-5.2	630	-20.8	466	-26.0	315	-32.5	197	-37.4	116	-41.0	-31.9
MOS Standard Logic	500	11.4	513	2.5	549	7.2	586	6.6	588	0.4	599	2.0	3.7
Total Other MOS Logic	2,292	7.6	2,365	3.2	2,661	12.5	3,018	13.4	3,298	9.3	3,737	13.3	10.3
Analog-Monolithic	4,977	8.7	5,058	1.6	5,509	8.9	6,030	9.5	6,551	8.6	7,033	7.4	7.2
Total Discrete	4,244	-3.7	4,361	2.8	4,701	7.8	5,148	9.5	5,522	7.3	5,903	6.9	6.8
Total Optical Semiconductor	2,725	3.3	2,640	-3.1	2,820	6.8	3,050	8.2	3,305	8.4	3,560	7.7	5.5

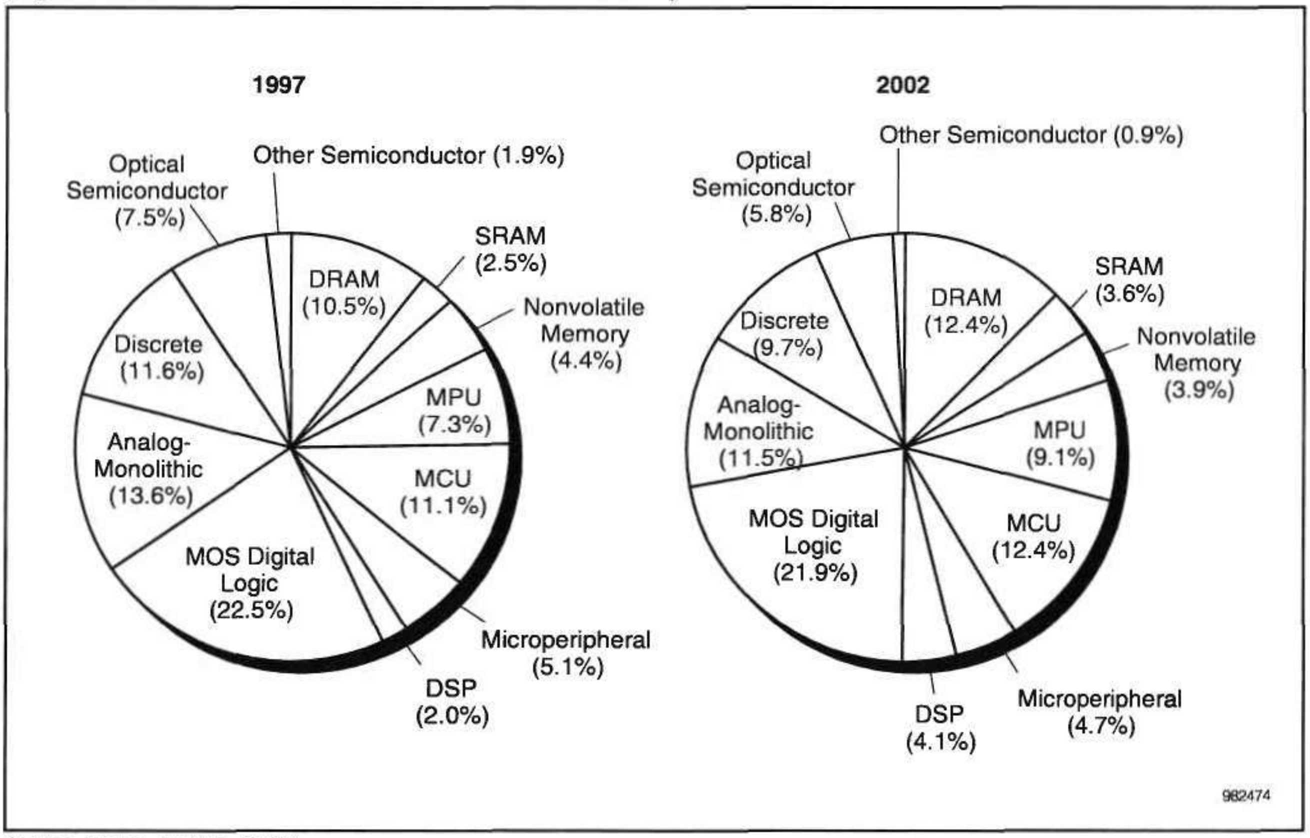
Source: Dataquest (May 1998)

Table 5-2
Japanese Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	20,582	-8.5	24,645	19.7	31,008	25.8	42,086	35.7	38,413	-8.7	36,499	-5.0	12.1
Total Integrated Circuit	15,949	-7.7	19,494	22.2	24,995	28.2	34,624	38.5	31,367	-9.4	29,530	-5.9	13.1
Bipolar Digital	1,154	-20.0	1,128	-2.3	1,216	7.8	1,068	-12.2	770	-27.9	530	-31.2	-14.4
MOS Memory	4,037	-4.5	5,570	38.0	7,246	30.1	12,168	67.9	8,487	-30.3	6,523	-23.1	10.1
Dynamic RAM	1,800	-7.6	2,687	49.3	4,012	49.3	8,490	111.6	5,057	-40.4	3,837	-24.1	16.3
Static RAM	1,029	-4.8	1,305	26.8	1,397	7.0	1,446	3.5	1,233	-14.7	911	-26.1	-2.4
Nonvolatile Memory	1,198	1.4	1,538	28.4	1,785	16.1	2,116	18.5	2,044	-3.4	1,612	-21.1	6.1
EPROM	314	-24.2	377	20.1	396	5.0	439	10.9	348	-20.7	169	-51.4	-11.7
EEPROM	79	0	88	11.4	122	38.6	143	17.2	167	16.8	151	-9.6	13.8
Flash Memory	11	0	34	183.3	120	252.9	361	200.8	786	117.7	637	-19.0	121.3
Mask ROM	309	0	1,039	31.0	1,147	10.4	1,173	2.3	743	-36.7	655	-11.8	-3.8
Other MOS Memory	10	-44.4	40	300.0	52	30.0	116	123.1	153	31.9	163	6.5	74.8
MOS Microcomponent	3,269	-8.7	3,987	22.0	5,603	40.5	7,826	39.7	8,797	12.4	9,336	6.1	23.4
Microprocessor	604	-1.9	835	38.2	1,247	49.3	1,686	35.2	2,334	38.4	2,676	14.7	34.7
Microcontroller	1,913	-12.2	2,284	19.4	2,964	29.8	4,140	39.7	3,930	-5.1	4,059	3.3	16.2
Microperipheral	650	-5.4	749	15.2	1,226	63.7	1,726	40.8	2,063	19.5	1,873	-9.2	23.6
Digital Signal Processor	102	5.2	119	16.7	166	39.5	274	65.1	470	71.5	728	54.9	48.2
MOS Digital Logic	3,837	-5.8	4,711	22.8	5,993	27.2	7,793	30.0	7,821	0.4	8,164	4.4	16.3
ASICs	1,749	-7.7	2,298	31.4	2,893	25.9	4,270	47.6	4,402	3.1	4,577	4.0	21.2
Custom IC	1,285	-3.8	1,477	14.9	1,308	-11.4	979	-25.2	839	-14.3	795	-5.2	-9.2
MOS Standard Logic	315	-7.1	386	22.5	443	14.8	519	17.2	449	-13.5	500	11.4	9.7
Total Other MOS Logic	488	-3.4	560	14.8	1,359	142.7	2,025	49.0	2,131	5.2	2,292	7.6	36.3
Analog-Monolithic	2,902	-6.2	3,278	13.0	4,048	23.5	4,745	17.2	4,577	-3.5	4,977	8.7	11.4
Total Discrete	3,077	-10.3	3,423	11.2	3,916	14.4	4,694	19.9	4,408	-6.1	4,244	-3.7	6.6
Total Optical Semiconductor	1,556	-12.9	1,728	11.1	2,097	21.4	2,768	32.0	2,638	-4.7	2,725	3.3	11.9

Source: Dataquest (May 1998)

Figure 5-1
Japanese Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 6
Europe, Middle East, and Africa Forecast by Product Family

Semiconductor Forecast by Region

The forecast calls for the Europe (including Middle East and Africa) market to grow at a 15 percent CAGR for 1997 through 2002. The market should grow by nearly 9 percent in 1998 to a total of $33 billion and reach $60 billion by 2002. The following assumptions guide the forecast with a focus on the near term.

The single most critical factor affecting the 1998 European semiconductor market will be DRAM average selling prices. A "side effect" of DRAM pricing and the excess capacity driving low DRAM pricing is the impact on the European pricing of other semiconductor products.

The prime application driver for Europe is the PC. For the near term, concern about "downside" forecast potential far outweighs upside potential. If European consumption of PCs is less than expected this year, MPU and DRAM revenue growth in the region would become lower than currently projected (about $0.5 billion).

A second major application driver in the European semiconductor market is mobile communications. The negative impact of the Asian crisis has been incorporated into the 1998 European semiconductor forecast. If the Asian crisis proves not as bad as expected, then the near-term European semiconductor forecast gains upside potential ($1.5 billion range).

Wireline communications mark a third key semiconductor application in Europe. France and Germany have started to "liberalize" their networks in 1998, which means increased semiconductor consumption. The European forecast is relatively pessimistic about the impact in this first year of new operators moving into the region. If the pace is faster than expected, then the European semiconductor forecast gains additional near-term upside potential.

Increasing Internet usage means growth in European data communication applications. The Internet now helps drive local European manufacture of switches, hubs, and routers by the major players. The current European semiconductor forecast is based on a conservative estimate of the regional production. The potential of faster growth means upside potential for the European semiconductor market.

By contrast, consumer digital applications create some downside forecast potential The current forecast expects strong growth in the set-top box market. Several pending European regulatory issues, however, might again delay European deployment of STB. This could lower European semiconductor consumption in this segment by about $100 million.

High-Growth Products

The products with the highest CAGRs in Europe over the five-year forecast period are as follows (with 2002 revenue in parentheses):

- DSPs—26 percent ($3.3 billion)
- ASICs—21 percent ($8.2 billion)
- SRAM—20 percent ($1.6 billion)
- Flash memory—17 percent ($1.4 billion)

Tables 6-1 and 6-2 provide details on the European semiconductor market.

Figure 6-1 shows the impact of the five-year forecast by product for the Europe, Middle East, and Africa market over the forecast period.

Table 6-1
Europe, Middle East, and Africa Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**30,046**	**5.9**	**32,627**	**8.6**	**38,425**	**17.8**	**46,927**	**22.1**	**56,152**	**19.7**	**59,335**	**5.7**	**14.6**
Total Integrated Circuit	**26,195**	**5.9**	**28,514**	**8.9**	**33,815**	**18.6**	**41,327**	**22.2**	**50,237**	**21.6**	**52,785**	**5.1**	**15.0**
Bipolar Digital	168	-31.7	141	-16.1	122	-13.5	97	-20.5	78	-19.6	56	-28.2	-19.7
MOS Memory	6,041	-12.7	6,092	0.8	7,718	26.7	10,756	39.4	14,831	37.9	12,127	-18.2	15.0
Dynamic RAM	4,032	-12.8	4,045	0.3	5,229	29.3	7,763	48.5	11,255	45.0	8,169	-27.4	15.2
Static RAM	646	-18.9	674	4.3	918	36.2	1,189	29.6	1,515	27.4	1,573	3.8	19.5
Nonvolatile Memory	1,216	-14.0	1,210	-0.5	1,390	14.9	1,604	15.4	1,839	14.6	2,140	16.4	12.0
EPROM	191	-32.3	128	-32.8	99	-23.0	80	-19.3	65	-17.9	55	-16.0	-22.0
EEPROM	302	-29.9	350	15.9	407	16.4	460	12.8	521	13.3	601	15.3	14.7
Flash Memory	11	4.5	690	2.9	837	21.4	1,016	21.5	1,207	18.7	1,439	19.2	16.5
Mask ROM	309	-11.7	42	-20.7	47	11.4	49	3.6	46	-5.2	46	-0.1	-2.8
Other MOS Memory	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
MOS Microcomponent	10,939	17.1	12,296	12.4	14,310	16.4	16,700	16.7	19,490	16.7	22,420	15.0	15.4
Microprocessor	5,901	16.6	6,702	13.6	7,760	15.8	8,930	15.1	10,200	14.2	11,600	13.7	14.5
Microcontroller	2,330	11.9	2,540	9.0	2,820	11.0	3,290	16.7	3,920	19.1	4,510	15.1	14.1
Microperipheral	1,661	8.0	1,755	5.6	2,070	18.0	2,360	14.0	2,720	15.3	3,030	11.4	12.8
Digital Signal Processor	1,047	59.1	1,300	24.2	1,660	27.7	2,120	27.7	2,650	25.0	3,280	23.8	25.7
MOS Digital Logic	4,159	5.2	4,634	11.4	5,515	19.0	6,714	21.7	7,889	17.5	9,531	20.8	18.0
ASICs	3,190	12.9	3,647	14.3	4,458	22.2	5,561	24.7	6,674	20.0	8,210	23.0	20.8
Custom IC	71	-47.8	49	-31.0	37	-25.0	26	-30.0	17	-35.0	10	-40.0	-32.4
MOS Standard Logic	466	11.0	487	4.4	512	5.2	532	4.0	538	1.0	548	2.0	3.3
Total Other MOS Logic	432	-24.5	451	4.5	509	12.7	595	16.9	660	11.0	763	15.5	12.0
Analog-Monolithic	4,888	17.8	5,350	9.5	6,150	15.0	7,060	14.8	7,950	12.6	8,650	8.8	12.1
Total Discrete	3,120	9.6	3,309	6.1	3,750	13.3	4,670	24.5	4,920	5.4	5,500	11.8	12.0
Total Optical Semiconductor	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	5.5	7.5

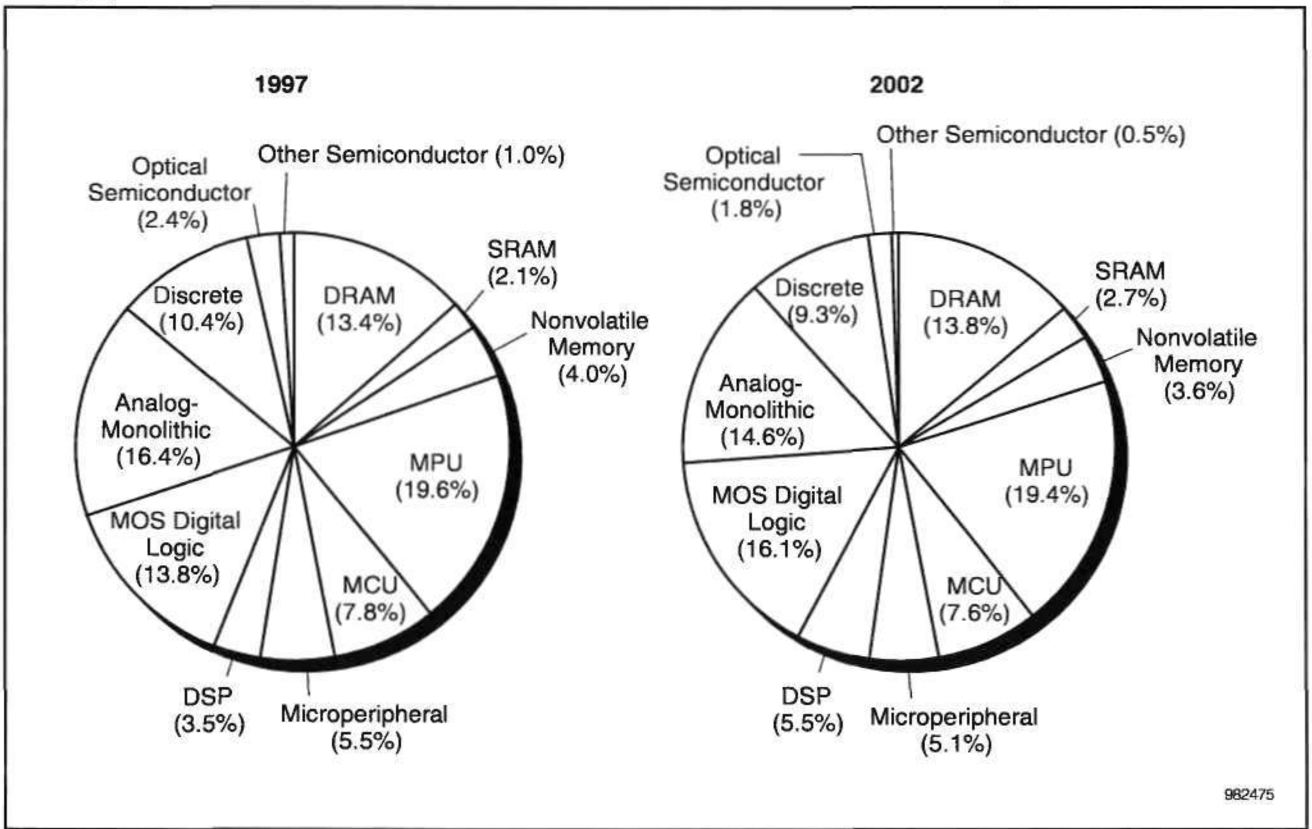
Source: Dataquest (May 1998)

Table 6-2
Europe, Middle East, and Africa Semiconductor Market, Revenue History, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**12,218**	**10.9**	**15,459**	**26.5**	**20,900**	**35.2**	**28,416**	**36.0**	**28,379**	**-0.1**	**30,046**	**5.9**	**19.7**
Total Integrated Circuit	**9,958**	**14.5**	**13,318**	**33.7**	**18,217**	**36.8**	**24,617**	**35.1**	**24,732**	**0.5**	**26,195**	**5.9**	**21.3**
Bipolar Digital	426	-12.3	390	-8.5	357	-8.5	306	-14.3	246	-19.6	168	-31.7	-17.0
MOS Memory	2,660	24.9	4,040	51.9	6,574	62.7	10,074	53.2	6,918	-31.3	6,041	-12.7	17.8
Dynamic RAM	1,557	29.2	2,671	71.5	4,927	84.5	7,887	60.1	4,622	-41.4	4,032	-12.8	21.0
Static RAM	458	21.5	525	14.6	620	18.1	921	48.5	797	-13.5	646	-18.9	7.1
Nonvolatile Memory	607	17.6	798	31.5	966	21.1	1,180	22.2	1,414	19.8	1,216	-14.0	14.9
EPROM	293	-3.3	323	10.2	350	8.4	333	-4.9	282	-15.3	191	-32.3	-8.2
EEPROM	170	0	214	25.9	300	40.2	274	-8.7	431	57.3	302	-29.9	12.2
Flash Memory	11	0	181	154.9	206	13.8	483	134.5	641	32.7	670	4.5	56.7
Mask ROM	309	0	80	9.6	110	37.5	90	-18.2	60	-33.3	53	-11.7	-6.2
Other MOS Memory	38	22.6	46	21.1	61	32.6	86	41.0	85	-1.2	147	72.9	31.1
MOS Microcomponent	2,723	30.9	4,037	48.3	5,408	34.0	7,000	29.4	9,341	33.4	10,939	17.1	32.1
Microprocessor	1,088	60.5	2,098	92.8	2,775	32.3	3,196	15.2	5,062	58.4	5,901	16.6	40.2
Microcontroller	934	17.8	1,106	18.4	1,431	29.4	2,030	41.9	2,083	2.6	2,330	11.9	20.1
Microperipheral	571	5.7	615	7.7	897	45.9	1,226	36.7	1,538	25.4	1,661	8.0	23.8
Digital Signal Processor	130	85.7	218	67.7	305	39.9	548	79.7	658	20.1	1,047	59.1	51.8
MOS Digital Logic	1,749	6.5	1,936	10.7	2,330	20.4	2,959	27.0	3,953	33.6	4,159	5.2	18.9
ASICs	965	9.8	1,114	15.4	1,369	22.9	1,867	36.4	2,825	51.3	3,190	12.9	27.0
Custom IC	171	1.8	140	-18.1	157	12.1	169	7.6	136	-19.5	71	-47.8	-16.1
MOS Standard Logic	248	18.1	311	25.4	419	34.7	483	15.3	420	-13.0	466	11.0	13.4
Total Other MOS Logic	366	-5.4	378	3.3	390	3.2	446	14.4	572	28.3	432	-24.5	3.4
Analog-Monolithic	2,249	3.0	2,736	21.7	3,370	23.2	4,134	22.7	4,148	0.3	4,888	17.8	16.8
Total Discrete	1,826	-0.1	1,769	-3.1	2,108	19.2	3,118	47.9	2,848	-8.7	3,120	9.6	11.3
Total Optical Semiconductor	434	-10.5	372	-14.3	575	54.6	681	18.4	799	17.3	731	-8.5	11.0

Source: Dataquest (May 1998)

Figure 6-1
Europe, Middle East, and Africa Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 7
Asia/Pacific Forecast by Product Family

Semiconductor Forecast by Region

Dataquest's forecast calls for the Asia/Pacific market to grow at a 16 percent CAGR from 1997 through 2002, which is lower than prior expectations. The market should grow by 10 percent this year to $36 billion and total $68 billion by 2002. The following assumptions guide the forecast.

The financial crisis in the Asia/Pacific region will have varying effects on semiconductor consumption in the region—many negative, but some positive. The effects also differ markedly on an Asian country-by-country basis. For example, growth has decelerated in countries such as Indonesia, Thailand, and the Philippines—but accelerated in China and Taiwan. Taiwan's electronics industry will fare well in this crisis, primarily because a larger percentage of components are supplied locally and because its financial sector is stronger than in the other countries.

All semiconductor vendors watch China. China's electronics equipment production will grow nearly 20 percent this year. China now stands as the largest semiconductor market in Asia/Pacific. China represents a huge consumer of communications and computer equipment, accounting for 25 percent of all personal computers purchased in Asia/Pacific. China's PC unit growth exceeds a 40 percent annual rate.

Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

The semiconductor market for PC applications represents more than one-third of all semiconductor consumption and will continue as the key role for semiconductor growth. The Asia/Pacific PC production will maintain steady growth over the forecast period. PC production in Asia/Pacific should total 23 million units in 1998. The PC production growth in this region will be attributed to Pentium II, DVD, 3-D graphics, Windows NT, and Windows 98. Although much of the production is shipped elsewhere in the world, PC unit consumption in the region should increase by more than 20 percent this year and reach 12 million units.

In the long term, Dataquest expects the region's most important semiconductor demand driver, the PC, to sustain solid growth in Asia/Pacific production, with a CAGR of 23 percent over the five-year forecast period. As a result, PC production in Asia/Pacific will exceed 45 million units in 2002. PC motherboard production will also continue in the region.

In terms of regional consumption, PC unit consumption in Asia/Pacific will grow at a 25 percent CAGR for the period and total 30 million units in 2002. PC revenue will grow at a slower, but still impressive, 20 percent CAGR.

Communications equipment will also generate outstanding Asia/Pacific semiconductor growth over the forecast period. This application will support the demand growth for ASICs, DSPs, application-specific standard products (ASSPs), and analog ICs. In the near term, most of the Asia/Pacific semiconductor market for communication in 1998 will be driven by mobile and wireless communications. Digital consumer products such as digital set-top-boxes will also begin to make a significant contribution to overall semiconductor demand.

The discrete device and optical semiconductor markets should be lower in 1998 than originally expected because of sluggish consumer equipment production, especially digital consumer applications. However, these markets will continue to achieve steady growth because of the post-1998 recovery in Asia/Pacific production of digital consumer equipment.

High-Growth Products

The following summarizes the CAGRs of the fastest-growing products in the region (with 2002 regional revenue shown in parentheses):

- DSPs—24 percent CAGR ($2.4 billion)
- SRAM—23 percent ($1.7 billion)
- Flash memory—21 percent ($1.6 billion)
- ASICs—22 percent ($4.4 billion)
- MPUs—20 percent ($11 billion)

Tables 7-1 and 7-2 provide details on the Asia/Pacific semiconductor market.

Figure 7-1 compares products in 1997 and 2002.

Table 7-1
Asia/Pacific Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	32,534	9.6	35,899	10.3	42,754	19.1	51,751	21.0	64,483	24.6	67,561	4.8	15.7
Total Integrated Circuit	27,804	8.4	30,803	10.8	37,160	20.6	45,388	22.1	57,622	27.0	59,880	3.9	16.6
Bipolar Digital	184	-22.0	170	-7.6	152	-10.6	128	-15.8	104	-18.8	84	-19.2	-14.5
MOS Memory	6,516	-18.7	6,576	0.9	8,100	23.2	10,436	28.8	16,566	58.7	12,527	-24.4	14.0
Dynamic RAM	4,642	-21.0	4,611	-0.7	5,690	23.4	7,393	29.9	13,030	76.3	8,500	-34.8	12.9
Static RAM	599	-35.3	626	4.4	893	42.7	1,294	44.9	1,520	17.5	1,680	10.5	22.9
Nonvolatile Memory	1,224	4.0	1,286	5.1	1,452	12.9	1,668	14.9	1,930	15.7	2,265	17.4	13.1
EPROM	205	-11.3	152	-25.9	128	-15.8	112	-12.5	100	-10.7	92	-8.0	-14.8
EEPROM	211	24.1	227	7.6	251	10.6	284	13.1	353	24.3	420	19.0	14.8
Flash Memory	11	23.3	731	21.2	882	20.7	1,073	21.7	1,287	19.9	1,565	21.6	21.0
Mask ROM	309	-28.6	176	-14.1	191	8.5	199	4.2	190	-4.5	188	-1.1	-1.7
Other MOS Memory	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0
MOS Microcomponent	10,885	24.5	12,651	16.2	15,360	21.4	18,260	18.9	21,710	18.9	25,170	15.9	18.3
Microprocessor	4,456	31.4	5,349	20.1	6,570	22.8	7,890	20.1	9,370	18.8	10,900	16.3	19.6
Microcontroller	2,313	12.8	2,630	13.7	3,060	16.3	3,710	21.2	4,430	19.4	5,080	14.7	17.0
Microperipheral	3,315	17.0	3,662	10.5	4,520	23.4	5,200	15.0	6,010	15.6	6,800	13.1	15.5
Digital Signal Processor	801	71.2	1,010	26.1	1,210	19.8	1,460	20.7	1,900	30.1	2,390	25.8	24.4
MOS Digital Logic	3,909	17.2	4,172	6.7	4,940	18.4	5,955	20.5	6,776	13.8	7,939	17.2	15.2
ASICs	1,662	4.7	1,893	13.9	2,380	25.7	3,015	26.7	3,625	20.2	4,443	22.6	21.7
Custom IC	425	-4.5	341	-19.8	256	-25.0	179	-30.0	116	-35.0	70	-40.0	-30.3
MOS Standard Logic	616	30.5	670	8.7	743	11.0	810	9.0	826	2.0	843	2.0	6.5
Total Other MOS Logic	1,206	45.1	1,269	5.2	1,561	23.0	1,951	25.0	2,208	13.2	2,584	17.0	16.5
Analog-Monolithic	6,310	24.1	7,234	14.6	8,608	19.0	10,610	23.3	12,467	17.5	14,160	13.6	17.5
Total Discrete	3,817	15.9	4,151	8.8	4,573	10.2	5,189	13.5	5,560	7.1	6,200	11.5	10.2
Total Optical Semiconductor	913	23.5	945	3.5	1,021	8.0	1,174	15.0	1,301	10.8	1,481	13.8	10.2

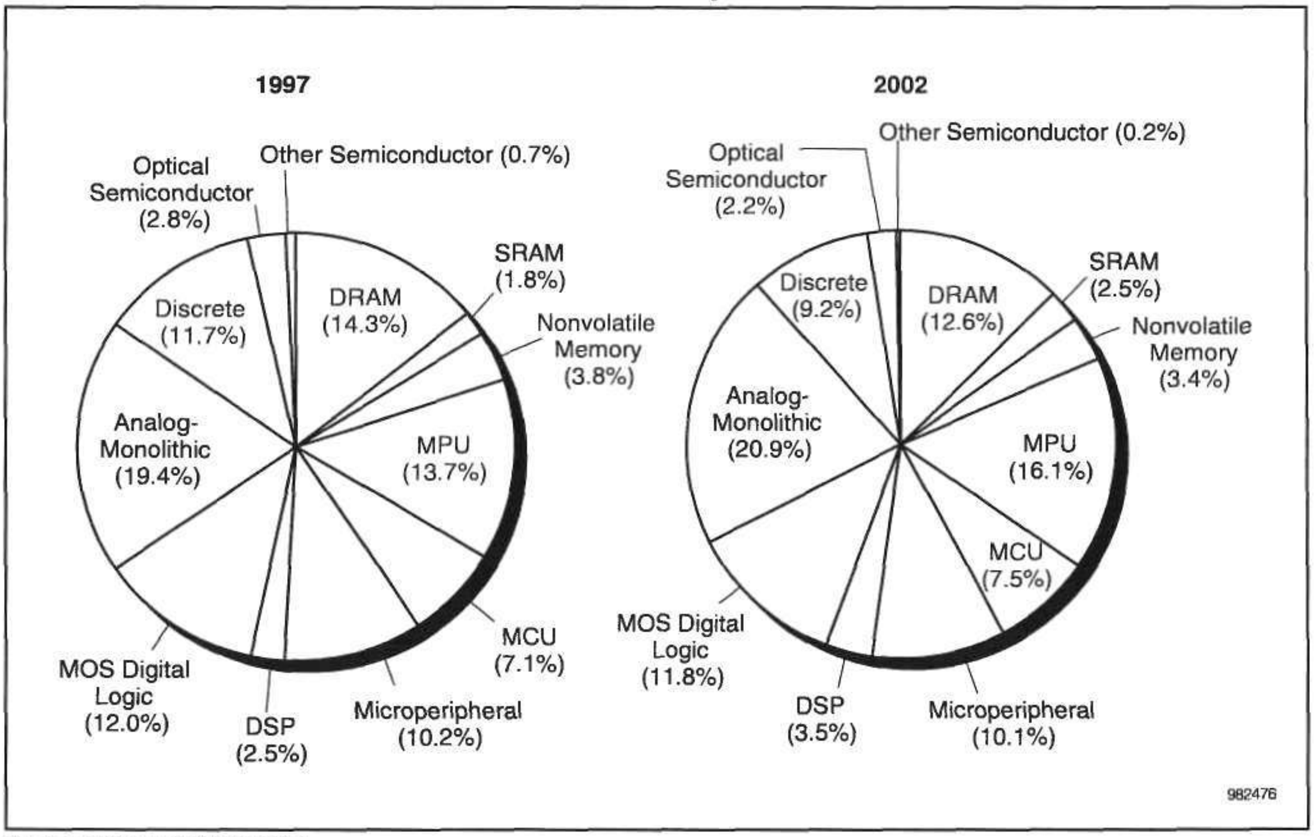
Source: Dataquest (May 1998)

Table 7-2
Asia/Pacific Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	12,034	30.9	17,486	45.3	22,832	30.6	32,465	42.2	29,686	-8.6	32,534	9.6	22.0
Total Integrated Circuit	10,110	32.9	14,988	48.2	19,785	32.0	28,252	42.8	25,653	-9.2	27,804	8.4	22.4
Bipolar Digital	381	3.3	388	1.8	372	-4.1	321	-13.7	236	-26.5	184	-22.0	-13.5
MOS Memory	2,904	47.1	4,911	69.1	7,216	46.9	12,565	74.1	8,017	-36.2	6,516	-18.7	17.5
Dynamic RAM	1,853	50.9	3,391	83.0	5,297	56.2	10,133	91.3	5,878	-42.0	4,642	-21.0	20.2
Static RAM	444	93.9	729	64.2	867	18.9	1,389	60.2	926	-33.3	599	-35.3	6.2
Nonvolatile Memory	587	17.4	766	30.5	1,022	33.4	992	-2.9	1,177	18.6	1,224	4.0	15.8
EPROM	229	12.8	271	18.3	288	6.3	246	-14.6	231	-6.1	205	-11.3	-2.2
EEPROM	38	0	81	113.2	91	12.3	86	-5.5	170	97.7	211	24.1	40.9
Flash Memory	11	0	49	345.5	84	71.4	246	192.9	489	98.8	603	23.3	122.7
Mask ROM	309	0	365	18.1	559	53.2	414	-25.9	287	-30.7	205	-28.6	-7.9
Other MOS Memory	20	17.6	25	25.0	30	20.0	51	70.0	36	-29.4	51	41.7	20.6
MOS Microcomponent	3,085	40.4	4,303	39.5	5,558	29.2	7,253	30.5	8,744	20.6	10,885	24.5	28.7
Microprocessor	1,135	33.4	1,527	34.5	1,969	28.9	2,587	31.4	3,392	31.1	4,456	31.4	31.5
Microcontroller	828	23.8	1,260	52.2	1,470	16.7	2,032	38.2	2,050	0.9	2,313	12.8	22.8
Microperipheral	1,094	64.8	1,453	32.8	1,981	36.3	2,382	20.2	2,834	19.0	3,315	17.0	24.8
Digital Signal Processor	28	115.4	63	125.0	138	119.0	252	82.6	468	85.7	801	71.2	95.6
MOS Digital Logic	1,277	14.6	2,015	57.8	2,363	17.3	3,114	31.8	3,336	7.1	3,909	17.2	25.1
ASICs	413	30.7	703	70.2	900	28.0	1,379	53.2	1,588	15.2	1,662	4.7	32.1
Custom IC	350	-17.5	459	31.1	544	18.5	466	-14.3	445	-4.5	425	-4.5	4.0
MOS Standard Logic	259	58.9	371	43.2	439	18.3	516	17.5	472	-8.5	616	30.5	18.9
Total Other MOS Logic	255	20.9	490	92.2	495	1.0	768	55.2	831	8.2	1,206	45.1	36.4
Analog-Monolithic	2,338	26.9	3,195	36.7	4,025	26.0	4,743	17.8	5,085	7.2	6,310	24.1	22.0
Total Discrete	1,649	19.0	2,080	26.1	2,527	21.5	3,475	37.5	3,294	-5.2	3,817	15.9	18.3
Total Optical Semiconductor	275	37.5	418	52.0	520	24.4	738	41.9	739	0.1	913	23.5	27.1

Source: Dataquest (May 1998)

Figure 7-1
Asia/Pacific Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 8
Exchange Rates

Dataquest does not forecast exchange rates. The following exchange rates are used for the forecast for 1998 through 2002:

- Japan—¥129.73 per U.S. dollar
- European Union—ECU 0.8994 per U.S. dollar

Table 8-1 shows exchange rates of the yen and ECU versus the U.S. dollar for the period from 1980 to 1997. The appreciation of the dollar against these local currencies is given in the last two columns.

Table 8-1
Exchange Rates

Year	Yen per U.S. Dollar	ECU per U.S. Dollar	U.S. Dollar Growth versus Yen (%)	U.S. Dollar Growth versus ECU (%)
1980	227.00	-	3.6	-
1981	221.00	-	-2.7	-
1982	248.00	-	12.2	-
1983	235.00	-	-5.2	-
1984	237.00	-	0.9	-
1985	238.00	-	0.4	-
1986	167.00	-	-29.8	-
1987	144.00	-	-13.8	-
1988	130.00	0.846	-9.7	-2.5
1989	138.00	0.908	6.2	7.3
1990	144.00	0.788	4.3	-13.2
1991	136.00	0.811	-5.6	2.9
1992	126.45	0.770	-7.0	-5.0
1993	111.20	0.858	-12.1	11.4
1994	101.81	0.840	-8.4	-2.1
1995	93.90	0.774	-7.8	-7.9
1996	108.81	0.800	15.9	3.2
1997	121.10	0.885	11.3	10.6

Source: Dataquest (May 1998)

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@dataquest.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Research Center
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

EUROPE

European Headquarters
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431 611
Facsimile: +44 1784 488 980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49 89 42 70 4-0
Facsimile: +49 89 42 70 4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153
Japan
Phone: 81-3-3481-3670
Facsimile: 81-3-3481-3644

ASIA/PACIFIC

Asia/Pacific Headquarters
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-2756-0389
Facsimile: 8862-2756-0663

Dataquest Singapore
6 Temasek Boulevard, #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: 65-333-6773
Facsimile: 65-333-6768

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Dataquest Australia
80 Alfred Street
Milsons Point NSW 2061
Australia
Phone: 61-2-9941-4860
Facsimile: 61-2-9941-4868

Dataquest
A Gartner Group Company

Dataquest
A Gartner Group Company

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

November 9, 1998

Errata

Tables 2-5, 2-6, 2-13, and 2-14 in Dataquest's *North American Semiconductor Prices, Fourth Quarter 1998* (SSPS-WW-MS-9804) have been revised. Please insert the enclosed corrected tables in your document and place this letter in the pocket of the binder.

Dataquest regrets the error and apologizes for any inconvenience. For further information, contact Senior Industry Analyst Evelyn Cronin at (408) 468-8075 or at evelyn.cronin@dataquest.com.

Table 2-5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
4Mbx1 DRAM 70ns SOJ 5V	2.17	2.09	1.90	1.95	2.03	2.00	2.01	2.05	2.07	2.03	3-8
1Mbx4 DRAM 60ns SOJ 5V FPM	1.80	1.55	1.44	1.44	1.56	1.40	1.45	1.60	1.65	1.53	3-8
1Mbx4 DRAM 60ns SOJ 5V EDO	1.80	1.55	1.44	1.44	1.56	1.39	1.44	1.60	1.65	1.52	3-8
256Kx16 DRAM 70ns SOJ 5V	2.64	2.39	2.20	2.20	2.36	2.20	2.22	2.30	2.36	2.27	3-8
4Mbx4 DRAM 60ns SOJ 5V FPM	3.50	2.60	2.20	2.45	2.69	2.50	2.55	2.60	2.70	2.59	3-7
4Mbx4 DRAM 60ns SOJ 5V EDO	3.50	2.55	1.95	2.18	2.55	2.18	2.18	2.30	2.30	2.24	3-7
1Mbx16 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.00	2.30	2.6	2.40	2.47	2.55	2.60	2.51	3-7
1Mbx16 DRAM 60ns TSOP 5V EDO	3.50	2.55	1.97	2.17	2.55	2.17	2.20	2.30	2.30	2.24	3-7
1Mbx16 3.3V SDRAM	4.97	3.35	2.85	2.70	3.47	2.65	2.60	2.70	2.90	2.71	3-7
2Mbx8 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.00	2.32	2.61	2.41	2.55	2.60	2.70	2.57	3-7
2Mbx8 DRAM SDRAM 3.3V	4.97	3.35	2.71	2.65	3.42	2.62	2.60	2.70	2.90	2.71	3-7
16Mbx4 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.52	13.12	8.50	8.46	8.40	8.35	8.43	2-6
16Mbx4 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	8.39	13.09	8.35	8.29	8.23	8.21	8.27	2-6
8Mbx8 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.52	13.12	8.60	8.50	8.40	8.35	8.46	2-6
8Mbx8 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	8.40	13.09	8.35	8.29	8.23	8.21	8.27	2-6
4Mbx16 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.51	13.12	8.60	8.50	8.40	8.35	8.46	2-6
4Mbx16 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	8.39	13.09	8.34	8.28	8.22	8.21	8.26	2-6
1Mbx32 SIMM 60ns 5V FPM	10.23	6.70	5.35	6.30	7.15	6.50	6.64	6.80	6.90	6.71	2-6
1Mbx36 SIMM 60ns 5V FPM	12.69	9.80	7.41	8.95	9.71	9.31	9.66	10.01	10.19	9.79	2-6
2Mbx32 SIMM 60ns 5V FPM	17.32	11.92	9.38	11.19	12.45	11.59	11.87	12.19	12.39	12.01	2-6
2Mbx36 SIMM 60ns 5V FPM	22.49	14.52	11.49	15.77	16.07	16.19	16.75	17.41	19.85	17.55	2-6
4Mbx32 SIMM 60ns 5V FPM	32.57	23.17	17.70	20.42	23.46	21.22	21.78	22.42	22.82	22.06	2-6
4Mbx36 SIMM 60ns 5V FPM	40.57	28.37	22.17	23.77	28.72	24.88	25.12	26.47	26.98	25.86	2-6
8Mbx32 SIMM 60ns 5V FPM	60.90	45.77	34.00	39.17	44.96	40.77	41.89	43.17	43.97	42.45	2-6
8Mbx36 SIMM 60ns 5V FPM	75.69	56.17	41.15	45.95	54.74	47.55	48.67	50.98	51.66	49.72	2-6
1Mbx32 SIMM 60ns 5V EDO	9.71	6.60	5.21	6.04	6.89	6.04	6.10	6.30	6.30	6.19	2-6
1Mbx36 SIMM 60ns 5V EDO	12.51	9.70	6.81	8.35	9.34	8.20	8.22	9.10	9.12	8.66	2-6
2Mbx32 SIMM 60ns 5V EDO	17.12	11.72	9.23	10.67	12.19	10.67	10.79	11.19	11.19	10.96	2-6

Table 2-5 (Continued)
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
2Mbx36 SIMM 60ns 5V EDO	22.31	14.27	11.23	14.65	15.62	14.39	14.40	15.66	15.68	15.03	2-6
4Mbx32 SIMM 60ns 5V EDO	32.07	22.77	17.72	19.38	22.98	19.38	19.62	20.42	20.42	19.96	2-6
4Mbx36 SIMM 60ns 5V EDO	40.11	27.87	21.55	23.15	28.17	23.15	23.39	24.19	24.19	23.73	2-6
8Mbx32 SIMM 60ns 5V EDO	60.71	44.97	33.62	37.09	44.10	37.09	37.57	39.17	39.17	38.25	2-6
8Mbx36 SIMM 60ns 5V EDO	75.21	55.17	40.70	43.78	53.72	43.78	43.78	47.98	47.98	45.88	2-6
2Mbx64 60ns 3.3V EDO	52.65	24.97	19.37	18.99	29.00	19.17	18.97	18.77	18.67	18.90	2-6
4Mbx64 60ns 3.3V EDO	101.10	49.37	36.77	36.01	55.81	36.37	35.97	35.57	35.37	35.82	2-6
8Mbx64 60ns 3.3V EDO	NA	NA	72.37	70.85	71.61	71.57	70.77	69.97	69.57	70.47	2-6
2Mbx64 3.3V SDRAM	52.75	25.17	19.07	18.75	28.94	18.65	18.53	18.41	18.39	18.50	2-6
4Mbx64 3.3V SDRAM	101.09	49.77	36.17	35.53	55.64	35.33	35.09	34.85	34.81	35.02	2-6
8Mbx64 3.3V SDRAM	NA	NA	70.50	69.17	69.84	68.69	68.21	67.73	67.65	68.07	2-6
256Kx32 SGRAM 66 MHz 3.3V	5.17	4.75	4.00	3.40	4.33	3.30	3.20	3.10	3.05	3.16	2-8
512Kx32 SGRAM 66 MHz 3.3V	11.44	9.75	8.00	7.50	9.17	7.25	7.10	6.85	6.20	6.85	2-8

NA = Not available
*Contract volume is at least 100,000 per order.
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 (November 1998)

Table 2-6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998	1999	2000	2001	2002
4Mbx1 DRAM 70ns SOJ 5V	2.03	2.03	2.10	2.15	2.30
1Mbx4 DRAM 60ns SOJ 5V FPM	1.56	1.53	1.95	2.15	2.30
1Mbx4 DRAM 60ns SOJ 5V EDO	1.56	1.52	1.95	2.15	2.30
256Kx16 DRAM 70ns SOJ 5V	2.36	2.27	2.65	2.90	3.20
4Mbx4 DRAM 60ns SOJ 5V FPM	2.69	2.59	2.85	2.90	3.10
4Mbx4 DRAM 60ns SOJ 5V EDO	2.55	2.24	2.55	2.90	3.10
1Mbx16 DRAM 60ns TSOP 5V FPM	2.6	2.51	2.69	2.92	3.15
1Mbx16 DRAM 60ns TSOP 5V EDO	2.55	2.24	2.56	2.90	3.10
1Mbx16 3.3V SDRAM	3.47	2.71	3.00	3.20	3.35
2Mbx8 DRAM 60ns TSOP 5V FPM	2.61	2.57	2.87	2.95	3.15
2Mbx8 DRAM SDRAM 3.3V	3.42	2.71	3.05	3.22	3.40
16Mbx4 DRAM 60ns SOJ 3.3V EDO	13.12	8.43	8.25	8.09	8.00
16Mbx4 DRAM SOJ 3.3V SDRAM	13.09	8.27	8.05	7.90	7.80
8Mbx8 DRAM 60ns SOJ 3.3V EDO	13.12	8.46	8.25	8.09	8.00
8Mbx8 DRAM SOJ 3.3V SDRAM	13.09	8.27	8.05	7.90	7.80
4Mbx16 DRAM 60ns SOJ 3.3V EDO	13.12	8.46	8.25	8.09	8.00
4Mbx16 DRAM SOJ 3.3V SDRAM	13.09	8.26	8.05	7.90	7.80
1Mbx32 SIMM 60ns 5V FPM	7.15	6.71	7.20	7.80	8.10
1Mbx36 SIMM 60ns 5V FPM	9.71	9.79	10.88	11.24	12.01
2Mbx32 SIMM 60ns 5V FPM	12.45	12.01	13.97	14.55	14.87
2Mbx36 SIMM 60ns 5V FPM	16.07	17.55	20.33	20.99	21.79
4Mbx32 SIMM 60ns 5V FPM	23.46	22.06	23.12	24.55	25.15
4Mbx36 SIMM 60ns 5V FPM	28.72	25.86	28.19	29.64	31.29
8Mbx32 SIMM 60ns 5V FPM	44.96	42.45	44.55	48.61	49.94
8Mbx36 SIMM 60ns 5V FPM	54.74	49.72	53.33	58.12	59.66
1Mbx32 SIMM 60ns 5V EDO	6.89	6.19	7.05	7.75	8.00
1Mbx36 SIMM 60ns 5V EDO	9.34	8.66	10.65	11.12	11.85
2Mbx32 SIMM 60ns 5V EDO	12.19	10.96	12.95	13.66	14.41
2Mbx36 SIMM 60ns 5V EDO	15.62	15.03	18.17	19.82	20.63
4Mbx32 SIMM 60ns 5V EDO	22.98	19.96	22.95	24.42	26.73
4Mbx36 SIMM 60ns 5V EDO	28.17	23.73	27.77	29.52	30.99
8Mbx32 SIMM 60ns 5V EDO	44.10	38.25	42.88	45.14	47.74
8Mbx36 SIMM 60ns 5V EDO	53.72	45.88	51.99	56.16	57.67
2Mbx64 60ns 3.3V EDO	29.00	18.90	18.10	17.95	17.85
4Mbx64 60ns 3.3V EDO	55.81	35.82	34.88	34.21	33.89
8Mbx64 60ns 3.3V EDO	71.61	70.47	68.13	67.77	66.35
2Mbx64 3.3V SDRAM	28.94	18.50	18.05	17.90	17.77
4Mbx64 3.3V SDRAM	55.64	35.02	34.18	33.68	33.12
8Mbx64 3.3V SDRAM	69.84	68.07	67.05	66.59	66.10
256Kx32 SGRAM 66 MHz 3.3V	4.33	3.16	3.00	2.94	2.90
512Kx32 SGRAM 66 MHz 3.3V	9.17	6.85	5.94	5.80	5.75

*Contract volume is at least 100,000 per order.
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 (November 1998)

Table 2-7
Estimated Static RAM Price Trends—North American Bookings (Volume: Slow SRAM—50,000 per Year; Fast SRAM—20,000 per Year; Package: PDIP; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
16Kx4 35ns	2.07	2.09	2.09	2.11	2.09	2.11	2.11	2.13	2.13	2.12	2-6
8Kx8 25ns	0.94	0.92	0.91	0.91	0.92	0.86	0.86	0.86	0.86	0.86	2-6
8Kx8 100-120ns	1.12	1.05	0.98	0.98	1.03	0.94	0.94	0.94	0.94	0.94	2-6
64Kx4 10ns	5.03	4.85	4.76	4.73	4.84	4.70	4.63	4.59	4.55	4.62	2-4
64Kx4 25ns	1.60	1.60	1.55	1.55	1.58	1.53	1.53	1.51	1.51	1.52	2-4
32Kx8 12ns	1.25	1.16	0.98	0.97	1.09	0.97	0.97	1.00	1.04	0.98	2-4
32Kx9 12ns Burst	3.27	3.25	3.23	3.21	3.24	3.19	3.19	3.17	3.17	3.18	2-4
32Kx8 15ns 5V	1.10	1.05	0.95	0.94	1.01	0.94	0.97	1.01	1.05	0.99	2-4
32Kx8 15ns 3.3V	1.02	0.99	0.95	0.94	0.97	0.94	0.97	1.03	1.08	1.07	2-4
32Kx8 25ns	1.12	1.00	0.97	0.96	1.01	0.96	0.97	1.03	1.08	1.00	2-4
32Kx8 70-100ns SOJ	1.21	1.11	1.03	1.00	1.09	1.00	1.00	1.04	1.11	1.02	2-4
64Kx8 12ns Burst	13.35	12.20	11.45	11.23	12.06	11.21	11.01	10.89	10.65	10.94	2-4
256Kx4 20ns	3.31	3.04	2.97	2.93	3.06	2.89	2.85	2.82	2.77	2.89	2-8
256Kx4 12ns 3.3V	4.19	4.11	3.82	3.69	3.95	3.41	3.25	3.13	2.91	3.18	3-8
256Kx8 12ns 3.3V	4.02	3.69	3.51	3.29	3.63	3.17	3.09	3.03	2.82	3.03	3-8
128Kx8 15ns	3.32	3.01	2.69	2.55	2.89	2.44	2.40	2.31	2.25	2.42	3-6
128Kx8 20ns	3.16	2.83	2.55	2.45	2.75	2.38	2.24	2.20	2.19	2.51	3-6
128Kx8 25ns	3.16	2.83	2.55	2.45	2.75	2.38	2.24	2.20	2.19	2.51	3-6
128Kx8 70-100ns SOJ	2.79	2.50	2.37	2.34	2.50	2.33	2.28	2.24	2.20	2.30	3-6
32Kx32 15ns 3.3V PQFP	3.18	3.13	3.00	2.93	3.06	2.90	2.90	2.90	2.90	3.06	2-6
32Kx32 8ns 3.3V PBSynch	2.76	2.70	2.55	2.40	2.60	2.35	2.30	2.30	2.30	2.66	2-6
64Kx32 8ns 3.3V PBSynch	5.17	5.05	4.80	4.55	4.89	4.40	4.30	4.25	4.20	4.44	2-6
64Kx32 5ns 3.3V PBSynch	7.00	6.60	6.18	5.69	6.37	5.55	5.36	5.05	4.85	5.29	2-6
256Kx16 70-100ns	13.63	13.00	12.43	12.19	12.81	12.02	11.92	11.65	11.31	11.92	3-6
256Kx16 25ns	16.79	16.32	15.03	14.38	15.63	14.22	14.00	13.55	13.13	13.95	3-6
512Kx8 70ns	13.06	12.56	11.91	11.80	12.33	11.61	11.24	11.04	10.95	11.27	3-6
512Kx8 25ns	16.91	15.98	14.70	14.02	15.40	13.69	13.08	12.88	12.45	13.19	3-6

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 1998)

Table 2-11
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
32Kx8 EPROM	1.26	1.23	1.22	1.21	1.23	1.21	1.19	1.18	1.15	1.18	2-3
64Kx8 EPROM	1.31	1.29	1.27	1.26	1.28	1.24	1.22	1.18	1.16	1.20	2-3
128Kx8 EPROM	1.65	1.60	1.56	1.56	1.59	1.50	1.50	1.48	1.48	1.49	2-3
256Kx8 EPROM	2.68	2.60	2.52	2.47	2.57	2.41	2.41	2.36	2.36	2.39	2-3
128Kx16 EPROM	3.08	3.09	2.87	2.77	2.95	2.75	2.75	2.68	2.68	2.72	2-3
512Kx8 EPROM	4.06	3.85	3.15	2.82	3.47	2.65	2.65	2.52	2.50	2.58	2-3
256Kx16 EPROM	5.33	4.55	3.45	2.98	4.08	2.88	2.75	2.67	2.67	2.74	2-3
1Mbx8 EPROM	7.38	7.14	6.75	6.60	6.97	6.24	6.01	5.89	5.75	5.97	2-3
512Kx16 EPROM	8.25	7.35	7.05	6.75	7.35	6.40	6.14	6.00	5.80	6.09	2-3

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 1998)

Table 2-12
Estimated Long-Range EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998	1999	2000	2001	2002
32Kx8 EPROM	1.23	1.18	1.18	1.24	1.27
64Kx8 EPROM	1.28	1.20	1.20	1.26	1.30
128Kx8 EPROM	1.59	1.49	1.39	1.46	1.59
256Kx8 EPROM	2.57	2.39	2.31	2.19	2.08
128Kx16 EPROM	2.95	2.72	2.36	2.24	2.13
512Kx8 EPROM	3.47	2.58	2.45	2.33	2.21
256Kx16 EPROM	4.08	2.74	2.52	2.39	2.27
1Mbx8 EPROM	6.97	5.97	4.10	3.90	3.70
512Kx16 EPROM	7.35	6.09	4.75	4.51	4.29

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 1998)

Table 2-13
Estimated Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
64Kx8 PDIP/PLCC	2.18	2.15	2.05	2.01	2.10	1.99	1.99	1.98	1.98	1.98	5
64Kx8 TSOP	2.12	2.09	2.09	2.08	2.10	2.05	2.00	1.95	1.95	1.99	5
128Kx8 PDIP/PLCC	2.14	2.16	2.07	2.03	2.10	2.03	1.98	1.97	1.95	1.98	3
128Kx8 TSOP 12V	2.16	2.18	2.14	2.12	2.15	2.11	2.09	2.09	2.08	2.09	4
128Kx8 TSOP 5V	2.50	2.40	2.24	2.18	2.33	2.09	2.00	1.89	1.80	1.95	4
256Kx8 TSOP 12V	4.13	3.33	3.06	2.96	3.37	2.84	2.77	2.71	2.66	2.74	4-6
256Kx8 TSOP 5V	3.70	3.11	2.97	2.87	3.16	2.79	2.72	2.68	2.61	2.74	4-6
256Kx8 PDIP/PLCC	3.65	3.05	2.95	2.84	3.12	2.75	2.70	2.66	2.59	2.75	4-6
512Kx8 PDIP/PLCC	3.80	3.50	3.25	3.16	3.43	3.02	2.93	2.85	2.78	2.90	4
512Kx8 TSOP 12V	4.52	4.08	3.65	3.55	3.95	3.41	3.31	3.22	3.13	3.27	4
512Kx8 TSOP 5V	4.06	3.55	3.43	3.26	3.57	3.16	3.05	2.97	2.90	3.02	4
512Kx8 SSOP 3V	3.75	3.49	3.41	3.26	3.48	3.16	3.05	2.97	2.90	3.02	4
1Mbx8 TSOP 12V	7.02	6.33	5.47	5.21	6.01	4.97	4.76	4.56	4.36	4.66	3-4
1Mbx8 TSOP 5V	6.97	5.95	5.24	4.99	5.79	4.75	4.56	4.38	4.20	4.47	3-4
1Mbx8 TSOP 3V	6.94	5.86	5.10	4.91	5.70	4.68	4.50	4.20	4.04	4.36	3-4
2Mbx8 TSOP 12V	13.09	11.75	10.83	10.40	11.52	9.82	9.27	8.86	8.42	9.09	3-4
2Mbx8 TSOP 5V	12.12	10.55	10.09	9.39	10.54	8.73	8.22	7.87	7.57	8.10	3-4
2Mbx8 TSOP 3V	12.14	10.35	10.03	9.28	10.45	8.66	8.20	7.86	7.57	8.62	3-4
1Mbx16 TSOP 12V	15.37	13.35	11.88	11.20	12.95	10.48	9.85	9.28	8.86	9.62	3-4
1Mbx16 TSOP 5V	16.79	14.04	12.06	11.27	13.54	10.24	9.66	9.08	8.60	9.39	3-4
1Mbx16 TSOP 3V	17.01	12.92	10.78	10.24	12.74	9.65	9.18	8.69	8.40	9.02	3-4

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 price guidelines.
Source: Dataquest (November 1998)

Table 2-14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998	1999	2000	2001	2002
64Kx8 PDIP/PLCC	2.10	1.98	1.95	2.00	2.05
64Kx8 TSOP	2.10	1.99	1.95	2.00	2.05
128Kx8 PDIP/PLCC	2.10	1.98	1.93	1.93	1.98
128Kx8 TSOP 12V	2.15	2.09	2.06	2.06	2.15
128Kx8 TSOP 5V	2.33	1.95	1.94	1.94	2.10
256Kx8 TSOP 12V	3.37	2.74	2.60	2.54	2.64
256Kx8 TSOP 5V	3.16	2.74	2.54	2.48	2.55
256Kx8 PDIP/PLCC	3.12	2.75	2.51	2.43	2.50
512Kx8 PDIP/PLCC	3.43	2.90	2.65	2.59	2.64
512Kx8 TSOP 12V	3.95	3.27	2.92	2.79	2.94
512Kx8 TSOP 5V	3.57	3.02	2.79	2.64	2.77
512Kx8 SSOP 3V	3.48	3.02	2.79	2.64	2.77
1Mbx8 TSOP 12V	6.01	4.66	4.14	3.97	3.86
1Mbx8 TSOP 5V	5.79	4.47	4.04	3.82	3.69
1Mbx8 TSOP 3V	5.70	4.36	3.91	3.73	3.58
2Mbx8 TSOP 12V	11.52	9.09	8.10	7.64	7.05
2Mbx8 TSOP 5V	10.54	8.10	8.00	7.46	6.90
2Mbx8 TSOP 3V	10.45	8.62	7.89	7.40	6.86
1Mbx16 TSOP 12V	12.95	9.62	8.09	7.66	7.04
1Mbx16 TSOP 5V	13.54	9.39	8.00	7.55	6.94
1Mbx16 TSOP 3V	12.74	9.02	7.90	7.42	6.85

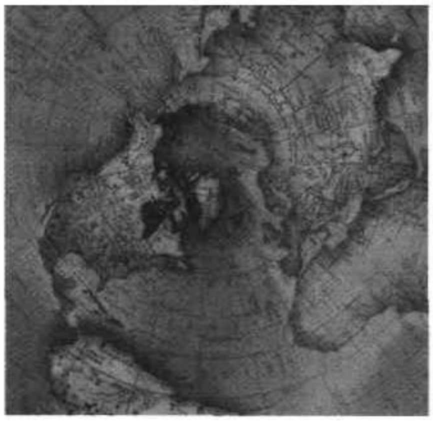
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (November 1998)

Table 2-15
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	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS										Production:
0.8 Micron	20.00	19.00	19.00	16.00	15.00	14.00	14.00	13.00	12.00	4-10
0.6 Micron	22.00	21.00	20.00	15.00	14.00	13.00	16.00	15.00	13.00	4-10
0.5 Micron	25.00	24.00	23.00	21.00	20.00	20.00	18.00	17.00	15.00	4-10
0.35 Micron	34.00	34.00	34.00	28.00	26.00	26.00	20.00	19.00	17.00	4-10
										Prototype:
NRE CMOS Average Charge ($K)	43.00	43.00	43.00	53.00	51.00	51.00	73.00	72.00	72.00	1-4

Gate Count	100-299.99K Gates			300K or More Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS							Production:
0.8 Micron	22.00	21.00	19.00	NR	NR	NR	4-10
0.6 Micron	22.00	21.00	19.00	30.00	29.00	29.00	4-10
0.5 Micron	24.00	22.00	20.00	32.00	32.00	32.00	4-10
0.35 Micron	31.00	30.00	29.00	38.00	38.00	38.00	4-10
							Prototype:
NRE CMOS Average Charge ($K)	105.00	103.00	103.00	125.00	120.00	120.00	1-4

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors. Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (September 1998)



Dataquest

North American Semiconductor Prices, Fourth Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9804
Publication Date: October 12, 1998
Filing: Market Statistics

North American Semiconductor Prices, Fourth Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9804
Publication Date: October 12, 1998
Filing: Market Statistics

Table of Contents

List of Tables

Chapter 1

North American Semiconductor Prices, Fourth Quarter 1998

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 (SSPS) 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 SSPS clients that use the SSPS online service through CompuServe, the prices presented here correlate with the quarterly and long-range price tables dated September 1998 in the SSPS online service. Clients who want to access the information on the World Wide Web can pay extra for a Dataquest on GartnerGroup Interactive subscription, which allows users to access all their deliverables at their desktops. 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.

Chapter 2
Market Statistics Tables

Tables 2-1 through 2-16 show statistics on North American semiconductor prices.

Table 2-1
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
74LS TTL											
74LS00	0.13	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	3-8
74LS74	0.16	0.15	0.14	0.14	0.15	0.13	0.13	0.12	0.12	0.13	3-8
74LS138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74LS244	0.22	0.21	0.20	0.20	0.21	0.19	0.19	0.18	0.18	0.19	3-8
74AC TTL											
74AC00	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	3-8
74AC74	0.18	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	3-8
74AC138	0.28	0.28	0.26	0.26	0.27	0.25	0.25	0.25	0.25	0.25	3-8
74AC244	0.36	0.36	0.36	0.36	0.36	0.33	0.33	0.33	0.33	0.33	3-8
74F TTL											
74F00	0.12	0.11	0.10	0.10	0.11	0.09	0.09	0.08	0.08	0.09	3-8
74F74	0.14	0.13	0.12	0.12	0.13	0.11	0.11	0.10	0.10	0.11	3-8
74F138	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	3-8
74F244	0.21	0.20	0.19	0.19	0.20	0.19	0.19	0.18	0.18	0.19	3-8
74HC CMOS											
74HC00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	3-8
74HC74	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	3-8
74HC138	0.17	0.16	0.15	0.15	0.16	0.14	0.14	0.14	0.14	0.14	3-8
74HC244	0.21	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.19	0.19	3-8
74ALS TTL											
74ALS00	0.14	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	3-8
74ALS74	0.15	0.15	0.14	0.14	0.15	0.13	0.13	0.13	0.13	0.13	3-8
74ALS138	0.20	0.20	0.20	0.20	0.20	0.19	0.19	0.18	0.18	0.19	3-8
74ALS244	0.27	0.25	0.25	0.24	0.25	0.23	0.23	0.22	0.22	0.23	3-8
74AS TTL											
74AS00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS74	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS138	0.40	0.39	0.39	0.39	0.39	0.38	0.38	0.37	0.37	0.38	3-8
74AS244	0.61	0.61	0.61	0.61	0.61	0.57	0.57	0.55	0.55	0.56	3-8

Table 2-1 (Continued)
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
74BC*											
74BC00	0.19	0.19	0.18	0.18	0.19	0.17	0.17	0.17	0.17	0.17	3-8
74BC244	0.48	0.48	0.46	0.46	0.47	0.44	0.44	0.40	0.40	0.42	3-8
74BC373	0.50	0.50	0.46	0.46	0.48	0.44	0.44	0.42	0.42	0.43	3-8
74ACT244	0.38	0.38	0.34	0.34	0.36	0.31	0.31	0.27	0.27	0.29	3-8
74ACT245	0.40	0.35	0.33	0.33	0.35	0.31	0.31	0.27	0.27	0.29	3-8
74ABT244	0.49	0.45	0.42	0.42	0.44	0.36	0.36	0.34	0.34	0.35	3-8
74ABT245	0.52	0.46	0.42	0.42	0.46	0.36	0.36	0.34	0.34	0.35	3-8

*Pricing for 74BC excludes 74ABT and 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (September 1998)

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

	1998	1999	2000	2001	2002
74LS TTL					
74LS00	0.13	0.12	0.12	0.13	0.13
74LS74	0.15	0.13	0.12	0.13	0.13
74LS138	0.17	0.17	0.18	0.19	0.19
74LS244	0.21	0.19	0.18	0.18	0.20
74AC TTL					
74AC00	0.15	0.14	0.14	0.14	0.16
74AC74	0.17	0.16	0.15	0.16	0.18
74AC138	0.27	0.25	0.24	0.26	0.26
74AC244	0.36	0.33	0.31	0.30	0.32
74F TTL					
74F00	0.11	0.09	0.08	0.08	0.10
74F74	0.13	0.11	0.09	0.09	0.10
74F138	0.16	0.15	0.15	0.15	0.16
74F244	0.20	0.19	0.18	0.18	0.19
74HC CMOS					
74HC00	0.11	0.11	0.11	0.11	0.13
74HC74	0.14	0.13	0.13	0.13	0.15
74HC138	0.16	0.14	0.14	0.14	0.16
74HC244	0.20	0.19	0.18	0.18	0.20
74ALS TTL					
74ALS00	0.14	0.13	0.12	0.12	0.14
74ALS74	0.15	0.13	0.12	0.12	0.14
74ALS138	0.20	0.19	0.18	0.17	0.19
74ALS244	0.25	0.23	0.20	0.20	0.22
74AS TTL					
74AS00	0.19	0.19	0.19	0.21	0.21
74AS74	0.19	0.19	0.19	0.21	0.21
74AS138	0.39	0.38	0.35	0.32	0.31
74AS244	0.61	0.56	0.52	0.50	0.49
74BC*					
74BC00	0.19	0.17	0.17	0.18	0.18
74BC244	0.47	0.42	0.37	0.35	0.34
74BC373	0.48	0.43	0.38	0.35	0.34
74ACT244	0.36	0.29	0.26	0.26	0.26
74ACT245	0.35	0.29	0.25	0.23	0.22
74ABT244	0.44	0.35	0.31	0.29	0.27
74ABT245	0.46	0.35	0.31	0.29	0.27

*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 1998)

Table 2-3
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
68EC020-25 PQFP	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	2-4
68040-25	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
68LC040-25 CQFP 184	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
Celeron 300A (Mendocino)	NA	NA	140.00	120.00	130.00	95.00	85.00	75.00	75.00	82.50	2-4
Celeron 333 (Mendocino)	NA	NA	190.00	140.00	165.00	115.00	95.00	85.00	75.00	92.50	2-4
Celeron 350 (Mendocino)	NA	NA	NA	NA	NA	190.00	145.00	115.00	95.00	136.25	2-4
Celeron 400 (Mendocino)	NA	NA	NA	NA	NA	NA	190.00	150.00	125.00	155.00	2-4
Pentium MMX 200 MHz 2.8V PGA	110.00	100.00	90.00	85.00	96.25	80.00	80.00	80.00	80.00	80.00	2-4
Pentium MMX 233 MHz 2.8V PGA	175.00	125.00	100.00	90.00	122.50	85.00	85.00	85.00	85.00	85.00	2-4
Pentium II 233 MHz 512KB Cache	260.00	190.00	190.00	190.00	207.50	190.00	190.00	190.00	190.00	190.00	2-4
Pentium II 266 MHz 512KB Cache	350.00	250.00	180.00	180.00	240.00	180.00	180.00	180.00	180.00	180.00	2-4
Pentium II 300 MHz 512KB Cache	500.00	350.00	300.00	200.00	337.50	185.00	185.00	185.00	185.00	185.00	2-4
Pentium II 350 MHz 512KB Cache	NA	600.00	360.00	310.00	423.33	240.00	200.00	180.00	145.00	191.25	2-4
Pentium II 400 MHz 512KB Cache	NA	800.00	560.00	520.00	626.67	400.00	290.00	250.00	200.00	285.00	2-4
Pentium II 450 MHz 512KB Cache	NA	NA	NA	770.00	770.00	600.00	400.00	350.00	275.00	406.25	2-4
Pentium Pro 166 MHz 512KB Cache	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	2-4
Pentium Pro 200 MHz 512KB Cache	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	2-4
Pentium Pro 200 MHz 1MB Cache	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2-4
Pentium II Xeon 400 MHz 512KB Cache	NA	NA	1,050.00	1,050.00	1,050.00	950.00	950.00	950.00	950.00	950.00	2-4
Pentium II Xeon 400 MHz 1024KB Cache	NA	NA	2,700.00	2,700.00	2,700.00	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	2-4
Pentium II Xeon 450 MHz 512KB Cache	NA	NA	NA	1,050.00	1,050.00	950.00	950.00	950.00	950.00	950.00	2-4
Pentium II Xeon 450 MHz 1024KB Cache	NA	NA	2,700.00	2,700.00	2,700.00	2,700.00	2,700.00	2,700.00	2,700.00	2,700.00	2-4
Pentium II Xeon 450 MHz 2048KB Cache	NA	NA	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	2-4
PowerPC 603e-100	34.00	33.32	32.65	32.00	32.99	31.36	30.73	30.12	29.52	30.43	2-4
PowerPC 603e-133	135.00	132.30	129.65	127.06	131.00	124.52	122.03	119.59	117.20	120.83	2-4
PowerPC 604e-250	375.00	367.50	360.15	352.95	363.90	345.89	338.97	332.19	325.55	335.65	2-4
PowerPC 604e-300	424.00	415.52	407.21	399.07	411.45	391.08	383.26	375.60	368.09	379.51	2-4
PowerPC 604e-350	475.00	465.50	456.19	447.07	460.94	438.12	429.36	420.78	412.36	425.16	2-4
PowerPC 740-200	150.00	147.00	144.06	141.18	145.56	138.36	135.59	132.88	130.22	134.26	2-4

Table 2-3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
PowerPC 740-233	175.00	171.50	168.07	164.71	169.82	161.41	158.19	155.02	151.92	156.64	2-4
PowerPC 740-266	275.00	269.50	264.11	258.83	266.86	253.65	248.58	243.61	238.73	246.14	2-4
PowerPC 750-233	200.00	196.00	192.08	188.24	194.08	184.47	180.78	177.17	173.63	179.01	2-4
PowerPC 750-266	300.00	294.00	288.12	282.36	291.12	276.71	271.18	265.75	260.44	268.52	2-4

EOL = End of life
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1998)

Table 2-4
Estimated Long-Range Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998	1999	2000	2001	2002
68EC020-25 PQFP	16.88	16.88	14.32	12.19	EOL
68040-25	24.20	24.20	20.57	17.48	EOL
68LC040-25 CQFP 184	24.20	24.20	20.57	17.48	EOL
Celeron 300A (Mendocino)	130.00	82.50	75.00	75.00	EOL
Celeron 333 (Mendocino)	165.00	92.50	75.00	75.00	EOL
Celeron 350 (Mendocino)	NA	136.25	95.00	95.00	EOL
Celeron 400 (Mendocino)	NA	155.00	125.00	125.00	EOL
Pentium MMX 200 MHz 2.8V PGA	96.25	80.00	80.00	EOL	EOL
Pentium MMX 233 MHz 2.8V PGA	122.50	85.00	85.00	EOL	EOL
Pentium II 233 MHz 512KB Cache	207.50	190.00	190.00	EOL	EOL
Pentium II 266 MHz 512KB Cache	240.00	180.00	180.00	EOL	EOL
Pentium II 300 MHz 512KB Cache	337.50	185.00	185.00	EOL	EOL
Pentium II 350 MHz 512KB Cache	423.33	191.25	145.00	EOL	EOL
Pentium II 400 MHz 512KB Cache	626.67	285.00	200.00	EOL	EOL
Pentium II 450 MHz 512KB Cache	770.00	406.25	275.00	EOL	EOL
Pentium Pro 166 512KB Cache	380.00	380.00	380.00	EOL	EOL
Pentium Pro 200 512KB Cache	940.00	940.00	940.00	EOL	EOL
Pentium Pro 200 1MB Cache	2,350.00	2,350.00	2,350.00	EOL	EOL
Pentium II Xeon 400 MHz 512KB Cache	1,050.00	950.00	950.00	EOL	EOL
Pentium II Xeon 400 MHz 1024KB Cache	2,700.00	2,400.00	2,700.00	EOL	EOL
Pentium II Xeon 450 MHz 512KB Cache	1,050.00	950.00	950.00	EOL	EOL
Pentium II Xeon 450 MHz 1024KB Cache	2,700.00	2,700.00	2,700.00	EOL	EOL
Pentium II Xeon 450 MHz 2048KB Cache	4,000.00	4,000.00	4,000.00	EOL	EOL
PowerPC 603e-100	32.99	30.43	EOL	EOL	EOL
PowerPC 603e-133	131.00	120.83	EOL	EOL	EOL
PowerPC 604e-250	363.90	335.65	EOL	EOL	EOL
PowerPC 604e-300	411.45	379.51	EOL	EOL	EOL
PowerPC 604e-350	460.94	425.16	EOL	EOL	EOL
PowerPC 740-200	145.56	134.26	130.22	130.22	130.22
PowerPC 740-233	169.82	156.64	151.92	151.92	151.92
PowerPC 740-266	266.86	246.14	238.73	238.73	238.73
PowerPC 750-233	194.08	179.01	173.63	173.63	173.63
PowerPC 750-266	291.12	268.52	260.44	260.44	260.44

EOL = End of life
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 1998)

Table 2-5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
4Mbx1 DRAM 70ns SOJ 5V	2.17	2.09	1.90	1.86	2.01	1.85	1.85	1.84	1.83	1.84	2-8
1Mbx4 DRAM 60ns SOJ 5V FPM	1.80	1.55	1.44	1.30	1.52	1.30	1.38	1.55	1.60	1.46	2-8
1Mbx4 DRAM 60ns SOJ 5V EDO	1.80	1.55	1.44	1.30	1.52	1.30	1.38	1.55	1.60	1.46	2-8
256Kx16 DRAM 70ns SOJ 5V	2.64	2.39	2.20	2.20	2.36	2.20	2.22	2.30	2.36	2.27	2-8
4Mbx4 DRAM 60ns SOJ 5V FPM	3.50	2.60	2.20	2.10	2.60	2.00	2.00	2.00	1.97	1.99	2-6
4Mbx4 DRAM 60ns SOJ 5V EDO	3.50	2.55	1.95	1.90	2.48	1.90	1.90	1.90	1.95	1.91	2-6
1Mbx16 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.00	1.95	2.51	1.90	1.90	1.95	2.05	1.95	2-6
1Mbx16 DRAM 60ns TSOP 5V EDO	3.50	2.55	1.97	1.90	2.48	1.85	1.85	2.00	2.10	1.95	2-6
1Mbx16 3.3V SDRAM	4.97	3.35	2.85	2.45	3.41	2.40	2.35	2.30	2.30	2.34	2-6
2Mbx8 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.00	1.92	2.51	1.92	1.92	1.92	1.97	1.93	2-6
2Mbx8 DRAM SDRAM 3.3V	4.97	3.35	2.71	2.41	3.36	2.38	2.33	2.28	2.28	2.32	2-6
16Mbx4 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.00	13.0	7.50	7.35	7.20	7.10	7.29	2-5
16Mbx4 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	7.75	12.93	6.50	6.37	6.30	6.08	6.31	2-5
8Mbx8 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.00	12.99	7.50	7.35	7.20	7.10	7.29	2-5
8Mbx8 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	7.75	12.93	6.50	6.37	6.30	6.08	6.31	2-5
4Mbx16 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	8.70	8.00	12.99	7.50	7.35	7.20	7.10	7.29	2-5
4Mbx16 DRAM SOJ 3.3V SDRAM	24.02	11.40	8.55	7.75	12.93	6.50	6.37	6.30	6.08	6.31	2-5
1Mbx32 SIMM 60ns 5V FPM	10.23	6.70	5.35	5.30	6.90	5.17	5.17	5.27	5.47	5.27	2-5
1Mbx36 SIMM 60ns 5V FPM	12.69	9.80	7.41	7.35	9.31	7.20	7.20	7.35	7.85	7.40	2-5
2Mbx32 SIMM 60ns 5V FPM	17.32	11.92	9.38	9.18	11.95	8.98	8.98	9.18	9.58	9.18	2-5
2Mbx36 SIMM 60ns 5V FPM	22.49	14.52	11.49	11.20	14.93	11.01	11.01	11.45	12.23	11.42	2-5
4Mbx32 SIMM 60ns 5V FPM	32.57	23.17	17.70	17.30	22.69	16.90	16.90	17.30	18.10	17.30	2-5
4Mbx36 SIMM 60ns 5V FPM	40.57	28.37	22.17	21.70	28.20	21.15	21.15	22.41	23.02	21.93	2-5
8Mbx32 SIMM 60ns 5V FPM	60.90	45.77	34.00	33.20	43.47	32.40	32.40	33.20	34.80	33.20	2-5
8Mbx36 SIMM 60ns 5V FPM	75.69	56.17	41.15	40.35	53.34	39.55	39.55	40.35	41.95	40.35	2-5
1Mbx32 SIMM 60ns 5V EDO	9.71	6.60	5.21	5.07	6.65	4.97	4.97	5.27	5.47	5.17	2-5
1Mbx36 SIMM 60ns 5V EDO	12.51	9.70	6.81	6.67	8.92	6.57	6.57	6.87	7.07	6.77	2-5
2Mbx32 SIMM 60ns 5V EDO	17.12	11.72	9.23	8.95	11.76	8.75	8.75	9.35	9.75	9.15	2-5
2Mbx36 SIMM 60ns 5V EDO	22.31	14.27	11.23	10.95	14.69	10.75	10.75	11.35	11.75	11.15	2-5
4Mbx32 SIMM 60ns 5V EDO	32.07	22.77	17.72	17.16	22.43	16.76	16.76	17.96	18.76	17.56	2-5

Table 2-5 (Continued)
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
4Mbx36 SIMM 60ns 5V EDO	40.11	27.87	21.55	20.99	27.63	20.59	20.59	21.79	22.59	21.39	2-5
8Mbx32 SIMM 60ns 5V EDO	60.71	44.97	33.62	32.50	42.95	31.70	31.70	34.10	35.70	33.30	2-5
8Mbx36 SIMM 60ns 5V EDO	75.21	55.17	40.70	39.58	52.67	38.78	38.78	41.18	42.78	40.38	2-5
2Mbx64 60ns 3.3V EDO	52.65	24.97	19.37	17.97	28.74	16.97	16.67	16.37	16.17	16.55	2-5
4Mbx64 60ns 3.3V EDO	101.10	49.37	36.77	33.97	55.30	31.97	31.37	30.77	30.37	31.12	2-5
8Mbx64 60ns 3.3V EDO	NA	NA	72.37	66.77	66.77	62.77	61.57	60.37	59.57	61.07	2-6
2Mbx64 3.3V SDRAM	52.75	25.17	19.07	17.47	28.62	14.97	14.71	14.57	14.13	14.60	2-5
4Mbx64 3.3V SDRAM	101.09	49.77	36.17	32.97	55.00	27.97	27.45	27.17	26.29	27.22	2-5
8Mbx64 3.3V SDRAM	NA	NA	70.50	64.05	64.05	53.97	52.93	52.37	50.61	52.47	2-5
256Kx32 SGRAM 66 MHz 3.3V	5.17	4.75	4.00	3.40	4.33	3.30	3.20	3.10	3.05	3.16	2-8
512Kx32 SGRAM 66 MHz 3.3V	11.44	9.75	8.00	7.50	9.17	7.25	7.10	6.85	6.20	6.85	2-8

NA = Not available
*Contract volume is at least 100,000 per order.
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 1998)

Table 2-6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998	1999	2000	2001	2002
4Mbx1 DRAM 70ns SOJ 5V	2.01	1.84	1.95	2.10	2.30
1Mbx4 DRAM 60ns SOJ 5V FPM	1.52	1.46	1.90	2.15	2.30
1Mbx4 DRAM 60ns SOJ 5V EDO	1.52	1.46	1.90	2.15	2.30
256Kx16 DRAM 70ns SOJ 5V	2.36	2.27	2.60	2.90	3.20
4Mbx4 DRAM 60ns SOJ 5V FPM	2.60	1.99	2.10	2.50	2.70
4Mbx4 DRAM 60ns SOJ 5V EDO	2.48	1.91	2.06	2.50	2.70
1Mbx16 DRAM 60ns TSOP 5V FPM	2.51	1.95	2.18	2.70	3.00
1Mbx16 DRAM 60ns TSOP 5V EDO	2.48	1.95	2.20	2.70	3.00
1Mbx16 3.3V SDRAM	3.41	2.34	2.28	2.85	3.35
2Mbx8 DRAM 60ns TSOP 5V FPM	2.51	1.93	2.10	2.50	2.70
2Mbx8 DRAM SDRAM 3.3V	3.36	2.32	2.28	2.84	3.33
16Mbx4 DRAM 60ns SOJ 3.3V EDO	12.99	7.29	7.01	6.94	6.81
16Mbx4 DRAM SOJ 3.3V SDRAM	12.93	6.31	5.98	5.86	5.79
8Mbx8 DRAM 60ns SOJ 3.3V EDO	12.99	7.29	7.01	6.94	6.81
8Mbx8 DRAM SOJ 3.3V SDRAM	12.93	6.31	5.98	5.86	5.79
4Mbx16 DRAM 60ns SOJ 3.3V EDO	12.99	7.29	7.01	6.94	6.81
4Mbx16 DRAM SOJ 3.3V SDRAM	12.93	6.31	5.98	5.86	5.79
1Mbx32 SIMM 60ns 5V FPM	6.90	5.27	5.73	6.77	7.37
1Mbx36 SIMM 60ns 5V FPM	9.31	7.40	7.84	8.81	9.40
2Mbx32 SIMM 60ns 5V FPM	11.95	9.18	10.10	12.18	13.38
2Mbx36 SIMM 60ns 5V FPM	14.93	11.42	13.12	15.20	16.36
4Mbx32 SIMM 60ns 5V FPM	22.69	17.30	19.14	23.30	25.70
4Mbx36 SIMM 60ns 5V FPM	28.20	21.93	24.61	28.19	30.99
8Mbx32 SIMM 60ns 5V FPM	43.47	33.20	36.88	45.20	50.00
8Mbx36 SIMM 60ns 5V FPM	53.34	40.35	44.03	52.35	57.15
1Mbx32 SIMM 60ns 5V EDO	6.65	5.17	5.67	6.67	7.27
1Mbx36 SIMM 60ns 5V EDO	8.92	6.77	7.27	8.27	8.87
2Mbx32 SIMM 60ns 5V EDO	11.76	9.15	10.15	12.15	13.35
2Mbx36 SIMM 60ns 5V EDO	14.69	11.15	12.15	14.15	15.35
4Mbx32 SIMM 60ns 5V EDO	22.43	17.56	19.56	23.56	25.96
4Mbx36 SIMM 60ns 5V EDO	27.63	21.39	23.39	27.39	29.79
8Mbx32 SIMM 60ns 5V EDO	42.95	33.30	37.30	45.30	50.10
8Mbx36 SIMM 60ns 5V EDO	52.67	40.38	44.38	52.38	57.18
2Mbx64 60ns 3.3V EDO	28.74	16.55	15.99	15.85	15.59
4Mbx64 60ns 3.3V EDO	55.30	31.12	30.01	29.73	29.21
8Mbx64 60ns 3.3V EDO	-	-	58.07	57.51	56.47
2Mbx64 3.3V SDRAM	28.62	14.60	13.93	13.69	13.55
4Mbx64 3.3V SDRAM	55.00	27.22	25.90	25.42	25.14
8Mbx64 3.3V SDRAM	-	-	49.83	48.87	48.31
256Kx32 SGRAM 66 MHz 3.3V	4.33	3.16	3.00	2.94	2.90
512Kx32 SGRAM 66 MHz 3.3V	9.17	6.85	5.94	5.80	5.75

*Contract volume is at least 100,000 per order.
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 1998)

Table 2-7
Estimated Static RAM Price Trends—North American Bookings (Volume: Slow SRAM—50,000 per Year; Fast SRAM—20,000 per Year; Package: PDIP; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
16Kx4 35ns	2.07	2.09	2.09	2.11	2.09	2.11	2.11	2.13	2.13	2.12	2-6
8Kx8 25ns	0.94	0.92	0.91	0.91	0.92	0.86	0.86	0.86	0.86	0.86	2-6
8Kx8 100-120ns	1.12	1.05	0.98	0.98	1.03	0.94	0.94	0.94	0.94	0.94	2-6
64Kx4 10ns	5.03	4.85	4.76	4.73	4.84	4.70	4.63	4.59	4.55	4.62	2-4
64Kx4 25ns	1.60	1.60	1.55	1.55	1.58	1.53	1.53	1.51	1.51	1.52	2-4
32Kx8 12ns	1.25	1.16	0.98	0.97	1.09	0.97	0.97	1.00	1.04	0.98	2-4
32Kx9 12ns Burst	3.27	3.25	3.23	3.21	3.24	3.19	3.19	3.17	3.17	3.18	2-4
32Kx8 15ns 5V	1.10	1.05	0.95	0.94	1.01	0.94	0.97	1.01	1.05	0.99	2-4
32Kx8 15ns 3.3V	1.02	0.99	0.95	0.94	0.97	0.94	0.97	1.03	1.08	1.07	2-4
32Kx8 25ns	1.12	1.00	0.97	0.96	1.01	0.96	0.97	1.03	1.08	1.00	2-4
32Kx8 70-100ns SOJ	1.21	1.11	1.03	1.00	1.09	1.00	1.00	1.04	1.11	1.02	2-4
64Kx8 12ns Burst	13.35	12.20	11.45	11.23	12.06	11.21	11.01	10.89	10.65	10.94	2-4
256Kx4 20ns	3.31	3.04	2.97	2.93	3.06	2.89	2.85	2.82	2.77	2.89	2-8
256Kx4 12ns 3.3V	4.19	4.11	3.82	3.69	3.95	3.41	3.25	3.13	2.91	3.18	3-8
256Kx8 12ns 3.3V	4.02	3.69	3.51	3.29	3.63	3.17	3.09	3.03	2.82	3.03	3-8
128Kx8 15ns	3.32	3.01	2.69	2.55	2.89	2.44	2.40	2.31	2.25	2.42	3-6
128Kx8 20ns	3.16	2.83	2.55	2.45	2.75	2.38	2.24	2.20	2.19	2.51	3-6
128Kx8 25ns	3.16	2.83	2.55	2.45	2.75	2.38	2.24	2.20	2.19	2.51	3-6
128Kx8 70-100ns SOJ	2.79	2.50	2.37	2.34	2.50	2.33	2.28	2.24	2.20	2.30	3-6
32Kx32 15ns 3.3V PQFP	3.18	3.13	3.00	2.93	3.06	2.90	2.90	2.90	2.90	3.06	2-6
32Kx32 8ns 3.3V PBSynch	2.76	2.70	2.55	2.40	2.60	2.35	2.30	2.30	2.30	2.66	2-6
64Kx32 8ns 3.3V PBSynch	5.17	5.05	4.80	4.55	4.89	4.40	4.30	4.25	4.20	4.44	2-6
64Kx32 5ns 3.3V PBSynch	7.00	6.60	6.18	5.69	6.37	5.55	5.36	5.05	4.85	5.29	2-6
256Kx16 70-100ns	13.63	13.00	12.43	12.19	12.81	12.02	11.92	11.65	11.31	11.92	3-6
256Kx16 25ns	16.79	16.32	15.03	14.38	15.63	14.22	14.00	13.55	13.13	13.95	3-6
512Kx8 70ns	13.06	12.56	11.91	11.80	12.33	11.61	11.24	11.04	10.95	11.27	3-6
512Kx8 25ns	16.91	15.98	14.70	14.02	15.40	13.69	13.08	12.88	12.45	13.19	3-6

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 1998)

Table 2-8
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)

	1998	1999	2000	2001	2002
16Kx4 35ns	2.09	2.12	2.13	2.15	2.15
8Kx8 25ns	0.92	0.86	0.87	0.86	0.90
8Kx8 100-120ns	1.03	0.94	0.94	1.00	1.10
64Kx4 10ns	4.84	4.62	4.40	4.32	4.24
64Kx4 25ns	1.58	1.52	1.53	1.57	1.65
32Kx8 12ns	1.09	0.98	1.30	1.35	1.37
32Kx9 12ns Burst	3.24	3.18	3.16	3.21	3.25
32Kx8 15ns 5V	1.01	0.99	1.17	1.21	1.28
32Kx8 15ns 3.3V	0.97	1.07	1.18	1.22	1.28
32Kx8 25ns	1.01	1.00	1.18	1.21	1.28
32Kx8 70-100ns SOJ	1.09	1.02	1.22	1.32	1.34
64Kx8 12ns Burst	12.06	10.94	10.35	10.22	10.14
256Kx4 20ns	3.06	2.89	2.65	2.57	2.51
256Kx4 12ns 3.3V	3.95	3.18	2.79	2.71	2.68
256Kx8 12ns 3.3V	3.63	3.03	2.62	2.51	2.47
128Kx8 15ns	2.89	2.42	2.15	2.09	2.09
128Kx8 20ns	2.75	2.51	2.13	2.09	2.09
128Kx8 25ns	2.75	2.51	2.13	2.09	2.09
128Kx8 70-100ns SOJ	2.50	2.30	2.14	2.10	2.10
32Kx32 15ns 3.3V PQFP	3.06	3.06	2.95	3.03	3.11
32Kx32 8ns 3.3V PBSynch	2.60	2.66	2.71	3.04	3.18
64Kx32 8ns 3.3V PBSynch	4.89	4.44	4.07	3.95	3.83
64Kx32 5ns 3.3V PBSynch	6.37	5.29	4.25	3.96	3.83
256Kx16 70-100ns	12.81	11.92	11.01	10.65	10.30
256Kx16 25ns	15.63	13.95	12.74	12.22	11.88
512Kx8 70ns	12.33	11.27	10.65	10.42	10.33
512Kx8 25ns	15.40	13.19	12.12	11.79	11.55

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 1998)

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

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
128Kx8 ROM	1.58	1.32	1.27	1.22	1.35	1.18	1.16	1.23	1.30	1.22	4-6
64Kx16 ROM	1.73	1.36	1.33	1.30	1.43	1.27	1.27	1.31	1.35	1.30	4-6
256Kx8 ROM	2.10	1.65	1.56	1.50	1.70	1.41	1.37	1.37	1.35	1.38	4-6
512Kx8 ROM	2.70	2.20	1.90	1.77	2.14	1.65	1.59	1.54	1.50	1.57	4-6
256Kx16 ROM[1]	2.70	2.20	1.90	1.77	2.14	1.65	1.59	1.54	1.50	1.57	4-6
1Mbx8 ROM[2]	3.62	2.86	2.69	2.29	2.87	2.22	2.15	2.10	2.00	2.12	4-6
1Mbx16 ROM	5.55	4.45	3.50	2.90	4.10	2.84	2.77	2.71	2.65	2.74	4-6
2Mbx8 ROM	5.55	4.45	3.50	2.90	4.10	2.84	2.77	2.71	2.65	2.74	4-6
2Mbx16 ROM	11.00	8.75	7.20	6.15	8.28	6.00	5.85	5.60	5.43	5.72	4-6
4Mbx8 ROM	11.00	8.75	7.21	6.15	8.28	6.00	5.85	5.60	5.43	5.72	4-6
4Mbx16 ROM	14.50	12.10	11.60	10.97	12.29	10.55	10.27	10.10	9.95	10.22	4-6
8Mbx8 ROM	14.40	12.10	11.55	10.92	12.24	10.55	10.27	10.10	9.95	10.22	4-6

[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 1998)

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

	1998	1999	2000	2001	2002
128Kx8 ROM	1.35	1.22	1.31	1.34	1.39
64Kx16 ROM	1.43	1.30	1.36	1.37	1.4
256Kx8 ROM	1.70	1.38	1.36	1.37	1.4
512Kx8 ROM	2.14	1.57	1.47	1.45	1.44
256Kx16 ROM[1]	2.14	1.57	1.47	1.45	1.44
1Mbx8 ROM[2]	2.87	2.12	1.94	1.87	1.87
1Mbx16 ROM	4.10	2.74	2.55	2.41	2.37
2Mbx8 ROM	4.10	2.74	2.55	2.41	2.37
2Mbx16 ROM	8.28	5.72	5.21	5.09	5.00
4Mbx8 ROM	8.28	5.72	5.21	5.09	5.00
4Mbx16 ROM	12.29	10.22	9.55	9.34	9.22
8Mbx8 ROM	12.24	10.22	9.55	9.34	9.22

[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 1998)

Table 2-11
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
32Kx8 EPROM	1.26	1.23	1.22	1.21	1.23	1.21	1.19	1.18	1.15	1.18	2-3
64Kx8 EPROM	1.31	1.29	1.27	1.26	1.28	1.24	1.22	1.18	1.16	1.20	2-3
128Kx8 EPROM	1.65	1.60	1.56	1.56	1.59	1.50	1.50	1.48	1.48	1.49	2-3
256Kx8 EPROM	2.68	2.60	2.52	2.47	2.57	2.41	2.41	2.36	2.36	2.39	2-3
128Kx16 EPROM	3.08	3.09	2.87	2.77	2.95	2.75	2.75	2.68	2.68	2.72	2-3
512Kx8 EPROM	4.06	3.85	3.15	2.82	3.47	2.65	2.65	2.52	2.50	2.58	2-3
256Kx16 EPROM	5.33	4.55	3.45	2.98	4.08	2.88	2.75	2.67	2.67	2.74	2-3
1Mbx8 EPROM	7.38	7.14	6.75	6.60	6.97	6.24	6.01	5.89	5.75	5.97	2-3
512Kx16 EPROM	8.25	7.35	7.05	6.75	7.35	6.40	6.14	6.00	5.80	6.09	2-3

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 1998)

Table 2-12
Estimated Long-Range EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998	1999	2000	2001	2002
32Kx8 EPROM	1.23	1.18	1.18	1.24	1.27
64Kx8 EPROM	1.28	1.20	1.20	1.26	1.30
128Kx8 EPROM	1.59	1.49	1.39	1.46	1.59
256Kx8 EPROM	2.57	2.39	2.31	2.19	2.08
128Kx16 EPROM	2.95	2.72	2.36	2.24	2.13
512Kx8 EPROM	3.47	2.58	2.45	2.33	2.21
256Kx16 EPROM	4.08	2.74	2.52	2.39	2.27
1Mbx8 EPROM	6.97	5.97	4.10	3.90	3.70
512Kx16 EPROM	7.35	6.09	4.75	4.51	4.29

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 1998)

Table 2-13
Estimated Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998					1999					Lead Times
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	(Weeks)
64Kx8 PDIP/PLCC	2.18	2.15	2.05	2.01	2.10	1.98	1.99	1.98	1.98	1.98	5
64Kx8 TSOP	2.12	2.09	2.09	2.08	2.10	1.99	2.00	1.95	1.95	1.97	5
128Kx8 PDIP/PLCC	2.14	2.16	2.07	2.03	2.10	1.98	1.98	1.97	1.95	1.97	3
128Kx8 TSOP 12V	2.16	2.18	2.14	2.12	2.15	2.09	2.09	2.09	2.08	2.09	4
128Kx8 TSOP 5V	2.50	2.40	2.24	2.18	2.33	1.95	2.01	1.90	1.80	1.91	4
256Kx8 TSOP 12V	4.13	3.33	3.06	2.96	3.37	2.74	2.77	2.71	2.66	2.72	4-6
256Kx8 TSOP 5V	3.70	3.11	2.97	2.87	3.16	2.70	2.75	2.72	2.69	2.71	4-6
256Kx8 PDIP/PLCC	3.65	3.05	2.95	2.84	3.12	2.68	2.79	2.71	2.67	2.71	4-6
512Kx8 PDIP/PLCC	3.80	3.50	3.25	3.16	3.43	2.90	2.93	2.85	2.78	2.87	4
512Kx8 TSOP 12V	4.52	4.08	3.65	3.55	3.95	3.27	3.31	3.22	3.13	3.23	4
512Kx8 TSOP 5V	4.06	3.55	3.43	3.26	3.57	3.02	3.05	2.97	2.90	2.99	4
512Kx8 SSOP 3V	3.75	3.49	3.41	3.26	3.48	3.02	3.05	2.97	2.90	2.99	4
1Mbx8 TSOP 12V	7.02	6.33	5.47	5.21	6.01	4.66	4.76	4.56	4.36	4.59	3-4
1Mbx8 TSOP 5V	6.97	5.95	5.24	4.99	5.79	4.47	4.56	4.38	4.20	4.40	3-4
1Mbx8 TSOP 3V	6.94	5.86	5.10	4.91	5.70	4.36	4.50	4.20	4.04	4.27	3-4
2Mbx8 TSOP 12V	13.09	11.75	10.83	10.40	11.52	9.09	9.27	8.86	8.42	8.91	3-4
2Mbx8 TSOP 5V	12.12	10.55	10.09	9.39	10.54	8.10	8.22	7.87	7.57	7.94	3-4
2Mbx8 TSOP 3V	12.14	10.35	10.03	9.28	10.45	8.07	8.75	8.40	8.07	8.32	3-4
1Mbx16 TSOP 12V	15.37	13.35	11.88	11.20	12.95	9.62	9.85	9.28	8.86	9.40	3-4
1Mbx16 TSOP 5V	16.79	14.04	12.06	11.27	13.54	9.39	9.66	9.08	8.60	9.18	3-4
1Mbx16 TSOP 3V	17.01	12.92	10.78	10.24	12.74	8.98	9.18	8.76	8.40	8.83	3-4

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 price guidelines.
Source: Dataquest (September 1998)

Table 2-14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998	1999	2000	2001	2002
64Kx8 PDIP/PLCC	2.10	1.98	1.95	2.00	2.05
64Kx8 TSOP	2.10	1.97	1.93	1.93	1.98
128Kx8 PDIP/PLCC	2.10	1.97	2.06	2.06	2.15
128Kx8 TSOP 12V	2.15	2.09	1.94	1.94	2.10
128Kx8 TSOP 5V	2.33	1.91	2.60	2.54	2.64
256Kx8 TSOP 12V	3.37	2.72	2.54	2.48	2.55
256Kx8 TSOP 5V	3.16	2.71	2.51	2.43	2.50
256Kx8 PDIP/PLCC	3.12	2.71	2.65	2.59	2.64
512Kx8 PDIP/PLCC	3.43	2.87	2.92	2.79	2.94
512Kx8 TSOP 12V	3.95	3.23	2.79	2.64	2.77
512Kx8 TSOP 5V	3.57	2.99	2.79	2.64	2.77
512Kx8 SSOP 3V	3.48	2.99	4.14	3.97	3.86
1Mbx8 TSOP 12V	6.01	4.59	4.04	3.82	3.69
1Mbx8 TSOP 5V	5.79	4.40	3.91	3.73	3.58
1Mbx8 TSOP 3V	5.70	4.27	8.10	7.64	7.05
2Mbx8 TSOP 12V	11.52	8.91	8.00	7.46	6.90
2Mbx8 TSOP 5V	10.54	7.94	7.89	7.40	6.86
2Mbx8 TSOP 3V	10.45	8.32	8.09	7.66	7.04
1Mbx16 TSOP 12V	12.95	9.40	8.00	7.55	6.94
1Mbx16 TSOP 5V	13.54	9.18	8.00	7.55	6.94
1Mbx16 TSOP 3V	12.74	8.83	7.90	7.42	6.85

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 1998)

Table 2-15
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	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS										Production:
0.8 Micron	20.00	19.00	19.00	16.00	15.00	14.00	14.00	13.00	12.00	4-10
0.6 Micron	22.00	21.00	20.00	15.00	14.00	13.00	16.00	15.00	13.00	4-10
0.5 Micron	25.00	24.00	23.00	21.00	20.00	20.00	18.00	17.00	15.00	4-10
0.35 Micron	34.00	34.00	34.00	28.00	26.00	26.00	20.00	19.00	17.00	4-10
										Prototype:
NRE CMOS Average Charge ($K)	43.00	43.00	43.00	53.00	51.00	51.00	73.00	72.00	72.00	1-4

Gate Count	100-299.99K Gates			300K or More Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS							Production:
0.8 Micron	22.00	21.00	19.00	NR	NR	NR	4-10
0.6 Micron	22.00	21.00	19.00	30.00	29.00	29.00	4-10
0.5 Micron	24.00	22.00	20.00	32.00	32.00	32.00	4-10
0.35 Micron	31.00	30.00	29.00	38.00	38.00	38.00	4-10
							Prototype:
NRE CMOS Average Charge ($K)	105.00	103.00	103.00	125.00	120.00	120.00	1-4

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors. Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (September 1998)

Table 2-16
Estimated CBIC Pricing—North American Production Bookings (Volume: 20,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype; Millicents per Gate)

Gate Count	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS										Production:
0.8 Micron	24.00	22.00	21.00	16.00	14.00	13.00	11.00	10.00	9.00	6-14
0.6 Micron	25.00	24.00	23.00	16.00	15.00	14.00	12.00	10.00	9.00	6-14
0.5 Micron	27.00	26.00	26.00	24.00	22.00	20.00	19.00	17.00	14.00	6-14
0.35 Micron	39.00	37.00	37.00	35.00	34.00	32.00	24.00	22.00	19.00	6-14
										Prototype:
NRE CMOS Average Charge ($K)	66.00	65.00	65.00	72.00	71.00	71.00	82.00	82.00	82.00	3-6

Gate Count	100-299.99K Gates			300K or More Gates			Lead Times
Technology	1998	1999	2000	1998	1999	2000	(Weeks)
CMOS							Production:
0.8 Micron	15.00	14.00	12.00	NR	NR	NR	6-14
0.6 Micron	14.00	13.00	10.00	18.00	17.00	15.00	6-14
0.5 Micron	12.00	10.00	9.00	15.00	14.00	12.00	6-14
0.35 Micron	11.00	10.00	9.00	9.00	8.00	7.00	6-14
							Prototype:
NRE CMOS Average Charge ($K)	133.00	131.00	131.00	161.00	160.00	158.00	3-6

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors. Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (September 1998)

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@dataquest.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest/Gartner Group
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: +1-408-468-8000
Facsimile: +1-408-954-1780

East Coast Research Center
Gartner Group Lowell
900 Chelmsford Street
Tower Two, Floor Nine
Lowell, Massachusetts 01851
United States
Phone: +1-978-323-6900
Facsimile: +1-978-323-6933

EUROPE

European Headquarters
Gartner Group Ltd.
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44-1784-431-611
Facsimile: +44-1784-488-980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33-1-41-35-13-00
Facsimile: +33-1-41-35-13-13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49-89-42-70-4-0
Facsimile: +49-89-42-70-4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153-0042
Japan
Phone: +81-3-3481-3670
Facsimile: +81-3-3481-3644

ASIA/PACIFIC

Asia Headquarters
Gartner Group Hong Kong
Suite 5904-7, Central Plaza
18 Harbour Road
Wanchai
Hong Kong
Phone: +852-2824-6168
Facsimile: +852-2824-6138

Pacific Headquarters
Gartner Group Pacific
80 Alfred Street - 6th Floor
Milsons Point, NSW 2061
Australia
Phone: +61-2-9941-4860
Facsimile: +61-2-9941-4868

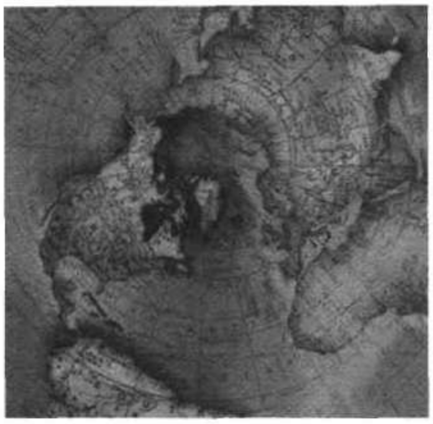
Korea
Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: +82-2-551-1331
Facsimile: +82-2-551-1330

Taiwan
Gartner Group Taiwan Ltd.
11F-2, 188, Section 5
Nan King East Road
Taipei 105
Taiwan R.O.C.
Phone: +886-2-2756-0389
Facsimile: +886-2-2756-2663/4122

Thailand
Gartner Group Thailand Ltd.
29 Vanissa Building, 12F
Soi Chidlom, Ploenchit Road
Pathumwan, Bangkok 10330
Thailand
Phone: +662-655-0577
Facsimile: +662-655-0576

Singapore
Gartner Group Advisory (S) Pte Ltd.
6 Temasek Boulevard #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: +65-333-6773
Facsimile: +65-333-6787

Dataquest
A Gartner Group Company



Dataquest

Semiconductor Analysis: Product/ Market Update

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9802
Publication Date: August 24, 1998
Filing: Reports

Semiconductor Analysis: Product/ Market Update

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9802
Publication Date: August 24, 1998
Filing: Reports

Table of Contents

List of Figures

List of Tables

Chapter 1
Semiconductor Device Forecast

This report examines the market share and life cycle curves for certain key semiconductor device families. These families are as follows:

- DRAM
- ASIC
- Nonvolatile
- SRAM

Dataquest forecasts that worldwide semiconductor revenue will grow 8.2 percent in 1998, reaching $159 billion. The world market is forecast to grow at a 14.4 percent compound average growth rate (CAGR) from 1997 through 2002, reaching $288 billion in 2002.

Table 1-1 highlights semiconductor market growth by product type from 1997 to 2002.

Given the chunk of the semiconductor pie occupied by MOS memory, a cold for MOS memory spells pneumonia for the semiconductor market. Thus, the instability in the MOS memory segment during the past number of years has had a serious impact on overall semiconductor growth rates and profitability. The good news is that Dataquest forecasts solid, double-digit growth for MOS memory through 2002. This means that the long-term forecast remains good, but we are still in choppy water for the moment.

Table 1-1
Worldwide Semiconductor Growth by Product Type, 1997 and 2002
(Revenue in Millions of Dollars)

	1997 Revenue	1997 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)	1997-2002 CAGR (%)
Total Semiconductor	**147,165**	**3.5**	**287,895**	**4.7**	**17.7**	**14.4**
Total Integrated Circuit	127,571	3.1	257,154	4.1	18.6	15.1
Bipolar Digital	1,239	-33.0	604	-14.6	-17.2	-13.4
MOS Memory	30,978	-18.6	61,202	-20.1	15.1	14.6
MOS Microcomponent	48,945	18.0	103,130	14.9	27.8	16.1
MOS Digital Logic	24,757	9.2	50,818	18.8	19.8	15.5
Analog-Monolithic	21,652	18.7	41,400	11.2	16.3	13.8
Total Discrete	14,255	5.8	23,300	10.4	11.8	10.3
Total Optical Semiconductor	5,339	8.6	7,441	8.2	14.7	6.9

Source: Dataquest (July 1998)

Chapter 2
Application-Specific Integrated Circuits (ASICs)

This chapter can be broken up into three main sections: ASIC life cycle analysis, ASIC market share, and ASIC applications.

Definitions

An ASIC is a logic product customized for a single user. Dataquest defines ASICs to include gate arrays, cell-based integrated circuits (CBICs), and programmable logic devices (PLDs). Dataquest defines gate arrays as semicustom digital or linear/digital ICs containing a configuration of uncommitted logic elements, which are customized by interconnecting the logic elements with one or more routing layers. CBICs are customized digital or mixed-linear/digital ICs that use a full set of masks. The devices consist 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.

Rankings are based on dollar shipments, which include the following four sources of revenue:

- Device revenue—both merchant and intracompany
- Nonrecurring engineering (NRE) revenue
- ASIC software revenue
- PLD development kit revenue

As mentioned earlier, ASIC revenue includes CBICs, gate arrays, and PLDs only. Full-custom IC revenue is excluded from the ASIC market share. Additionally, the ASIC revenue is from MOS/BiCMOS products only—it excludes bipolar products.

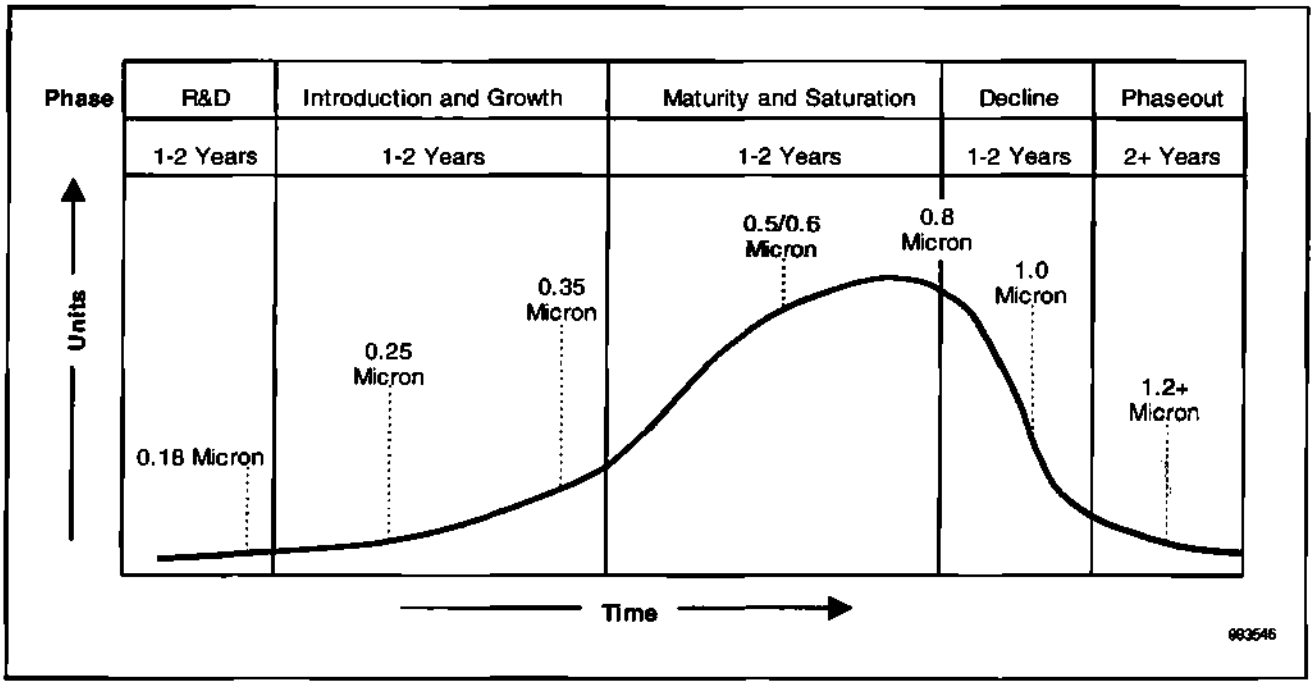
ASIC Technology Life Cycles

The process technology life cycles will be analyzed, covering the main generational changes to ASICs. This section is designed to assist users in adjusting to forces affecting the marketplace over the short to long term. Because an ASIC is as much a technology as a specific product, this market does not lend itself to traditional life cycle analysis. Thus, there are two separate figures in this section—one looking at the life cycle of the ASIC technologies, and the other looking at the most notable ASIC milestones over a seven-year period.

ASIC Process Life Cycle

Figure 2-1 shows the ASIC technology life cycle curve for the different process generations. Each process can manufacture CBICs, gate arrays, and PLDs. Depending on the supplier, there is typically a backlog of a quarter or two for CBICs over gate arrays, caused by the time needed to update cell libraries.

Figure 2-1
ASIC Life Cycle Curve



Source: Dataquest (July 1998)

The latest and greatest process generation is the 0.18 micron. Most suppliers have made product announcements, and some designs have appeared. However, it was not shipped in any sizable volume in 1997. In 1998, it should take off and move into the introduction phase of its life-cycle curve.

The rising stars are the 0.25- and 0.35-micron ASIC generations. These have been around for some time but now have become well established in the introduction/growth phase of their life cycle. Volumes increased significantly in 1997 as new designs using them have increased in unit shipment terms. The 0.35 micron is further to the right in the figure than the 0.25 micron, indicating larger unit shipments of the former in 1997. Both are set to take off in the coming years.

The workhorse designs of the ASIC world remain the 0.5/0.6-micron and 0.8-micron generation designs. Based on 1997 shipments, these were the highest volumes. The 0.5/0.6-micron ASICs are established products in the maturity-saturation phase of their life cycles. The 0.8 micron is on the line between maturity-saturation and decline. While the 0.5/0.6-micron technology probably has about one more year left before moving to the decline stage, the 0.8 micron will decrease significantly in volume terms during 1998.

The 1.0-micron technology has been in production-only status with most suppliers since 1996 and 1997. Essentially, that means that only older designs are using it, where it makes no sense to rework, or where reworking is not an option. Thus, in 1997 the number of units shipped at this size fell even further from 1996, and the technology is rapidly dropping down the decline curve of its life cycle.

The 1.2 micron is on its last legs from a volume point of view and is in the phaseout stage of its life cycle curve, where it will remain for the foreseeable future. Some existing production designs still require support for many years, and suppliers will have to honor contractual agreements.

All process generations greater than 1.2 micron are in the phaseout stage as well. In fact, in the case of 2 micron, most manufacturers do not support it at all. The only option in many cases is a custom manufacturer.

While accurate forecasting is vital on all ASICs, it is even more critical on products in the decline and phaseout process stage. Buyers need to ensure that suppliers are fully aware of anticipated needs over time.

It is worth remembering that with ASICs, phaseout doesn't mean an automatic production switch off. In many cases, a product is in the phaseout stage for up to seven years (or longer, depending on what was agreed on). A product may not be the most sleek, sexy design, but if it is the best fit for the chosen application, then rework makes no sense.

That said, designing a new product using phaseout stage technology is similar to jumping off a skyscraper just to see what would happen. Likewise, any new product designed with old technology or any decision to ramp up volumes on products at their life end is foolhardy. Chances are that the buyer will get badly burned.

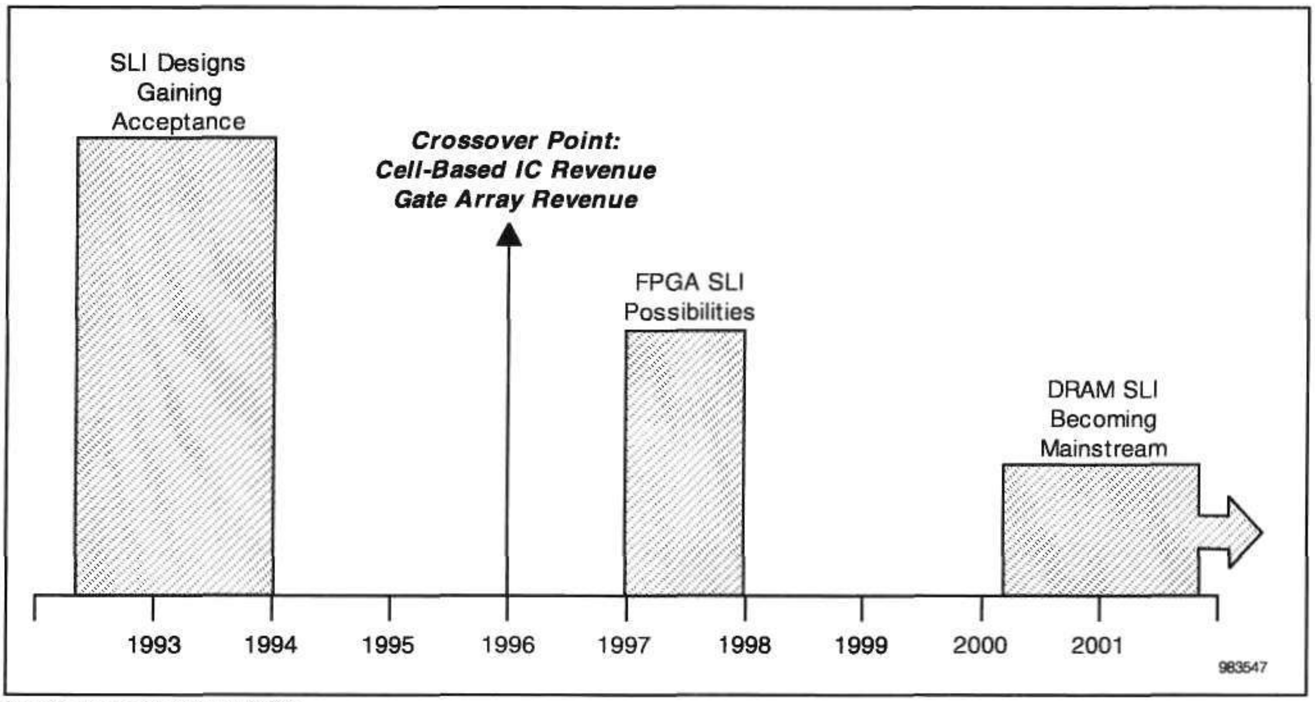
ASIC Milestones

Figure 2-2 shows some of the notable milestones in the ASIC world. Looking back in time, two things hit the ASIC watcher. The first was the awakening of interest in system-level integration (SLI) and the emergence of SLI ASIC designs around 1993 and 1994. In 1996, a major psychological barrier was broken: CBIC revenue surpassed that of gate arrays. CBICs had come of age! Looking forward, the next notable milestone involves both PLDs and SLI. SLI and field programmable gate array (FPGA) combined products are becoming a possibility.

Although DRAM SLI is possible, it will not approach "mainstream" until the next millennium. This is mainly due to the market dynamics for commodity DRAM. Currently, commodity DRAM is in oversupply and prices are cheap. Thus, by contrast, DRAM SLI is very expensive and seemingly unnecessary. No volume applications exist at the moment where surface minimization is so critical that there is no alternative but DRAM SLI. As the millennium approaches, commodity DRAM is set to slowly approach supply/demand equilibrium. When commodity DRAM returns to an undersupply situation, then DRAM SLI will make more sense and should increase in volume.

A backdrop to the events mentioned above is the continued process generation change occurring behind the scenes, facilitating many of the milestones. Newer and newer gate array and CBIC designs will use the smaller geometries, and buyers and designers alike will be faced with the challenge of coming up with the most cost-effective and compact solution for their given application. Exciting times are ahead as a world of possibilities emerge.

Figure 2-2
Notable ASIC Milestones



Source: Dataquest (July 1998)

Market Share

This section analyzes the supplier market share for both overall ASICs and the three individual subfamilies. Table 2-1 highlights Dataquest's final 1997 worldwide overall ASIC market share ranking of the top 10 suppliers in terms of revenue.

Table 2-1
1997 Worldwide Market Share Rankings for Total MOS/BiCMOS ASIC Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	NEC	1,836
2	5	IBM	1,541
3	4	Lucent Technologies	1,486
4	3	Fujitsu	1,248
5	2	LSI Logic	1,182
6	6	TI	886
7	8	VLSI Technology	667
8	7	Toshiba	660
9	-	Altera	631
10	10	Xilinx	612

Source: Dataquest (July 1998)

The key change in the 1997 ranking is that LSI Logic Corporation, a focused ASIC supplier, dropped in the rankings, while both IBM and Lucent Technologies moved up. IBM and Lucent are both broad-based semiconductor manufacturers and vertically integrated suppliers. It was once thought that more focused ASIC suppliers would dominate the market because they are more nimble. It turns out that broad-based and vertically integrated suppliers are winning because they have large R&D budgets, standard products to turn into reusable intellectual property (IP), and much better economies of scale in manufacturing.

Cell-Based IC Supplier Ranking

Table 2-2 shows the Dataquest final 1997 CBIC ranking based on revenue. IBM was the big winner in 1997, moving into second place close behind Lucent. Vertically integrated and broad-based IC suppliers such as IBM and Lucent had much larger revenue gains from 1996 to 1997 in this product area than the focused, ASIC-only suppliers such as LSI Logic and VLSI Technology Inc.

Table 2-2
1997 Worldwide Market Share Rankings for CBIC Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Lucent Technologies	1,396
2	3	IBM	1,380
3	6	NEC	888
4	2	LSI Logic	765
5	5	VLSI Technology	595
6	4	TI	480
7	7	Hewlett-Packard	466
8	8	Fujitsu	439
9	9	SGS-Thomson*	305
10	10	Symbios	288

*Now STMicroelectronics
Source: Dataquest (July 1998)

Gate Array Supplier Ranking

Table 2-3 shows the Dataquest final 1997 gate array ranking based on revenue. Being the top gate array supplier in a declining market does not mean much, compared to being the top cell-based IC supplier in a fast-growing market. The gate array rankings remain largely unchanged from last year, with the only changes occurring at the lower end of the top 10. The significant change from 1996 to 1997 is the revenue decline over the 12 months, a trend set to continue in the future.

Table 2-3
1997 Worldwide Market Share Rankings for Gate Array ASIC Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	NEC	975
2	2	Fujitsu	809
3	3	LSI Logic	417
4	4	Toshiba	408
5	5	TI	403
6	6	Hitachi	353
7	8	Mitsubishi	254
8	7	IBM	161
9	9	Motorola	147
10	-	Matsushita	130

Source: Dataquest (July 1998)

PLD Supplier Ranking

Table 2-4 shows the Dataquest final 1997 gate array ranking based on revenue. Altera Corporation and Xilinx Incorporated have been in a PLD battle for more than five years. Altera became the No. 1 ranked supplier in 1997 for the first time. However, the victory was greeted with little celebration because the PLD market did not grow nearly as much as anticipated. Another battle is being waged between Lattice Semiconductor Corporation and Vantis Corporation. It was almost a tie for 1997, but in the longer term, Lattice shows much stronger growth and will likely overtake Vantis in 1998.

Table 2-4
1997 Worldwide Market Share Rankings for PLD ASIC Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	2	Altera	631
2	1	Xilinx	612
3	3	Vantis	243
4	4	Lattice	242
5	5	Actel	156
6	6	Lucent Technologies	90
7	7	Cypress	52
8	8	Atmel	33
9	10	QuickLogic	29
10	9	Philips	4

Source: Dataquest (July 1998)

ASIC Applications

This section shows the specific applications for ASICs for the semiconductor applications tracked by Dataquest.

Data Processing

Data processing is defined as computer systems, data storage devices, input/output (I/O devices), electronic printers, and office equipment.

Key products that consume large quantities of ASICs include the following:

- Workstations and personal computers
- Midrange computers, mainframes, and supercomputers
- Disk drives
- Electronic printers
- Copiers

Emerging data processing products with ASIC opportunities include the following:

- Portable computers
- High-density 3.5-inch disk drives
- 2.5- and 1.8-inch disk drives
- Video compression and decompression
- Digital video (color space conversion, image digitizing)

Communications

Dataquest defines communications as personal communications, networking, image communications, and voice communications. Applications for ASICs in communications include the following:

- Cellular and cordless phones
- LAN systems
- PBX
- Central office switching systems
- Multiplexing
- Modems
- Integrated services digital network (ISDN) adapters
- Line cards
- Fiber-optic transmission
- Encryption
- Infrared communications
- Asynchronous Transfer Mode

Industrial

Industrial is defined as test equipment, manufacturing systems, process control equipment, instrumentation, medical equipment, and robotics. ASIC-consuming applications in the industrial segment include the following:

- Automated test equipment
- Medical electronics
- Logic analyzers
- Motor control
- Robotics

Military

Military is defined as military electronic equipment. Applications for ASICs in the military segment include the following:

- Radar
- Sonar
- Missile guidance and control
- Navigation
- Reconnaissance
- Flight simulators

Transportation

Dataquest defines transportation as in-car entertainment systems, body control electronics, driver information, power train electronics, safety electronics, and convenience electronics.

Transportation segments that use ASICs include:

- Navigation systems
- Automatic braking systems (ABS)
- Active suspension
- Collision avoidance systems
- Multiplex systems such as driver door and steering wheel
- Electronic instrument clusters
- Power train controls
- Engine management

Consumer

Key consumer applications include the following:

- Set-top boxes
- DVD players
- Camcorders
- Digital TVs
- Electronic games
- Digital still cameras
- Video CD players

Chapter 3
Dynamic Random-Access Memory (DRAM)

This chapter examines the technology life cycle, market share, and key trends for DRAM, based on 1997 unit shipments and current market dynamics.

DRAM Technology Life Cycle Analysis

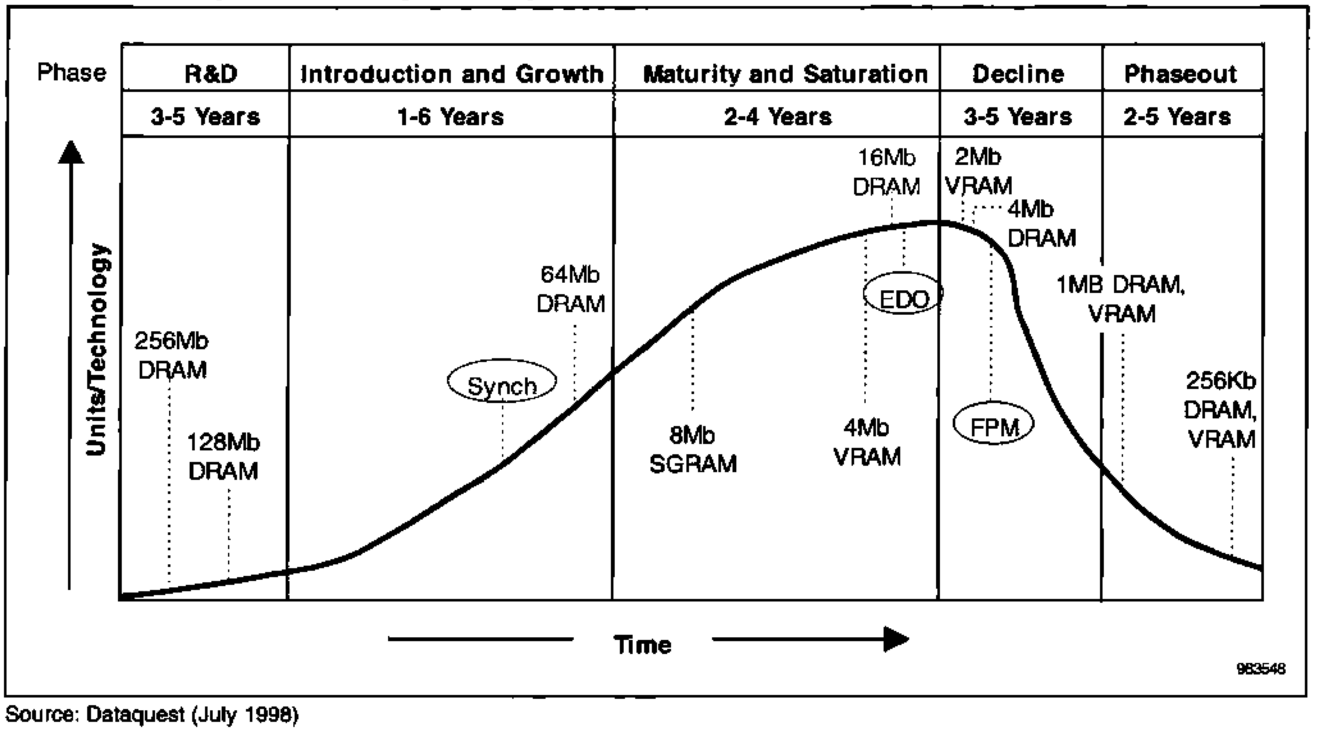
The position of the devices on the life cycle curve is based on the Dataquest forecast of unit shipments of the devices over time. Figure 3-1 uses 1997 DRAM unit shipments as the starting point and looks to the historical actual shipment and forecast shipment data to determine the position of individual devices.

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.

Both the video RAM (VRAM) and DRAM 256Kb chips remain in the phaseout stage of their life cycle curves. The 1Mb DRAM has moved into its phaseout stage, as has the 1Mb VRAM chip.

The 4Mb DRAM chip reached its peak in 1995 and now has dropped into the decline phase of its life cycle curve. The 2Mb VRAM has fallen into the decline stage as well, based on the unit shipments of this device worldwide.

Figure 3-1
DRAM Life Cycle Curve by Density



Source: Dataquest (July 1998)

The 16Mb DRAM chips (x1 and x16 16Mb and x4 and x8 16Mb) are in the maturity and saturation phase of their life cycle curve and have just about reached their peak volumes (forecast to peak in 1998). From here on, volumes should decline.

The 4Mb VRAM has rapidly moved up its life cycle curve and has entered its saturation phase. Its progression has been accelerated mainly because of price competition with regular DRAM and the rapid acceptance of synchronous graphics RAM (SGRAM).

The 8Mb SGRAM is also progressing very quickly through its life cycle curve and is well established in its maturity and saturation phase. Dataquest predicts that this device will reach the peak of the saturation curve in 1999 (the year of its maximum unit shipment level). This device definitely was on the fast track through the life cycle curve as it quickly became the dominant graphics chip for PC motherboard applications.

The 64Mb, at all configurations, has entered its growth phase. Dataquest forecasts that this device will move steadily through the growth and maturity phase as its unit shipments ramp up over time. Dataquest forecasts that the 64Mb should enter the maturity phase in 1999.

Dataquest would recommend not using the 256Kb, 1Mb, and 4Mb devices for new product designs because these products will not be available in high volumes from most suppliers. These devices will be available for existing customers, however, to support older products where a design-out is impossible.

The 16Mb will remain a cost-competitive solution for some time but will not offer as good a price/performance ratio as the 64Mb chip over the long haul.

Technology Type

Figure 3-1 also examines the relative position of the DRAM technology types on the life cycle curve. In terms of technology type, the three main types featured on this life cycle curve are fast page mode (FPM), extended data output (EDO), and synchronous DRAM. Both FPM and EDO DRAM are asynchronous technologies. FPM DRAM has been the main driver for all applications for the past number of years. However, it was rapidly replaced by EDO DRAM in 1996, initially for PC applications.

Currently, the FPM has moved to the decline phase of its life cycle curve, but it will still be available for a number of years to come. Dataquest would not advise using this technology for PC applications if EDO or SDRAM can be substituted.

EDO is now at the saturation phase of its life cycle curve. Dataquest expects that the oversupply of 16Mb and 64Mb EDO products will continue through 1998 and 1999. This should help ensure price declines over time.

SDRAM was launched very aggressively by some key suppliers at the end of 1996, and it began to take off in 1997.The year 1998 is witnessing the rapid migration to SDRAM, especially for PC application. Intel Corporation's PC 100-MHz bus means that SDRAM at 100 MHz will be a hot, volume commodity for the Christmas 1998 PC market. As with asynchronous devices, SDRAM is set to remain in oversupply, particularly at the 64Mb density. Pricing is currently on a parity between 64Mb EDO and 64Mb SDRAM, and over the long term, the SDRAM density is forecast to become cheaper.

DRAM Market Share

Table 3-1 shows the market share for DRAM for 1997, based on dollar revenue. The overall DRAM market revenue dropped from 1996 to 1997 by over 20 percent. The oversupply plaguing the DRAM market is well documented and is set to continue, to some degree, until the beginning of the next millennium.

There was little change in the top four supplier rankings from 1996 to 1997. Samsung Electronics Company Ltd. and NEC Electronics Inc. held onto their positions, while Hyundai and Hitachi swapped places. LG Semicon Co. Ltd. dropped one place, coming in at No. 6 position. Texas Instruments Inc. and Fujitsu Ltd. stayed at No. 7 and No. 10, respectively.

While Mitsubishi Electric Corporation climbed up to eighth position from ninth, Toshiba descended three places to come in at ninth position for 1997. All nine of these vendors experienced negative revenue growth from 1996 to 1997.

Micron was the only top 10 DRAM supplier to post a revenue increase in 1997, growing by just over 9 percent from 1996 and rising from the No. 8 to the No. 5 position.

Table 3-1
1997 Worldwide Market Share Rankings for DRAM Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Samsung	3,897
2	2	NEC	2,519
3	4	Hyundai	1,867
4	3	Hitachi	1,710
5	8	Micron Technology	1,649
6	5	LG Semicon	1,388
7	7	TI	1,284
8	9	Mitsubishi	1,116
9	6	Toshiba	1,028
10	10	Fujitsu	991

Source: Dataquest (July 1998)

DRAM Trends

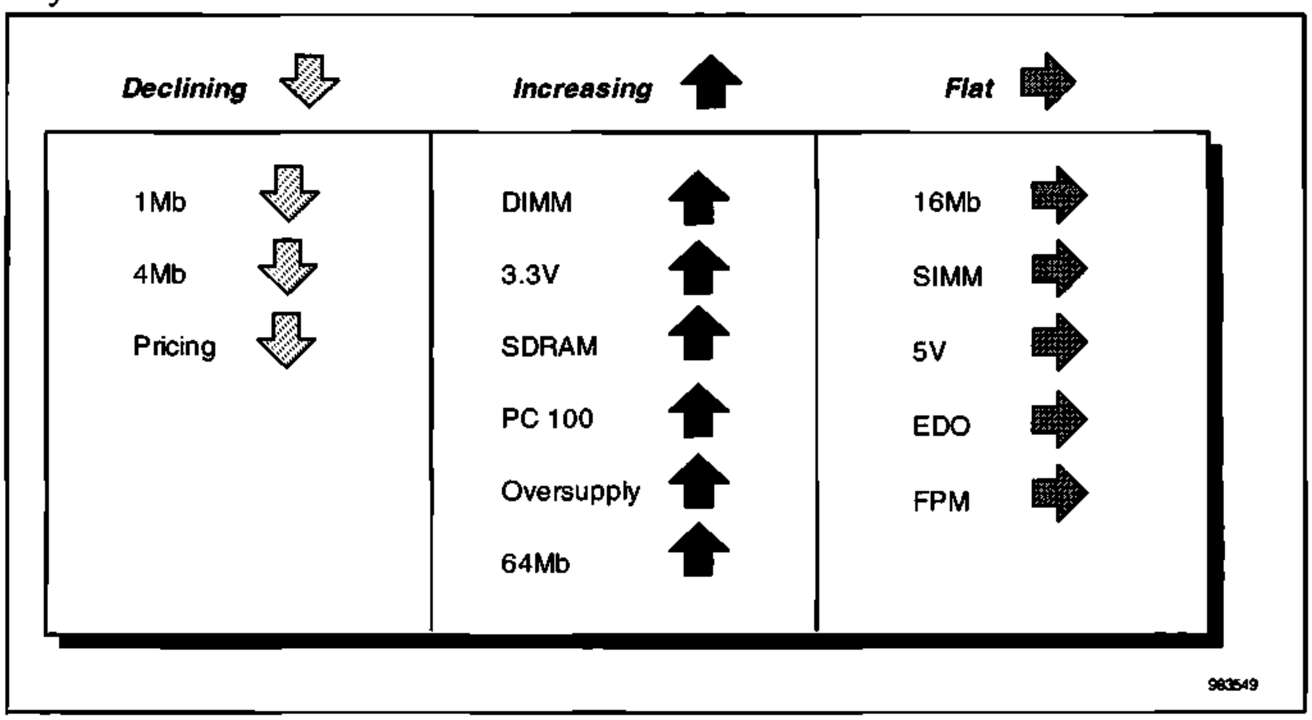
Figure 3-2 illustrates some of the key trends occurring in the DRAM market at present, which range from density, voltage, and technology issues to market conditions.

In terms of DRAM densities, the 64Mb is rapidly ramping up in volume terms and will soon be the main density manufactured. By contrast, the 1Mb and 4Mb are declining in unit terms and are usually shipped only for certain existing customer applications. The 16Mb is being overtaken by the 64Mb but will be readily available for some time to come. If possible, it is in the buyers' best interest to use the 64Mb for high-volume products for the future. It will offer the most attractive pricing and availability.

From a technology standpoint, synchronous is really taking off, especially in the PC arena. Certainly at the 64Mb density, SDRAM will be the dominant technology type shipped in the future. The asynchronous technologies (FPM and EDO) are still readily available and being used for many non-PC applications.

Both single in-line memory modules (SIMMs) and dual in-line memory modules (DIMMs) are available at the moment, but DIMMs are becoming the module of choice for PC applications. All modular SDRAM is shipped in DIMMs. The PC 100-MHz is increasing market share, driven by Intel's Pentium applications. Likewise, voltages on DRAM chips and modules are reducing from 5V to 3.3V.

Figure 3-2
Key DRAM Trends



Source: Dataquest (July 1998)

Oversupply has been a fact of life in the DRAM market since 1995, and Dataquest forecasts that this is set to continue until the end of 2000. Supply/demand imbalance has caused massive price destabilization. Dataquest has completed its third quarter contract price forecast, and the strong message was that DRAM price reductions are forecast to remain a reality until 2002 (forecast end).

While prices on 1Mb, 4Mb, and 16Mb devices will stabilize and begin to rise over the duration of the forecast, 64Mb should have good price reductions quarter on quarter and year on year.

Chapter 4
Nonvolatile Memory: Flash, ROM, EPROM, and EEPROM

This chapter is divided into a number of sections, including product definitions, life cycle analysis, market share (both overall and by device family), and technology trends by device family. Because flash is the most dominant nonvolatile device from a revenue standpoint and has the largest long-term growth forecast, the main differences between code and data flash are examined.

Nonvolatile Devices

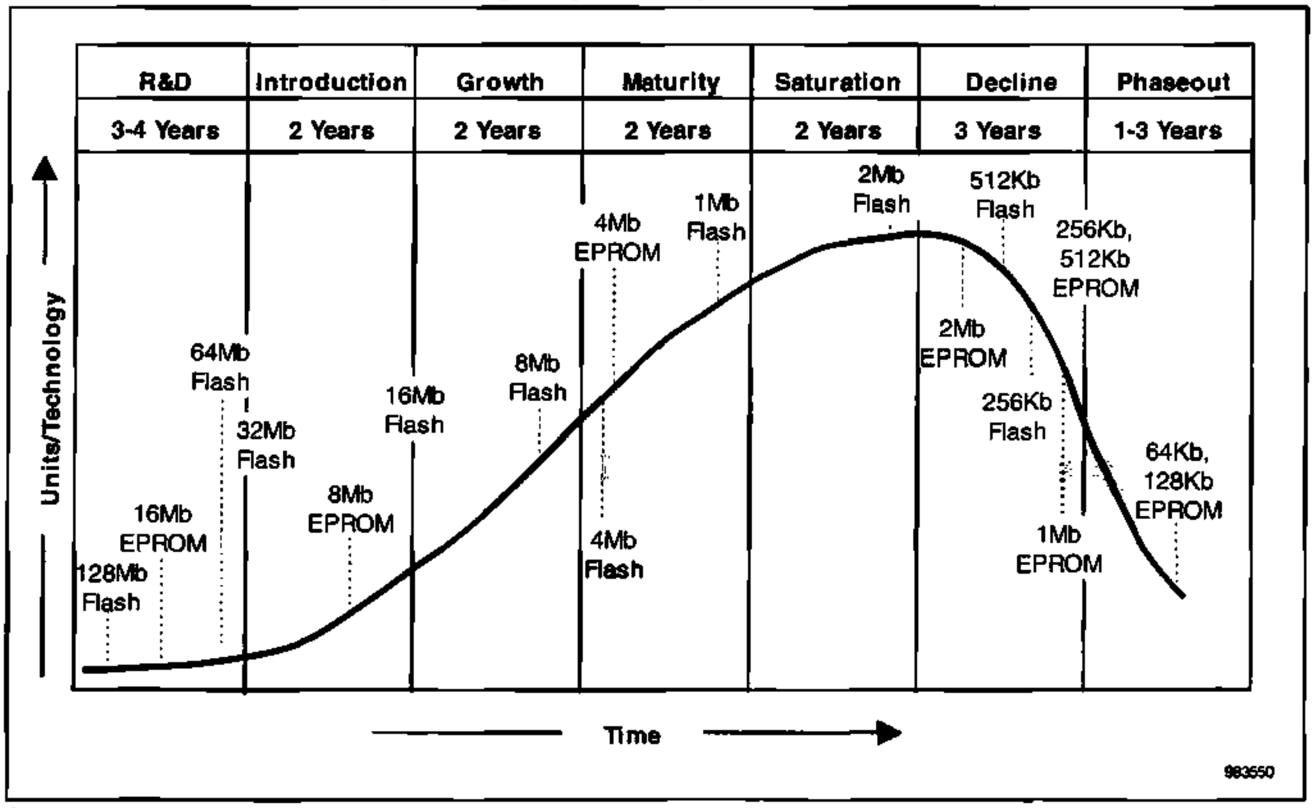
The nonvolatile market comprises four distinct devices: flash memory, EPROM, EEPROM, and mask ROM. The Dataquest definitions for these devices are as follows:

- Flash memory: Includes nonvolatile product designed as flash EPROM/EEPROM that incorporates 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 only erase data by bulk/chip, not by byte.
- EPROM: Erasable programmable read-only memory. This product classification includes ultraviolet (UV) EPROM and one-time programmable read-only memory (OTP ROM). EPROMs have memory cells consisting of a single transistor and do not require memory cell refreshes.
- 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 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.
- Mask ROM: Mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacturer to a customer specification using a mask step. Mask ROM is programmed in hardware rather than 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 units shipments per technology density. This is divided into two sections: flash and EPROM in Figure 4-1 and EEPROM and mask ROM in Figure 4-2.

Figure 4-1
Flash and EPROM Life Cycle Stages by Density



Source: Dataquest (July 1998)

Flash and EPROM

Figure 4-1 shows the life cycle curves for flash and EPROM at various densities. Clearly, EPROM is stronger in the lower-density parts, while flash dominates the higher densities.

The sole EPROM density at the R&D stage is the 16Mb device. This remains the highest-density EPROM on the Dataquest life cycle curve. The 8Mb EPROM has moved swiftly into the introduction stage on its life cycle. Volume will continue to increase at this density, despite the overall shrinkage of the worldwide EPROM market. The 4Mb EPROM is now in the maturity phase, with volumes continuing to ramp up.

The 256Kb and 512Kb EPROMs are both positioned on the borderline between the decline and phaseout stages of their life cycle curve. The 1Mb and 2Mb EPROM devices are also in the decline stage. However, the position of these four EPROM devices is in ascending density order—the higher the density, the further left in the decline section of the figure.

Three flash devices are set to become the volume players in years to come—32Mb, 64Mb, and 128Mb. They are all currently in the R&D stage, although the 32Mb is getting ready to move to the introduction stage.

The 1Mb and 2Mb flash devices are still volume players, but the 4Mb, 8Mb, and 16Mb densities are in a quick volume ramp up. The 2Mb flash is pretty much at the top of the hill. It will be downhill from here on, meaning it should fall into its decline stage during 1998. The 1Mb flash is in the maturity phase of its life cycle curve based on its 1997 unit shipments. However, by 1998 it will have migrated to the saturation stage.

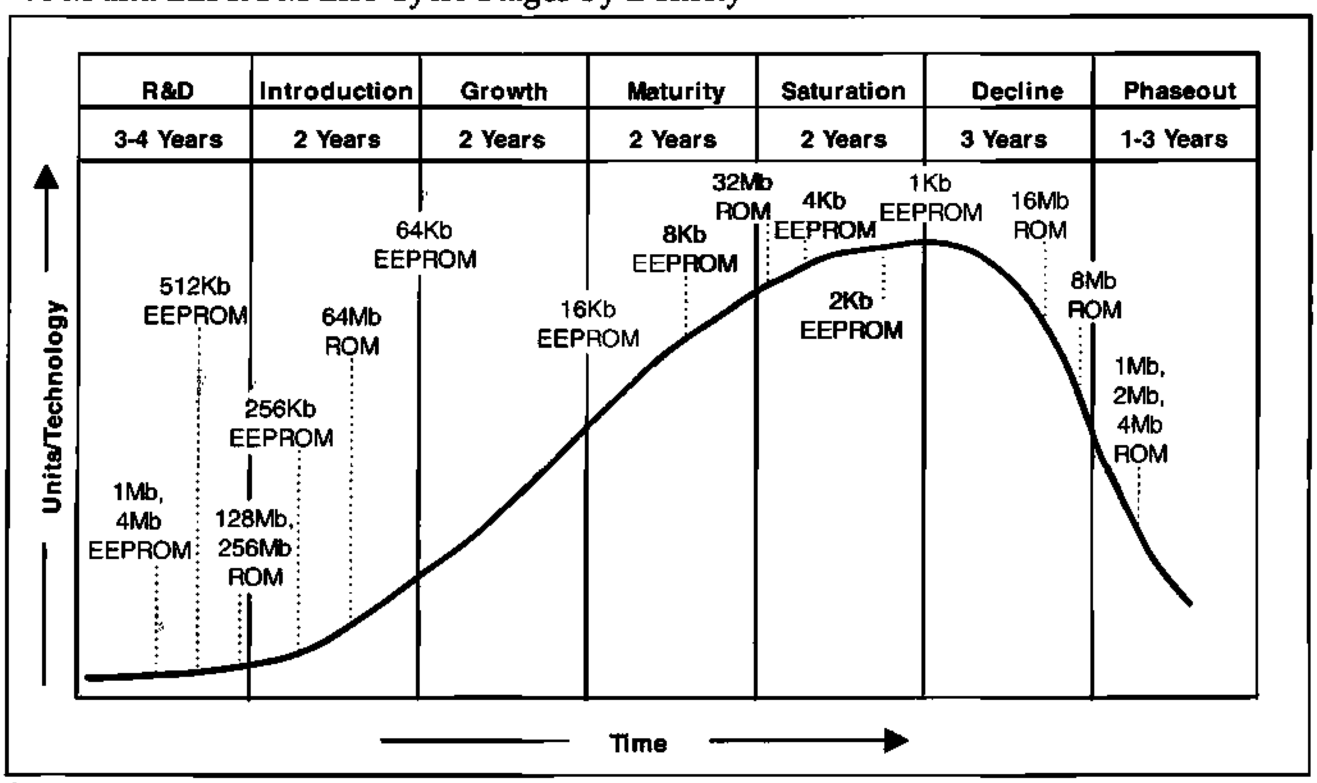
The 4Mb flash density has just entered its maturity phase. Volume is set to ramp up faster over the next few years before it begins to wane. The 8Mb flash density is in the middle of its growth stage, and if telecommunications volumes take off in 1998, it may well move to the maturity phase during 1998. The 16Mb flash density is climbing the barrier dividing introduction and growth stages. This density will definitely be in the growth phase during 1998.

No flash densities are in the phaseout stage at the moment, but there are two densities in the decline stage—the 256Kb and 512Kb.

Mask ROM and EEPROM

Figure 4-2 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 ROM densities are much higher. Typically, EEPROMs are in kilobytes, while ROMs are in megabytes. For example, while the 1Mb and 4Mb ROMs are in the phaseout stage, the EEPROMs at these densities are only at the R&D stage.

Figure 4-2
ROM and EEPROM Life Cycle Stages by Density



Source: Dataquest (July 1998)

EEPROMs are "newer" in terms of life cycle positioning. There are no EEPROMs in either the decline or phaseout stages. Three EEPROM densities are in the saturation stage—the 1Kb, 2Kb, and 4Kb. While the 1Kb and 2Kb are set to drop into the decline stage, the 4Kb density has yet to reach its highest volume point.

The 8Kb EEPROM is halfway through the maturity phase of its life cycle, while the 16Kb EEPROM is stuck between the growth and maturity phases. Bottom line, both have potential for much more volume growth. The 64Kb EEPROM is beginning to increase in volumes and should move well into the growth stage during 1998.

The 256Kb EEPROM is just starting to ship in any meaningful volumes and is at the halfway point in its introduction stage. As mentioned earlier, the 512Kb, 1Mb, and 4Mb EEPROM devices remain in the R&D stage. There is still a lack of EEPROM applications for these higher-density devices.

The ROM market is transitioning between the 16Mb and 32Mb densities. The 16Mb has just slipped into the decline phase, but the 32Mb has entered its saturation stage and has plenty of time for further unit shipment growth. Currently, there are no ROM densities in either the growth or maturity stages.

The up-and-coming ROM density, the 64Mb, is in the introduction phase; depending on 1998 shipments, it may move to the growth phase soon. Two densities are in the R&D stage of their life cycle—the 128Mb and 256Mb products. At the other end of the scale, the 1Mb, 2Mb, and 4Mb ROM densities are in the twilight zone and represent a rapidly shrinking market. They are all at the phaseout stage of their life cycle curve.

Market Share

Table 4-1 shows the 1997 nonvolatile total worldwide market share by supplier, based on vendor revenue. It was a poor year for revenue, with the market shrinking from 1996 to 1997. All four nonvolatile devices families experienced a revenue decline over the 12-month period. While the EPROM market has been weakening for some time, the other growth areas did suffer from production overcapacity, which caused price declines.

The big news on the overall ranking is that Advanced Micro Devices Inc. moved into second place, behind Intel, at the expense of Altera. Likewise, Sharp Electronics Corporation swapped places with SGS-Thomson (now STMicroelectronics) between 1996 and 1997 and moved into fourth position. All other suppliers maintained their 1996 market share placing.

Table 4-1
1997 Worldwide Market Share Rankings for Nonvolatile Memory Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Intel	850
2	3	AMD	707
3	2	Atmel	670
4	5	Sharp	475
5	4	SGS-Thomson	467
6	6	Fujitsu	459
7	7	Macronix	300
8	8	NEC	236
9	9	TI	236
10	10	Samsung	135

Source: Dataquest (July 1998)

Market Share by Device Family

Flash

Table 4-2 shows the top 10 flash suppliers by revenue for 1997. While the flash market experienced a slight shrinkage of 3.2 percent from 1996 to 1997, there were some big individual revenue winners and losers.

Table 4-2
1997 Worldwide Market Share Rankings for Flash Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Intel	850
2	2	AMD	613
3	3	Fujitsu	443
4	4	Atmel	245
5	5	Sharp	144
6	6	SGS-Thomson	79
7	7	Silicon Storage Technology	75
8	9	TI	62
9	11	Macronix	47
10	14	Mitsubishi	38

Source: Dataquest (July 1998)

Even though Intel and Atmel held on to the No. 1 and No. 4 positions, respectively, they both experienced revenue declines. AMD and Fujitsu, however, both expanded their revenue significantly, even though their market position was unchanged.

Market share positions changed little in the 12 months, apart from positions No. 8 through 10. TI moved up a place into No. 8, while Macronix and Mitsubishi moved up two and four places, respectively, and placed in the top 10 for 1997.

EPROM

The year 1997 saw another decline in terms of growth for EPROM, with the market dropping by over 37 percent. Table 4-3 shows the worldwide ranking for EPROM suppliers for 1997.

No change occurred in market share ranking from 1996 to 1997 for the top five EPROM suppliers. However, positions No. 6 to No. 10 saw plenty of volatility, save for Hitachi, which remained at No. 8. NEC, Fairchild, and Oki all climbed places while Cypress Semiconductor fell some. Any market share rise can be viewed as positive. However, as the total EPROM market is rapidly declining, the achievement is more of a pyrrhic victory.

Table 4-3
1997 Worldwide Market Share Rankings for EPROM Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	SGS-Thomson	251
2	2	Atmel	190
3	3	AMD	94
4	4	TI	93
5	5	Macronix	49
6	10	NEC	35
7	-	Fairchild	25
8	8	Hitachi	17
9	13	Oki	10
10	6	Cypress	8

Source: Dataquest (July 1998)

EEPROM

The EEPROM market revenue declined by just under 8 percent from 1996 to 1997. Table 4-4 shows the top 10 EEPROM suppliers by revenue for 1997.

While many of the suppliers changed their positions, only Fairchild jumped into the top 10. The big shakeup was SGS-Thomson dropping to No. 2, with Atmel taking over the No. 1 spot. Both these vendors lost revenue in 1997, but where Atmel dropped by 0.4 percent, SGS-Thomson took a battering nearly 47 percent revenue dip.

Table 4-4
1997 Worldwide Market Share Rankings for EEPROM Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	2	Atmel	235
2	1	SGS-Thomson	137
3	4	Microchip Technology	124
4	3	Xicor	122
5	6	TI	80
6	7	Siemens	76
7	8	Catalyst	62
8	-	Fairchild	51
9	9	NEC	31
10	10	Rohm	29

Source: Dataquest (July 1998)

Mask ROM

Table 4-5 shows the top 10 mask ROM suppliers by revenue for 1997. Mask ROM revenue is shrinking, down nearly a fifth from 1996.

Macronix was the only top 10 mask ROM vendor to post positive revenue growth, which helped propel it into the No. 2 position, behind Sharp but ahead of NEC and Samsung. Toshiba and Oki both retained their 1996 market positions (No. 5 and No. 8, respectively), but LG Semicon swapped places with Hitachi and rose a place, as did Hualon Microelectronics Corporation, which climbed from No. 10 to No. 9. Winbond Electronics Corporation ascended into the top 10 from its No. 11 position in 1996.

Table 4-5
1997 Worldwide Market Share Rankings for Mask ROM Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Sharp	329
2	4	Macronix	204
3	3	NEC	154
4	2	Samsung	101
5	5	Toshiba	76
6	7	LG Semicon	46
7	6	Hitachi	41
8	8	Oki	31
9	10	Hualon	14
10	11	Winbond Electronics	11

Source: Dataquest (July 1998)

Nonvolatile Technology Trends

Flash

The flash market shows the following trends:

- Dominated by strong alliances—Intel and Sharp versus AMD and Fujitsu
- NOR technology still the strongest from a revenue point of view
- Smart-voltage NOR technology available from Intel, Sharp, and Micron; Fujitsu and AMD offer true low-voltage devices, down to 2.7V
- Seeing NOR suppliers investigating NAND technology and vice versa
- Current applications: cellular phones, flash cards, PC basic input/output system (BIOS)
- New applications: voice storage, camera, auto navigation, and handy phone

EPROM

The EPROM market shows the following trends:

- Market is mature and new applications are converting to flash
- Fewer and fewer suppliers making the high-density parts
- Traditional users: Telecommunications (modems and cellular telephone handsets), data processing (PC BIOS and hard disk drive [HDD] controllers)

EEPROM

The EEPROM market shows the following trends:

- This is the most nichelike area of nonvolatile memory, but it will have steady growth patterns.
- New higher-density parts are increasing in use.
- In Europe, use of smart/memory cards is growing.
- Applications are varied: DRAM DIMMs, automobile air bags, communications (cellular mobile handsets and pagers), and various microcontroller (MCU)-based applications.

Mask ROM

The mask ROM market shows the following trends:

- The slump in the Japanese consumer electronics market is hitting this segment particularly hard.
- No new markets are developing—games are still the mask ROM driver.
- Some video games are starting to use CD-ROM.

Flash—Code versus Data

There are many ways of splitting the flash market, but perhaps the most basic technical division is into "code" and "data" segments.

The basic model for code storage is executable software for an MCU stored in a flash chip and subsequently directly executed from it at the processor clock frequency. A variation on this theme is code stored in a flash chip but not directly executed. Instead, the program is moved to RAM and executed there. Dataquest refers to this as indirect execution. This distinction is important as it has a bearing on device specifications and bit growth rates; embedded code tends to be smaller and less subject to expansion than data, especially if the data being recorded is sounds or images.

Data storage is information stored (or written) in the flash chip but not read at top speed. A variation of data storage is used for remembering a small number of critical program parameters, such as setup preferences, which the operating software refers to for decisions. Systems without flash often use EEPROM for this function, but having a flash chip in the systems allows the designer to remove a redundant chip if desired.

Table 4-5 outlines the basic characteristics associated with code and data storage flash.

For code storage, fast read speed, boot block organization, and in-system update are clearly the principal characteristics. For data storage, fast write speed, lower price, higher density, and small erase blocks are main attributes.

Table 4-6
Code versus Data Flash Characteristics

	Code Storage	Data Storage
Fast Read Speed	X	-
Boot Block Organization	X	-
In-System Update	X	-
Fast Write Speed	-	X
Low Price per Bit	-	X
High Density	-	X
Small Erase Blocks	-	X

Source: Dataquest (July 1998)

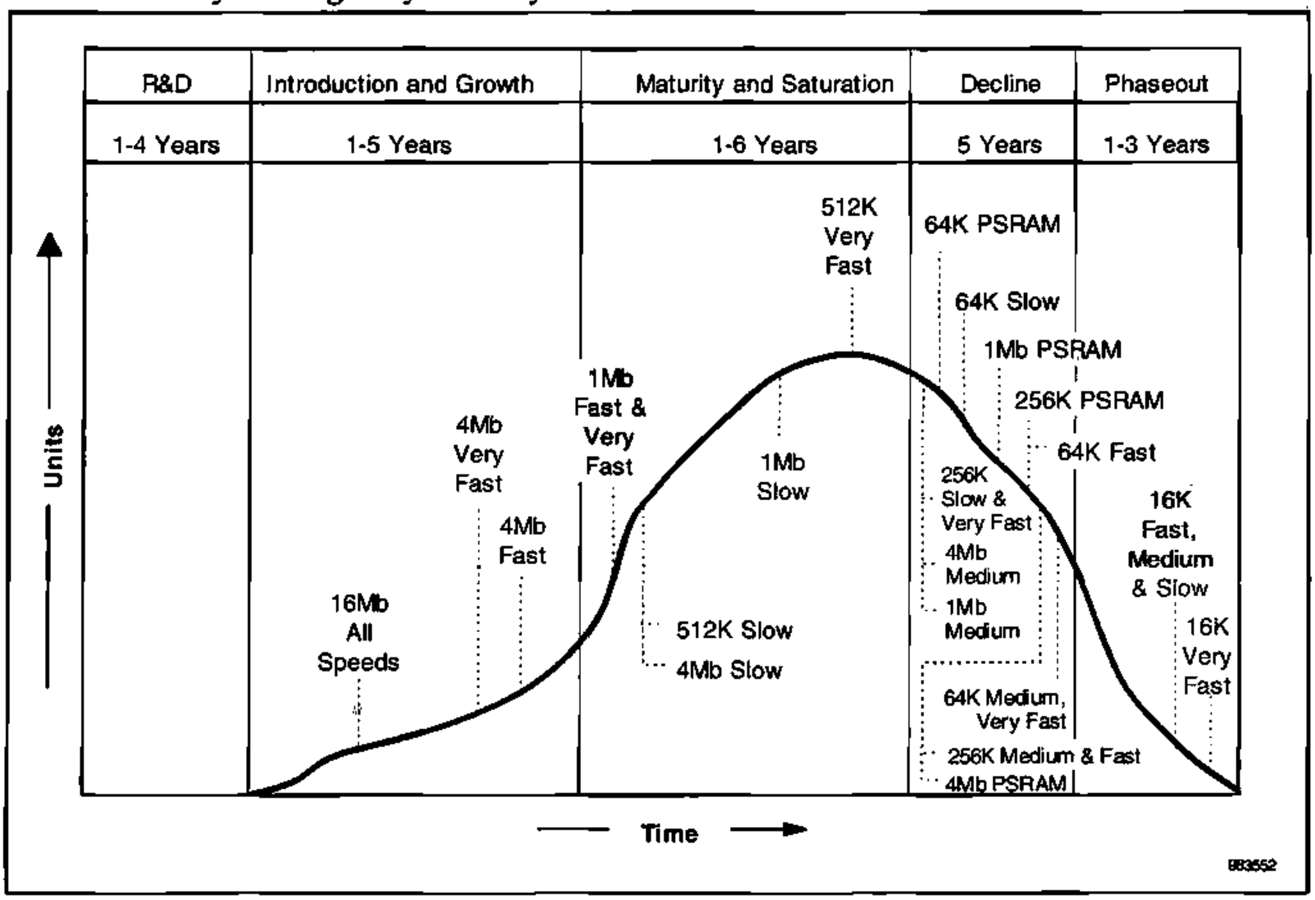
Chapter 5
Static Random-Access Memory—SRAM

This chapter looks at the SRAM life cycle and market share.

SRAM Product Life Cycles

The life cycle curve in Figure 5-1 is based on actual 1997 SRAM shipment volume. Because of the varied applications that utilize SRAM, the overall SRAM life cycle is about twice that of DRAM. It is important to note that SRAM used in PCs (primarily pipelined burst x32 products) will have a much shorter-than-average SRAM life cycle because of the accelerated life cycle of the end system application. Additionally, due to changes made by Intel to its next-generation processors, the makeup of the SRAM supplier base and overall discrete SRAM end applications may change.

Figure 5-1
SRAM Life Cycle Stages by Density



PSRAM = Pseudo SRAM
Note: Speeds are defined as slow (>70ns), medium (45 to 70ns), fast (10 to 44ns), and very fast (<10ns).
Source: Dataquest (July 1998)

The 512Kb very fast SRAM device has nearly reached its maximum unit shipment level and thus is almost at the peak of the maturity/saturation curve. The 1Mb slow SRAM is about one to two years behind and still has growth time left in the maturity/saturation stage.

The 1Mb fast and very fast devices have just entered the maturity/saturation section of their life cycle curve. Volumes are starting to take off, and good growth is forecast for the medium term. Slightly ahead of them are the 512Kb slow and 4Mb slow devices. Both are still growing in terms of unit volume and offering attractive price declines.

The low-density SRAM devices are slowly making their way through their life cycle, and now all speeds of the 16Kb SRAM are in the phaseout stage. Both the 64Kb and 256Kb devices (at all speeds) are all in the decline stage but in different positions. Keeping these two densities company in the decline stage are the medium speeds 1Mb and 4Mb and the 1Mb and 4Mb pseudo SRAM (PSRAM) densities.

At the opposite end of the spectrum are the devices in their introduction/growth stage. Currently, all 16Mb SRAM devices are climbing up this section of the curve but trailing behind the two 4Mb devices there. The 4Mb fast device is nearly ready to move to the maturity/saturation stage, while the 4Mb very fast device still has about another year left in the introduction/growth stage.

SRAM Market Share

Table 5-1 shows the top 10 SRAM suppliers by revenue for 1997. SRAM revenue fell by over 20 percent from 1996 to 1997. Again, excess capacity caused price declines so that despite an increase in unit shipments, overall revenue declined.

Table 5-1
1997 Worldwide Market Share Rankings for SRAM Suppliers (Revenue in Millions of Dollars)

1997 Ranking	1996 Ranking	Company	1997 Revenue
1	1	Samsung	591
2	2	Hitachi	425
3	5	NEC	360
4	9	IBM	350
5	4	Toshiba	347
6	3	Motorola	316
7	7	Mitsubishi	275
8	8	Cypress	208
9	6	Sony	191
10	10	IDT	172

Source: Dataquest (July 1998)

It was a bad year for SRAM suppliers; most lost revenue despite retaining market share position. Samsung, Hitachi, Mitsubishi, Cypress, and Integrated Device Technology (IDT) all stayed at the same ranking. NEC rose two places to come in third, while Toshiba dropped from fourth to fifth position. Sony and Motorola both fell three places, to No. 9 and No. 6 positions, respectively.

IBM was the only one of top 10 SRAM suppliers that gained revenue in 1997. It grew by over 52 percent despite the shrinking market characteristics and as a result was catapulted from No. 9 position in 1996 to No. 4 position in 1997, just $10 million behind NEC.

Chapter 6
Summary

The year 1997 was tough for semiconductor suppliers, which found their golden cash cow drying out. Plummeting prices caused massive revenue declines in many areas, particularly memory. With continued oversupply of semiconductor capacity, 1998 looks set to mirror the price declines of 1997.

Despite the declining revenue in most of the semiconductor arenas, actual customer requirements remain strong and are growing in unit terms. However, as the level of price decrease is faster than the rate of unit increase, it appears that the semiconductor market is shrinking. This is not the case. Dataquest is forecasting strong long-term growth for semiconductors out to 2002.

This is not entirely a tale of doom and gloom. The winners in this shrinking semiconductor revenue market are the buyers, which have never had it so good. Not only have product lead times reduced (due to oversupply), but prices reductions have become the norm. Buyers first moved into the driver seat in late 1995 and are now extremely comfortable in front of the pricing dashboard.

Dataquest expects the production excesses to slowly shrink over time so that by the end of 2000 greater supply/demand equilibrium will be approached, to be followed by a period of shortage. However, it will be difficult for suppliers to take back pricing control. Buyers will do their utmost to resist any upward price movement, so suppliers should be warned.

Some of the main semiconductor wild cards include the following:

- Antidumping trusts by the U.S. Department of Commerce or European Union
- Financial troubles forcing a decrease in the semiconductor supplier base (bankruptcy) or a decrease in semiconductor focus (plant closures or plant fire sales)
- Semiconductor mergers and acquisitions in an effort to save money
- Taiwanese suppliers causing further destabilization in an effort to gain market share
- Continued Asian financial crisis (AFC) rumors

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@dataquest.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest/Gartner Group
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: +1-408-468-8000
Facsimile: +1-408-954-1780

East Coast Research Center
Gartner Group Lowell
900 Chelmsford Street
Tower Two, Floor Nine
Lowell, Massachusetts 01851
United States
Phone: +1-978-446-0006
Facsimile: +1-978-323-6933

EUROPE

European Headquarters
Gartner Group Ltd.
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44-1784-431-611
Facsimile: +44-1784-488-980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33-1-41-35-13-00
Facsimile: +33-1-41-35-13-13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49-89-42-70-4-0
Facsimile: +49-89-42-70-4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153-0042
Japan
Phone: +81-3-3481-3670
Facsimile: +81-3-3481-3644

ASIA/PACIFIC

Asia Headquarters
Gartner Group Hong Kong
Suite 5904-7, Central Plaza
18 Harbour Road
Wanchai
Hong Kong
Phone: +852-2824-6168
Facsimile: +852-2824-6138

Pacific Headquarters
Gartner Group Pacific
80 Alfred Street - 6th Floor
Milsons Point, NSW 2061
Australia
Phone: +61-2-9941-4860
Facsimile: +61-2-9941-4868

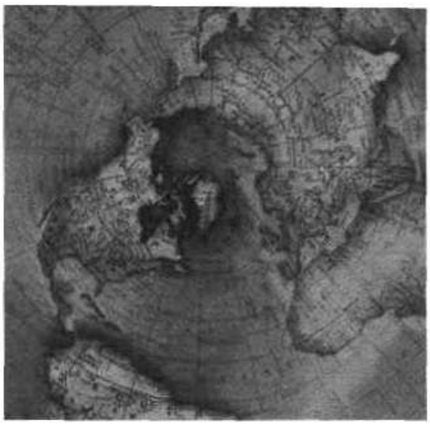
Korea
Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: +82-2-551-1331
Facsimile: +82-2-551-1330

Taiwan
Gartner Group Taiwan Ltd.
11F-2, 188, Section 5
Nan King East Road
Taipei 105
Taiwan R.O.C.
Phone: +886-2-2756-0389
Facsimile: +886-2-2756-2663/4122

Thailand
Gartner Group Thailand Ltd.
29 Vanissa Building, 12F
Soi Chidlom, Ploenchit Road
Pathumwan, Bangkok 10330
Thailand
Phone: +662-655-0577
Facsimile: +662-655-0576

Singapore
Gartner Group/DQ Research Pte Ltd.
6 Temasek Boulevard #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: +65-333-6773
Facsimile: +65-333-6787

Dataquest
A Gartner Group Company



Dataquest

North American Semiconductor Prices, Third Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9803
Publication Date: June 29, 1998
Filing: Market Statistics

North American Semiconductor Prices, Third Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9803
Publication Date: June 29, 1998
Filing: Market Statistics

Table of Contents

List of Tables

Chapter 1

North American Semiconductor Prices, Third Quarter 1998

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 (SSPS) 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 SSPS clients that use the SSPS online service through CompuServe, the prices presented here correlate with the quarterly and long-range price tables dated June 1998 in the SSPS online service. Clients who want to access the information on the World Wide Web can pay extra for a Dataquest on GartnerGroup Interactive subscription, which allows users to access all their deliverables at their desktops. 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.

Chapter 2
Market Statistics Tables

Tables 2-1 through 2-16 show statistics on North American semiconductor prices.

Table 2-1
Estimated Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
74LS TTL											
74LS00	0.13	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	3-8
74LS74	0.16	0.15	0.14	0.14	0.15	0.13	0.13	0.12	0.12	0.13	3-8
74LS138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74LS244	0.22	0.21	0.20	0.20	0.21	0.19	0.19	0.18	0.18	0.19	3-8
74AC TTL											
74AC00	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	3-8
74AC74	0.18	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	3-8
74AC138	0.28	0.28	0.26	0.26	0.27	0.25	0.25	0.25	0.25	0.25	3-8
74AC244	0.36	0.36	0.36	0.36	0.36	0.33	0.33	0.33	0.33	0.33	3-8
74F TTL											
74F00	0.12	0.11	0.10	0.10	0.11	0.09	0.09	0.08	0.08	0.09	3-8
74F74	0.14	0.13	0.12	0.12	0.13	0.11	0.11	0.10	0.10	0.11	3-8
74F138	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	3-8
74F244	0.21	0.20	0.19	0.19	0.20	0.19	0.19	0.18	0.18	0.19	3-8
74HC CMOS											
74HC00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	3-8
74HC74	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	3-8
74HC138	0.17	0.16	0.15	0.15	0.16	0.14	0.14	0.14	0.14	0.14	3-8
74HC244	0.21	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.19	0.19	3-8
74ALS TTL											
74ALS00	0.14	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	3-8
74ALS74	0.15	0.15	0.14	0.14	0.15	0.13	0.13	0.13	0.13	0.13	3-8
74ALS138	0.20	0.20	0.20	0.20	0.20	0.19	0.19	0.18	0.18	0.19	3-8
74ALS244	0.27	0.25	0.25	0.24	0.25	0.23	0.23	0.22	0.22	0.23	3-8
74AS TTL											
74AS00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS74	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS138	0.40	0.39	0.39	0.39	0.39	0.38	0.38	0.37	0.37	0.38	3-8
74AS244	0.61	0.61	0.61	0.61	0.61	0.57	0.57	0.55	0.55	0.56	3-8

Table 2-1 (Continued)
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
74BC											
74BC00	0.19	0.19	0.18	0.18	0.19	0.17	0.17	0.17	0.17	0.17	3-8
74BC244	0.48	0.48	0.46	0.46	0.47	0.44	0.44	0.40	0.40	0.42	3-8
74BC373	0.50	0.50	0.46	0.46	0.48	0.44	0.44	0.42	0.42	0.43	3-8
74ACT244	0.38	0.38	0.34	0.34	0.36	0.31	0.31	0.27	0.27	0.29	3-8
74ACT245	0.40	0.35	0.33	0.33	0.35	0.31	0.31	0.27	0.27	0.29	3-8
74ABT244	0.49	0.45	0.42	0.42	0.44	0.36	0.36	0.34	0.34	0.35	3-8
74ABT245	0.52	0.46	0.42	0.42	0.46	0.36	0.36	0.34	0.34	0.35	3-8

*Pricing for 74BC excludes 74ABT and 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount.
These prices are intended for use as price guidelines.
Source: Dataquest (June 1998)

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

	1998	1999	2000	2001	2002
74LS TTL					
74LS00	0.13	0.12	0.12	0.13	0.13
74LS74	0.15	0.13	0.12	0.13	0.13
74LS138	0.17	0.17	0.18	0.19	0.19
74LS244	0.21	0.19	0.18	0.18	0.20
74AC TTL					
74AC00	0.15	0.14	0.14	0.14	0.16
74AC74	0.17	0.16	0.15	0.16	0.18
74AC138	0.27	0.25	0.24	0.26	0.26
74AC244	0.36	0.33	0.31	0.30	0.32
74F TTL					
74F00	0.11	0.09	0.08	0.08	0.10
74F74	0.13	0.11	0.09	0.09	0.10
74F138	0.16	0.15	0.15	0.15	0.16
74F244	0.20	0.19	0.18	0.18	0.19
74HC CMOS					
74HC00	0.11	0.11	0.11	0.11	0.13
74HC74	0.14	0.13	0.13	0.13	0.15
74HC138	0.16	0.14	0.14	0.14	0.16
74HC244	0.20	0.19	0.18	0.18	0.20
74ALS TTL					
74ALS00	0.14	0.13	0.12	0.12	0.14
74ALS74	0.15	0.13	0.12	0.12	0.14
74ALS138	0.20	0.19	0.18	0.17	0.19
74ALS244	0.25	0.23	0.20	0.20	0.22
74AS TTL					
74AS00	0.19	0.19	0.19	0.21	0.21
74AS74	0.19	0.19	0.19	0.21	0.21
74AS138	0.39	0.38	0.35	0.32	0.31
74AS244	0.61	0.56	0.52	0.50	0.49
74BC					
74BC00	0.19	0.17	0.17	0.18	0.18
74BC244	0.47	0.42	0.37	0.35	0.34
74BC373	0.48	0.43	0.38	0.35	0.34
74ACT244	0.36	0.29	0.26	0.26	0.26
74ACT245	0.35	0.29	0.25	0.23	0.22
74ABT244	0.44	0.35	0.31	0.29	0.27
74ABT245	0.46	0.35	0.31	0.29	0.27

*Pricing for 74BC excludes 74ABT and 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (June 1998)

Table 2-3
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
68EC020-25 PQFP	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	2-4
68040-25	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
68LC040-25 CQFP 184	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
Pentium-166 MHz 3.3v PGA	85.00	80.00	78.00	75.00	79.50	EOL	EOL	EOL	EOL	EOL	2-4
Pentium-200 MHz 3.3v PGA	110.00	100.00	90.00	85.00	96.25	EOL	EOL	EOL	EOL	EOL	2-4
Pentium MMX 166 MHz 2.8v PGA	90.00	85.00	83.00	80.00	84.50	EOL	EOL	EOL	EOL	EOL	2-4
Pentium MMX 200 MHz 2.8v PGA	110.00	100.00	90.00	85.00	96.25	80.00	80.00	80.00	80.00	80.00	2-4
Pentium MMX 233 MHz 2.8V PGA	175.00	125.00	100.00	90.00	122.50	85.00	85.00	85.00	85.00	85.00	2-4
Pentium II 233 MHz 512KB Cache	260.00	190.00	190.00	150.00	197.50	145.00	145.00	145.00	145.00	145.00	2-4
Pentium II 266 MHz 512KB Cache	350.00	250.00	180.00	145.00	231.25	145.00	145.00	145.00	145.00	145.00	2-4
Pentium II 300 MHz 512KB Cache	500.00	350.00	300.00	200.00	337.50	175.00	175.00	150.00	150.00	162.50	2-4
Pentium II 350 MHz 512KB Cache	NA	600.00	425.00	200.00	408.33	190.00	185.00	175.00	145.00	173.75	2-4
Pentium II 400 MHz 512KB Cache	NA	800.00	475.00	350.00	541.67	350.00	300.00	250.00	200.00	275.00	2-4
Pentium II 450 MHz 512KB Cache	NA	NA	NA	640.00	640.00	540.00	450.00	350.00	275.00	403.75	2-4
Pentium II 266 MHz 0KB Cache	NA	140.00	99.00	90.00	109.67	90.00	90.00	90.00	90.00	90.00	2-4
Pentium II 300 MHz 128 KB intCache	NA	NA	140.00	130.00	135.00	105.00	95.00	90.00	90.00	95.00	2-4
Pentium Pro-166 512KB Cache	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	2-4
Pentium Pro-200 512KB Cache	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	940.00	2-4
Pentium Pro-200 1MB Cache	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2,350.00	2-4
Pentium II/2 400MHz 512KB Cache	NA	NA	1,050.00	800.00	925.00	800.00	775.00	775.00	775.00	781.25	2-4
Pentium II/2 400 MHz 1024KB Cache	NA	NA	2,700.00	2,700.00	2,700.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	2-4
Pentium II/2 450 MHz 512KB Cache	NA	NA	1,050.00	800.00	925.00	800.00	775.00	775.00	775.00	781.25	2-4
Pentium II/2 450 MHz 1024KB Cache	NA	NA	2,700.00	2,700.00	2,700.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	2-4
Pentium II/2 450 MHz 2048KB Cache	NA	NA	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	2-4
PowerPC603e-100	34.00	33.32	32.65	32.00	32.99	31.36	30.73	30.12	29.52	30.43	2-4
PowerPC603e-133	135.00	132.30	129.65	127.06	131.00	124.52	122.03	119.59	117.20	120.83	2-4
PowerPC604e-250	375.00	367.50	360.15	352.95	363.90	345.89	338.97	332.19	325.55	335.65	2-4
PowerPC604e-300	424.00	415.52	407.21	399.07	411.45	391.08	383.26	375.60	368.09	379.51	2-4

Table 2-3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
PowerPC604e-350	475.00	465.50	456.19	447.07	460.94	438.12	429.36	420.78	412.36	425.16	2-4
PowerPC740-200	150.00	147.00	144.06	141.18	145.56	138.36	135.59	132.88	130.22	134.26	2-4
PowerPC740-233	175.00	171.50	168.07	164.71	169.82	161.41	158.19	155.02	151.92	156.64	2-4
PowerPC740-266	275.00	269.50	264.11	258.83	266.86	253.65	248.58	243.61	238.73	246.14	2-4
PowerPC750-233	200.00	196.00	192.08	188.24	194.08	184.47	180.78	177.17	173.63	179.01	2-4
PowerPC750-266	300.00	294.00	288.12	282.36	291.12	276.71	271.18	265.75	260.44	268.52	2-4

EOL = End of life
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 1998)

Table 2-4
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998	1999	2000	2001	2002
68EC020-25 PQFP	16.88	16.88	16.88	16.88	16.88
68040-25	24.20	24.20	24.20	24.20	24.20
68LC040-25 CQFP 184	24.20	24.20	24.20	24.20	24.20
Pentium-166 MHz 3.3v PGA	79.50	EOL	EOL	EOL	EOL
Pentium-200 MHz 3.3v PGA	96.25	EOL	EOL	EOL	EOL
Pentium MMX 166 MHz 2.8v PGA	84.50	EOL	EOL	EOL	EOL
Pentium MMX 200 MHz 2.8v PGA	96.25	80.00	EOL	EOL	EOL
Pentium MMX 233 MHz 2.8V PGA	122.50	85.00	EOL	EOL	EOL
Pentium II 233 MHz 512KB Cache	197.50	145.00	EOL	EOL	EOL
Pentium II 266 MHz 512KB Cache	231.25	145.00	EOL	EOL	EOL
Pentium II 300 MHz 512KB Cache	337.50	162.50	EOL	EOL	EOL
Pentium II 350 MHz 512KB Cache	408.33	173.75	EOL	EOL	EOL
Pentium II 400 MHz 512KB Cache	541.67	275.00	200.00	200.00	EOL
Pentium II 450 MHz 512KB Cache	640.00	403.75	250.00	250.00	EOL
Pentium II 266 MHz 0KB Cache	109.67	90.00	EOL	EOL	EOL
Pentium II 300 MHz 128 KB intCache	135.00	95.00	EOL	EOL	EOL
Pentium Pro-166 512KB Cache	380.00	380.00	EOL	EOL	EOL
Pentium Pro-200 512KB Cache	940.00	940.00	EOL	EOL	EOL
Pentium Pro-200 1MB Cache	2,350.00	2,350.00	EOL	EOL	EOL
Pentium II/2 400MHz 512KB Cache	925.00	781.25	775.00	775.00	775.00
Pentium II/2 400 MHz 1024KB Cache	2,700.00	1,800.00	1,800.00	1,800.00	1,800.00
Pentium II/2 450 MHz 512KB Cache	925.00	781.25	775.00	775.00	775.00
Pentium II/2 450 MHz 1024KB Cache	2,700.00	1,800.00	1,800.00	1,800.00	1,800.00
Pentium II/2 450 MHz 2048KB Cache	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00
PowerPC603e-100	32.99	30.43	29.52	29.52	29.52
PowerPC603e-133	131.00	120.83	117.20	117.20	117.20
PowerPC604e-250	363.90	335.65	325.55	325.55	325.55
PowerPC604e-300	411.45	379.51	368.09	368.09	368.09
PowerPC604e-350	460.94	425.16	412.36	412.36	412.36
PowerPC740-200	145.56	134.26	130.22	130.22	130.22
PowerPC740-233	169.82	156.64	151.92	151.92	151.92
PowerPC740-266	266.86	246.14	238.73	238.73	238.73
PowerPC750-233	194.08	179.01	173.63	173.63	173.63
PowerPC750-266	291.12	268.52	260.44	260.44	260.44

EOL = End of life
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 1998)

Table 2-5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
4Mbx1 DRAM 70ns SOJ 5V	2.17	2.09	2.07	2.00	2.08	2.00	1.95	1.93	1.90	1.95	2-8
1Mbx4 DRAM 60ns SOJ 5V FPM	1.80	1.55	1.48	1.44	1.57	1.44	1.44	1.80	1.80	1.62	2-8
1Mbx4 DRAM 60ns SOJ 5V EDO	1.80	1.55	1.48	1.44	1.57	1.44	1.44	1.80	1.80	1.62	2-8
256Kx16 DRAM 70ns SOJ 5V	2.64	2.39	2.23	2.20	2.37	2.20	2.20	2.40	2.40	2.30	2-8
4Mbx4 DRAM 60ns SOJ 5V FPM	3.50	2.60	2.05	1.95	2.53	1.90	1.90	1.90	1.90	1.90	2-6
4Mbx4 DRAM 60ns SOJ 5V EDO	3.50	2.55	2.00	1.90	2.49	1.85	1.85	1.85	1.85	1.85	2-6
1Mbx16 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.05	1.95	2.53	1.90	1.90	1.90	1.90	1.90	2-6
1Mbx16 DRAM 60ns TSOP 5V EDO	3.50	2.55	2.00	1.90	2.49	1.85	1.85	1.85	1.85	1.85	2-6
1Mbx16 3.3V SDRAM	4.97	3.35	2.90	2.50	3.43	2.45	2.40	2.35	2.30	2.38	2-6
2Mbx8 DRAM 60ns TSOP 5V FPM	3.50	2.60	2.05	1.95	2.53	1.90	1.90	1.90	1.90	1.90	2-6
2Mbx8 DRAM SDRAM 3.3V	4.97	3.35	2.90	2.50	3.43	2.45	2.40	2.35	2.30	2.38	2-6
16Mbx4 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	9.50	8.00	13.19	7.60	7.30	7.10	7.00	7.25	2-5
16Mbx4 DRAM SOJ 3.3V SDRAM	24.02	11.40	9.50	8.00	13.23	7.55	7.24	7.05	6.95	7.20	2-5
8Mbx8 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	9.50	8.00	13.19	7.60	7.30	7.10	7.00	7.25	2-5
8Mbx8 DRAM SOJ 3.3V SDRAM	24.02	11.40	9.50	8.00	13.23	7.55	7.24	7.05	6.95	7.20	2-5
4Mbx16 DRAM 60ns SOJ 3.3V EDO	23.97	11.30	9.50	8.00	13.19	7.60	7.30	7.10	7.00	7.25	2-5
4Mbx16 DRAM SOJ 3.3V SDRAM	24.02	11.40	9.50	8.00	13.23	7.55	7.24	7.05	6.95	7.20	2-5
1Mbx32 SIMM 60ns 5V FPM	8.50	6.70	5.60	5.40	6.55	5.30	5.30	5.30	5.30	5.30	2-5
1Mbx36 SIMM 60ns 5V FPM	12.10	9.80	8.56	8.28	9.69	8.18	8.18	8.90	8.90	8.54	2-5
2Mbx32 SIMM 60ns 5V FPM	15.52	11.92	9.72	9.32	11.62	9.12	9.12	9.12	9.12	9.12	2-5
2Mbx36 SIMM 60ns 5V FPM	19.02	14.52	11.77	11.27	14.15	11.02	11.02	11.02	11.02	11.02	2-5
4Mbx32 SIMM 60ns 5V FPM	30.37	23.17	18.77	17.97	22.57	17.57	17.57	17.57	17.57	17.57	2-5
4Mbx36 SIMM 60ns 5V FPM	37.37	28.37	22.87	21.87	27.62	21.37	21.37	21.37	21.37	21.37	2-5
8Mbx32 SIMM 60ns 5V FPM	60.17	45.77	36.97	35.37	44.57	34.57	34.57	34.57	34.57	34.57	2-5
8Mbx36 SIMM 60ns 5V FPM	74.17	56.17	45.17	43.17	54.67	42.17	42.17	42.17	42.17	42.17	2-5
1Mbx32 SIMM 60ns 5V EDO	8.50	6.60	5.50	5.30	6.48	5.20	5.20	5.20	5.20	5.20	2-5
1Mbx36 SIMM 60ns 5V EDO	12.10	9.70	8.46	8.18	9.61	8.08	8.08	8.80	8.80	8.44	2-5

Table 2-5 (Continued)
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
2Mbx32 SIMM 60ns 5V EDO	15.52	11.72	9.52	9.12	11.47	8.92	8.92	8.92	8.92	8.92	2-5
2Mbx36 SIMM 60ns 5V EDO	19.02	14.27	11.52	11.02	13.96	10.77	10.77	10.77	10.77	10.77	2-5
4Mbx32 SIMM 60ns 5V EDO	30.37	22.77	18.37	17.57	22.27	17.17	17.17	17.17	17.17	17.17	2-5
4Mbx36 SIMM 60ns 5V EDO	37.37	27.87	22.37	21.37	27.25	20.87	20.87	20.87	20.87	20.87	2-5
8Mbx32 SIMM 60ns 5V EDO	60.17	44.97	36.17	34.57	43.97	33.77	33.77	33.77	33.77	33.77	2-5
8Mbx36 SIMM 60ns 5V EDO	74.17	55.17	44.17	42.17	53.92	41.17	41.17	41.17	41.17	41.17	2-5
1Mbx64 60ns 3.3V EDO	15.59	11.79	9.59	9.19	11.54	8.99	8.99	8.99	8.99	8.99	2-5
2Mbx64 60ns 3.3V EDO	50.31	24.97	21.37	18.37	28.76	17.57	16.97	16.57	16.37	16.87	2-5
4Mbx64 60ns 3.3V EDO	100.05	49.37	42.17	36.17	56.94	34.57	33.37	32.57	32.17	33.17	2-5
1Mbx64 3.3V SDRAM	21.41	14.93	13.13	11.53	15.25	11.33	11.13	10.93	10.73	11.03	2-5
2Mbx64 3.3V SDRAM	50.41	25.17	21.37	18.37	28.83	17.47	16.85	16.47	16.27	16.77	2-5
4Mbx64 3.3V SDRAM	100.25	49.77	42.17	36.17	57.09	34.37	33.13	32.37	31.97	32.96	2-5
256Kx32 SGRAM 66 MHz 3.3V	5.17	4.75	4.25	4.05	4.55	3.90	3.82	3.78	3.75	3.81	2-8
512Kx32 SGRAM 66 MHz 3.3V	11.44	9.75	8.90	8.10	9.55	7.75	7.60	7.45	7.35	7.54	2-8

*Contract volume is at least 100,000 per order.
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 1998)

Table 2-6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998	1999	2000	2001	2002
4Mbx1 DRAM 70ns SOJ 5V	2.08	1.95	1.90	2.00	2.20
1Mbx4 DRAM 60ns SOJ 5V FPM	1.57	1.62	1.90	2.00	2.10
1Mbx4 DRAM 60ns SOJ 5V EDO	1.57	1.62	1.90	2.00	2.10
256Kx16 DRAM 70ns SOJ 5V	2.37	2.30	2.60	2.90	3.20
4Mbx4 DRAM 60ns SOJ 5V FPM	2.53	1.90	2.10	2.50	2.70
4Mbx4 DRAM 60ns SOJ 5V EDO	2.49	1.85	2.05	2.50	2.70
1Mbx16 DRAM 60ns TSOP 5V FPM	2.53	1.90	2.10	2.50	2.70
1Mbx16 DRAM 60ns TSOP 5V EDO	2.49	1.85	2.05	2.50	2.70
1Mbx16 3.3V SDRAM	3.43	2.38	2.25	2.70	3.00
2Mbx8 DRAM 60ns TSOP 5V FPM	2.53	1.90	2.10	2.50	2.70
2Mbx8 DRAM SDRAM 3.3V	3.43	2.38	2.25	2.50	3.00
16Mbx4 DRAM 60ns SOJ 3.3V EDO	13.19	7.25	6.85	6.80	6.74
16Mbx4 DRAM SOJ 3.3V SDRAM	13.23	7.20	6.80	6.74	6.71
8Mbx8 DRAM 60ns SOJ 3.3V EDO	13.19	7.25	6.85	6.80	6.74
8Mbx8 DRAM SOJ 3.3V SDRAM	13.23	7.20	6.80	6.74	6.71
4Mbx16 DRAM 60ns SOJ 3.3V EDO	13.19	7.25	6.85	6.80	6.74
4Mbx16 DRAM SOJ 3.3V SDRAM	13.23	7.20	6.80	6.74	6.71
1Mbx32 SIMM 60ns 5V FPM	6.55	5.30	5.70	6.50	6.90
1Mbx36 SIMM 60ns 5V FPM	9.69	8.54	9.50	10.50	11.10
2Mbx32 SIMM 60ns 5V FPM	11.62	9.12	9.92	11.52	12.32
2Mbx36 SIMM 60ns 5V FPM	14.15	11.02	12.02	14.02	15.02
4Mbx32 SIMM 60ns 5V FPM	22.57	17.57	19.17	22.37	23.97
4Mbx36 SIMM 60ns 5V FPM	27.62	21.37	23.37	27.37	29.37
8Mbx32 SIMM 60ns 5V FPM	44.57	34.57	37.77	44.17	47.37
8Mbx36 SIMM 60ns 5V FPM	54.67	42.17	46.17	54.17	58.17
1Mbx32 SIMM 60ns 5V EDO	6.48	5.20	5.60	6.50	6.90
1Mbx36 SIMM 60ns 5V EDO	9.61	8.44	9.40	10.50	11.10
2Mbx32 SIMM 60ns 5V EDO	11.47	8.92	9.72	11.52	12.32
2Mbx36 SIMM 60ns 5V EDO	13.96	10.77	11.77	14.02	15.02
4Mbx32 SIMM 60ns 5V EDO	22.27	17.17	18.77	22.37	23.97
4Mbx36 SIMM 60ns 5V EDO	27.25	20.87	22.87	27.37	29.37
8Mbx32 SIMM 60ns 5V EDO	43.97	33.77	36.97	44.17	47.37
8Mbx36 SIMM 60ns 5V EDO	53.92	41.17	45.17	54.17	58.17
1Mbx64 60ns 3.3V EDO	11.54	8.99	9.79	11.59	12.39
2Mbx64 60ns 3.3V EDO	28.76	16.87	16.07	15.97	15.85
4Mbx64 60ns 3.3V EDO	56.94	33.17	31.57	31.37	31.13
1Mbx64 3.3V SDRAM	15.25	11.03	10.53	12.33	13.53
2Mbx64 3.3V SDRAM	28.83	16.77	15.97	15.85	15.79
4Mbx64 3.3V SDRAM	57.09	32.96	31.37	31.13	31.01
256Kx32 SGRAM 66 MHz 3.3V	4.55	3.81	3.65	3.58	3.56
512Kx32 SGRAM 66 MHz 3.3V	9.55	7.54	7.20	7.08	7.04

*Contract volume is at least 100,000 per order.

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 1998)

Table 2-7
Estimated Static RAM Price Trends—North American Bookings (Volume: Slow SRAM—50,000 per Year; Fast SRAM—20,000 per Year; Package: PDIP; Dollars)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
16Kx4 35ns	2.07	2.09	2.09	2.11	2.09	2.11	2.11	2.13	2.13	2.12	2-6
8Kx8 25ns	0.94	0.92	0.91	0.91	0.92	0.87	0.87	0.87	0.87	0.87	2-6
8Kx8 100-120ns	1.12	1.05	1.03	1.03	1.06	0.98	0.98	0.98	0.98	0.98	2-6
64Kx4 10ns	5.03	4.85	4.76	4.73	4.84	4.70	4.63	4.59	4.55	4.62	2-4
64Kx4 25ns	1.60	1.60	1.55	1.55	1.58	1.53	1.53	1.51	1.51	1.52	2-4
32Kx8 12ns	1.25	1.16	1.10	1.10	1.15	1.13	1.13	1.15	1.25	1.16	2-4
32Kx9 12ns Burst	3.27	3.25	3.23	3.21	3.24	3.19	3.19	3.17	3.17	3.18	2-4
32Kx8 15ns 5V	1.10	1.05	1.00	1.00	1.04	1.00	1.02	1.09	1.15	1.07	2-4
32Kx8 15ns 3.3V	1.02	0.99	1.00	1.00	1.00	1.00	1.02	1.09	1.15	1.07	2-4
32Kx8 25ns	1.12	1.00	1.00	1.00	1.03	1.00	1.02	1.10	1.14	1.07	2-4
32Kx8 70-100ns SOJ	1.21	1.11	1.07	1.04	1.11	1.00	1.02	1.10	1.20	1.08	2-4
64Kx8 12ns Burst	13.35	12.20	11.45	11.23	12.06	11.21	11.01	10.89	10.65	10.94	2-4
256Kx4 20ns	3.31	3.04	3.02	3.01	3.09	2.93	2.92	2.90	2.89	2.91	2-8
256Kx4 12ns 3.3V	4.19	4.11	3.82	3.69	3.95	3.41	3.25	3.13	2.91	3.18	3-8
256Kx8 12ns 3.3V	4.02	3.69	3.51	3.29	3.63	3.17	3.09	3.03	2.82	3.03	3-8
128Kx8 15ns	3.32	3.01	2.88	2.74	2.99	2.62	2.60	2.59	2.58	2.60	3-6
128Kx8 20ns	3.16	2.83	2.77	2.73	2.87	2.62	2.60	2.59	2.58	2.60	3-6
128Kx8 25ns	3.16	2.83	2.77	2.73	2.87	2.62	2.60	2.59	2.58	2.60	3-6
128Kx8 70-100ns SOJ	2.79	2.50	2.44	2.41	2.54	2.35	2.33	2.32	2.29	2.32	3-6
32Kx32 15ns 3.3V PQFP	3.18	3.13	3.06	3.03	3.10	3.00	2.95	2.95	2.95	2.96	2-6
32Kx32 8ns 3.3V PBSynch	2.76	2.70	2.66	2.62	2.68	2.59	2.56	2.56	2.56	2.57	2-6
64Kx32 8ns 3.3V PBSynch	5.17	5.05	4.90	4.61	4.93	4.57	4.51	4.46	4.42	4.49	2-6
64Kx32 5ns 3.3V PBSynch	7.00	6.60	6.20	5.75	6.39	5.60	5.40	5.15	5.00	5.29	2-6
256Kx16 70-100ns	13.63	13.00	12.45	12.25	12.83	12.12	12.02	11.91	11.64	11.92	3-6
256Kx16 25ns	16.79	16.32	15.63	15.05	15.95	14.55	14.29	13.65	13.31	13.95	3-6
512Kx8 70ns	13.06	12.56	12.12	11.85	12.40	11.65	11.30	11.11	11.01	11.27	3-6
512Kx8 25ns	16.91	15.98	14.75	14.04	15.42	13.75	13.25	12.97	12.78	13.19	3-6

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 (June 1998)

Table 2-8
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)

	1998	1999	2000	2001	2002
16Kx4 35ns	2.09	2.12	2.13	2.15	2.15
8Kx8 25ns	0.92	0.87	0.87	0.90	0.90
8Kx8 100-120ns	1.06	0.98	0.98	1.00	1.02
64Kx4 10ns	4.84	4.62	4.45	4.55	4.57
64Kx4 25ns	1.58	1.52	1.51	1.55	1.59
32Kx8 12ns	1.15	1.16	1.30	1.30	1.30
32Kx9 12ns Burst	3.24	3.18	3.16	3.21	3.25
32Kx8 15ns 5V	1.04	1.07	1.18	1.21	1.26
32Kx8 15ns 3.3V	1.00	1.07	1.18	1.21	1.26
32Kx8 25ns	1.03	1.07	1.18	1.21	1.26
32Kx8 70-100ns SOJ	1.11	1.08	1.24	1.30	1.31
64Kx8 12ns Burst	12.06	10.94	10.42	10.31	10.22
256Kx4 20ns	3.09	2.91	2.85	2.80	2.80
256Kx4 12ns 3.3V	3.95	3.18	2.87	2.78	2.78
256Kx8 12ns 3.3V	3.63	3.03	2.76	2.74	2.74
128Kx8 15ns	2.99	2.60	2.57	2.57	2.57
128Kx8 20ns	2.87	2.60	2.57	2.57	2.57
128Kx8 25ns	2.87	2.60	2.57	2.57	2.57
128Kx8 70-100ns SOJ	2.54	2.32	2.18	2.17	2.17
32Kx32 15ns 3.3V PQFP	3.10	2.96	2.93	2.99	3.10
32Kx32 8ns 3.3V PBSynch	2.68	2.57	2.69	3.00	3.15
64Kx32 8ns 3.3V PBSynch	4.93	4.49	4.35	4.32	4.30
64Kx32 5ns 3.3V PBSynch	6.39	5.29	4.64	4.35	4.30
256Kx16 70-100ns	12.83	11.92	11.30	11.01	10.79
256Kx16 25ns	15.95	13.95	13.03	12.56	12.02
512Kx8 70ns	12.40	11.27	10.88	10.75	10.70
512Kx8 25ns	15.42	13.19	12.32	11.95	11.88

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (June 1998)

Table 2-9
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)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
128Kx8 ROM	1.58	1.32	1.27	1.22	1.35	1.18	1.16	1.23	1.30	1.22	4-6
64Kx16 ROM	1.73	1.36	1.33	1.30	1.43	1.27	1.27	1.31	1.35	1.30	4-6
256Kx8 ROM	2.1	1.65	1.56	1.50	1.70	1.41	1.37	1.37	1.35	1.38	4-6
512Kx8 ROM	2.7	2.20	1.90	1.77	2.14	1.65	1.59	1.54	1.50	1.57	4-6
256Kx16 ROM[1]	2.7	2.20	1.90	1.77	2.14	1.65	1.59	1.54	1.50	1.57	4-6
1Mbx8 ROM[2]	3.62	2.86	2.69	2.29	2.87	2.22	2.15	2.10	2.00	2.12	4-6
1Mbx16 ROM	5.55	4.45	3.50	2.90	4.10	2.84	2.77	2.71	2.65	2.74	4-6
2Mbx8 ROM	5.55	4.45	3.50	2.90	4.10	2.84	2.77	2.71	2.65	2.74	4-6
2Mbx16 ROM	11	8.75	7.20	6.15	8.28	6.00	5.85	5.60	5.43	5.72	4-6
4Mbx8 ROM	11	8.75	7.21	6.15	8.28	6.00	5.85	5.60	5.43	5.72	4-6
4Mbx16 ROM	14.5	12.10	11.60	10.97	12.29	10.55	10.27	10.10	9.95	10.22	4-6
8Mbx8 ROM	14.4	12.10	11.55	10.92	12.24	10.55	10.27	10.10	9.95	10.22	4-6

[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 (June 1998)

Table 2-10
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)

	1998	1999	2000	2001	2002
128Kx8 ROM	1.35	1.22	1.31	1.34	1.39
64Kx16 ROM	1.43	1.30	1.36	1.37	1.4
256Kx8 ROM	1.70	1.38	1.36	1.37	1.4
512Kx8 ROM	2.14	1.57	1.47	1.45	1.44
256Kx16 ROM[1]	2.14	1.57	1.47	1.45	1.44
1Mbx8 ROM[2]	2.87	2.12	1.94	1.87	1.87
1Mbx16 ROM	4.10	2.74	2.55	2.41	2.37
2Mbx8 ROM	4.10	2.74	2.55	2.41	2.37
2Mbx16 ROM	8.28	5.72	5.21	5.09	5
4Mbx8 ROM	8.28	5.72	5.21	5.09	5
4Mbx16 ROM	12.29	10.22	9.55	9.34	9.22
8Mbx8 ROM	12.24	10.22	9.55	9.34	9.22

[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 (June 1998)

Table 2-11
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
32Kx8 EPROM	1.26	1.23	1.22	1.21	1.23	1.21	1.19	1.18	1.15	1.18	2-3
64Kx8 EPROM	1.31	1.29	1.27	1.26	1.28	1.24	1.22	1.18	1.16	1.20	2-3
128Kx8 EPROM	1.65	1.60	1.56	1.56	1.59	1.50	1.50	1.48	1.48	1.49	2-3
256Kx8 EPROM	2.68	2.60	2.52	2.47	2.57	2.41	2.41	2.36	2.36	2.39	2-3
128Kx16 EPROM	3.08	3.09	2.87	2.77	2.95	2.75	2.75	2.68	2.68	2.72	2-3
512Kx8 EPROM	4.06	3.85	3.15	2.82	3.47	2.65	2.65	2.52	2.50	2.58	2-3
256Kx16 EPROM	5.33	4.55	3.45	2.98	4.08	2.88	2.75	2.67	2.67	2.74	2-3
1Mbx8 EPROM	7.38	7.14	6.75	6.60	6.97	6.24	6.01	5.89	5.75	5.97	2-3
512Kx16 EPROM	8.25	7.35	7.05	6.75	7.35	6.40	6.14	6.00	5.80	6.09	2-3

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 1998)

Table 2-12
Estimated Long-Range EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

	1998	1999	2000	2001	2002
32Kx8 EPROM	1.23	1.18	1.18	1.24	1.27
64Kx8 EPROM	1.28	1.20	1.20	1.26	1.30
128Kx8 EPROM	1.59	1.49	1.39	1.46	1.59
256Kx8 EPROM	2.57	2.39	2.31	2.19	2.08
128Kx16 EPROM	2.95	2.72	2.36	2.24	2.13
512Kx8 EPROM	3.47	2.58	2.45	2.33	2.21
256Kx16 EPROM	4.08	2.74	2.52	2.39	2.27
1Mbx8 EPROM	6.97	5.97	4.10	3.90	3.70
512Kx16 EPROM	7.35	6.09	4.75	4.51	4.29

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 1998)

Table 2-13
Estimated Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998					1999					
	Q1	Q2	Q3	Q4	1998	Q1	Q2	Q3	Q4	1999	Lead Times (Weeks)
64Kx8 PDIP/PLCC	2.18	2.15	2.05	2.03	2.10	1.98	1.98	1.95	1.95	1.96	5
64Kx8 TSOP	2.12	2.09	2.09	2.08	2.10	2.05	2.00	1.95	1.95	1.99	5
128Kx8 PDIP/PLCC	2.14	2.16	2.11	2.08	2.12	2.07	2.04	2.03	2.00	2.03	3
128Kx8 TSOP 12V	2.16	2.18	2.16	2.16	2.16	2.15	2.15	2.15	2.15	2.20	4
128Kx8 TSOP 5V	2.50	2.40	2.25	2.19	2.33	2.10	2.01	1.90	1.80	2.05	4
256Kx8 TSOP 12V	4.13	3.33	3.22	3.13	3.45	3.05	2.90	2.83	2.70	2.94	4-6
256Kx8 TSOP 5V	3.60	3.11	3.04	2.96	3.18	2.89	2.83	2.76	2.68	2.80	4-6
256Kx8 PDIP/PLCC	3.85	3.05	2.98	2.91	3.20	2.85	2.78	2.72	2.66	2.75	4-6
512Kx8 PDIP/PLCC	3.91	3.50	3.36	3.29	3.52	3.14	3.04	2.96	2.88	3.00	4
512Kx8 TSOP 12V	4.52	4.08	3.94	3.80	4.08	3.67	3.58	3.48	3.38	3.53	4
512Kx8 TSOP 5V	4.06	3.55	3.43	3.26	3.57	3.16	3.05	2.97	2.90	3.02	4
512Kx8 SSOP 3V	3.75	3.49	3.41	3.26	3.48	3.16	3.05	2.97	2.90	3.20	4
1Mbx8 TSOP 12V	6.63	6.33	6.09	5.83	6.22	5.59	5.38	5.17	4.96	5.27	3-4
1Mbx8 TSOP 5V	7.03	5.95	5.63	5.38	6.00	5.15	4.98	4.80	4.65	4.90	3-4
1Mbx8 TSOP 3V	6.94	5.86	5.36	5.21	5.84	5.02	4.86	4.45	4.33	4.66	3-4
2Mbx8 TSOP 12V	13.09	11.75	11.11	10.95	11.72	10.55	10.05	9.61	9.18	9.87	3-4
2Mbx8 TSOP 5V	11.20	10.55	10.10	9.78	10.41	9.43	8.99	8.69	8.48	8.89	3-4
2Mbx8 TSOP 3V	13.43	10.35	10.08	9.78	10.91	9.42	8.99	8.69	8.48	9.13	3-4
1Mbx16 TSOP 12V	15.37	13.35	12.70	12.05	13.37	11.40	10.80	10.05	9.68	10.48	3-4
1Mbx16 TSOP 5V	16.79	14.04	13.07	12.18	14.02	10.93	10.41	9.66	9.15	10.19	3-4
1Mbx16 TSOP 3V	17.01	12.92	10.80	10.31	12.76	9.91	9.45	9.01	8.75	8.98	3-4

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 price guidelines.
Source: Dataquest (June 1998)

Table 2-14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998	1999	2000	2001	2002
64Kx8 PDIP/PLCC	2.10	1.96	1.95	2.00	2.05
64Kx8 TSOP	2.10	1.99	1.95	2.00	2.05
128Kx8 PDIP/PLCC	2.12	2.03	2.00	2.00	2.10
128Kx8 TSOP 12V	2.16	2.20	2.08	2.08	2.20
128Kx8 TSOP 5V	2.33	2.05	1.75	1.75	2.00
256Kx8 TSOP 12V	3.45	2.94	2.60	2.55	2.65
256Kx8 TSOP 5V	3.18	2.80	2.55	2.50	2.65
256Kx8 PDIP/PLCC	3.20	2.75	2.52	5.48	2.60
512Kx8 PDIP/PLCC	3.52	3.00	2.70	2.62	2.68
512Kx8 TSOP 12V	4.08	3.53	3.15	3.00	3.20
512Kx8 TSOP 5V	3.57	3.02	2.73	2.65	2.75
512Kx8 SSOP 3V	3.48	3.20	2.73	2.65	2.75
1Mbx8 TSOP 12V	6.22	5.27	4.45	4.15	3.90
1Mbx8 TSOP 5V	6.00	4.90	4.30	4.00	3.85
1Mbx8 TSOP 3V	5.84	4.66	4.04	3.85	3.70
2Mbx8 TSOP 12V	11.72	9.87	8.80	8.50	8.35
2Mbx8 TSOP 5V	10.41	8.89	8.10	7.80	7.65
2Mbx8 TSOP 3V	10.91	9.13	8.10	7.80	7.65
1Mbx16 TSOP 12V	13.37	10.48	8.90	7.85	7.65
1Mbx16 TSOP 5V	14.02	10.19	8.10	7.65	7.10
1Mbx16 TSOP 3V	12.76	8.98	8.00	7.50	6.90

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 1998)

Table 2-15
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	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	Lead Times (Weeks)
CMOS										Production:
0.8 Micron	20.00	19.00	19.00	16.00	15.00	14.00	14.00	13.00	12.00	4-10
0.6 Micron	22.00	21.00	20.00	15.00	14.00	13.00	16.00	15.00	13.00	4-10
0.5 Micron	25.00	24.00	23.00	21.00	20.00	20.00	18.00	17.00	15.00	4-10
0.35 Micron	34.00	34.00	34.00	28.00	26.00	26.00	20.00	19.00	17.00	4-10
										Prototype:
NRE CMOS Average Charge ($K)	43.00	43.00	43.00	53.00	51.00	51.00	73.00	72.00	72.00	1-4

Gate Count	100-299.99K Gates			≥300K Gates			
Technology	1998	1999	2000	1998	1999	2000	Lead Times (Weeks)
CMOS							Production:
0.8 Micron	22.00	21.00	19.00	NR	NR	NR	4-10
0.6 Micron	22.00	21.00	19.00	30.00	29.00	29.00	4-10
0.5 Micron	24.00	22.00	20.00	32.00	32.00	32.00	4-10
0.35 Micron	31.00	30.00	29.00	38.00	38.00	38.00	4-10
							Prototype:
NRE CMOS Average Charge ($K)	105.00	103.00	103.00	125.00	120.00	120.00	1-4

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors.
Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (June 1998)

Table 2-16
Estimated CBIC Pricing—North American Production Bookings (Volume: 20,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype; Millicents per Gate)

Gate Count	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	Lead Times (Weeks)
CMOS										Production:
0.8 Micron	24.00	22.00	21.00	16.00	14.00	13.00	11.00	10.00	9.00	6-14
0.6 Micron	25.00	24.00	23.00	16.00	15.00	14.00	12.00	10.00	9.00	6-14
0.5 Micron	27.00	26.00	26.00	24.00	22.00	20.00	19.00	17.00	14.00	6-14
0.35 Micron	39.00	37.00	37.00	35.00	34.00	32.00	24.00	22.00	19.00	6-14
										Prototype:
NRE CMOS Average Charge ($K)	66.00	65.00	65.00	72.00	71.00	71.00	82.00	82.00	82.00	3-6

Gate Count	100-299.99K Gates			≥300K Gates			
Technology	1998	1999	2000	1998	1999	2000	Lead Times (Weeks)
CMOS							Production:
0.8 Micron	15.00	14.00	12.00	NR	NR	NR	6-14
0.6 Micron	14.00	13.00	10.00	18.00	17.00	15.00	6-14
0.5 Micron	12.00	10.00	9.00	15.00	14.00	12.00	6-14
0.35 Micron	11.00	10.00	9.00	9.00	8.00	7.00	6-14
							Prototype:
NRE CMOS Average Charge ($K)	133.00	131.00	131.00	161.00	160.00	158.00	3-6

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors.
Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (June 1998)

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA
Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Research Center
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

EUROPE
European Headquarters
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431 611
Facsimile: +44 1784 488 980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49 89 42 70 4-0
Facsimile: +49 89 42 70 4-270

JAPAN
Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153
Japan
Phone: 81-3-3481-3670
Facsimile: 81-3-3481-3644

ASIA/PACIFIC
Asia/Pacific Headquarters
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

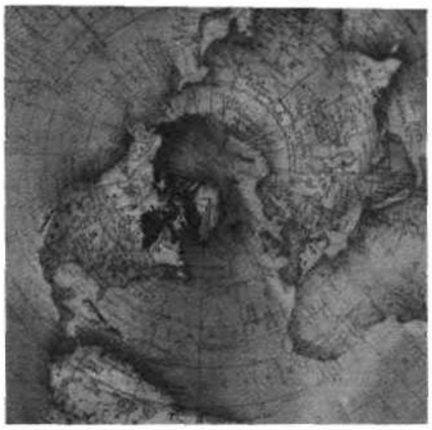
Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-2756-0389
Facsimile: 8862-2756-0663

Dataquest Singapore
6 Temasek Boulevard, #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: 65-333-6773
Facsimile: 65-333-6768

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Dataquest Australia
80 Alfred Street
Milsons Point NSW 2061
Australia
Phone: 61-2-9941-4860
Facsimile: 61-2-9941-4868

Dataquest
A Gartner Group Company



Dataquest

Final 1997 Worldwide Semiconductor Market Share

Market Statistics

FILE COPY:
MARIA VALENZUELA

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9802
Publication Date: April 27, 1998
Filing: Market Statistics

Final 1997 Worldwide Semiconductor Market Share

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9802
Publication Date: April 27, 1998
Filing: Market Statistics

Table of Contents

List of Tables

Chapter 1
Final 1997 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:

- 1995-1997 market share estimates
- 1996-1997 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 Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

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. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

Chapter 2
Market Share Tables

Tables 2-1 through 2-10 show each company's factory revenue by technology category. Tables 2-11 through 2-20 show the top companies' factory revenue by technology category.

Table 2-1
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**151,262**	**142,150**	**147,165**	**100**	**100**	**100**
Americas Companies	**60,021**	**64,076**	**72,339**	**39.7**	**45.1**	**49.2**
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0	0.2	0.2
Advanced Micro Devices	2,337	1,947	2,341	1.5	1.4	1.6
Allegro MicroSystems	185	200	155	0.1	0.1	0.1
Alliance Semiconductor	220	76	120	0.1	0	0
Altera	402	497	631	0.3	0.3	0.4
Anadigics	0	0	97	0	0	0
Analog Devices	983	1,260	1,370	0.6	0.9	0.9
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	49	56	36	0	0	0
ATI Technologies	0	130	260	0	0	0.2
Atmel	589	1,024	950	0.4	0.7	0.6
Burr-Brown	186	207	165	0.1	0.1	0.1
C-Cube	0	150	171	0	0.1	0.1
California Micro Devices	13	8	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	87	100	112	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0	0.1	0
CID Technologies	5	6	6	0	0	0
Cirrus Logic	1,003	891	880	0.7	0.6	0.6
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.4	0.4	0.3
Dallas Semiconductor	228	277	304	0.2	0.2	0.2
Digital	0	271	359	0	0.2	0.2
DSP Group	60	67	76	0	0	0
Eastman Kodak	3	3	3	0	0	0
Elantec	25	35	36	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Electronic Designs	43	51	10	0	0	0
ESS	0	0	245	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	147	96	102	0	0	0
Fairchild	0	0	448	0	0	0.3
G-Link USA	14	15	34	0	0	0
General Semiconductor	413	362	370	0.3	0.3	0.3
Gennum	34	37	39	0	0	0
Gould AMI	72	95	194	0	0	0.1
Harris Semiconductor	685	629	697	0.5	0.4	0.5
Hewlett-Packard	648	945	1,025	0.4	0.7	0.7
Honeywell	64	71	68	0	0	0
Hughes	36	39	38	0	0	0
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	2.3	2.3	2.3
IC Sensors	6	7	7	0	0	0
IMI	35	39	36	0	0	0
IMP	54	35	19	0	0	0
Integrated Circuit Systems	97	79	95	0	0	0
Integrated Device Technology	617	554	536	0.4	0.4	0.4
Integrated Silicon Solution	158	111	125	0.1	0	0
Intel	13,172	17,781	21,746	8.7	12.5	14.8
International CMOS Technology	16	12	5	0	0	0
International Rectifier	486	520	511	0.3	0.4	0.3
Ixys	65	66	69	0	0	0
Lattice	186	200	242	0.1	0.1	0.2
Level One Communications	78	112	127	0	0	0
Linear Technology	305	365	419	0.2	0.3	0.3
Linfinity	50	51	53	0	0	0
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	0.8	0.9	0.9
Lucent Technologies	1,615	2,110	2,762	1.1	1.5	1.9
Maxim	189	387	463	0.1	0.3	0.3
Micrel	26	24	104	0	0	0
Micro Linear	54	54	62	0	0	0
Microchip Technology	271	330	422	0.2	0.2	0.3
Micron Technology	2,601	1,558	1,704	1.7	1.1	1.2
Microsemi	118	146	156	0	0.1	0.1

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Mitel	88	145	159	0	0.1	0.1
Motorola	8,722	8,076	8,067	5.8	5.7	5.5
National Semiconductor	2,408	2,380	2,759	1.6	1.7	1.9
NeoMagic	0	0	120	0	0	0
Oak Technology	84	172	163	0	0.1	0.1
Optek	62	69	73	0	0	0
OPTi	167	119	68	0.1	0	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	143	188	214	0	0.1	0.1
Powerex	98	98	98	0	0	0
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
Quality Technologies	61	52	54	0	0	0
QuickLogic	16	25	29	0	0	0
Ramtron	25	14	15	0	0	0
Raytheon	125	131	127	0	0	0
Rockwell	744	1,351	1,487	0.5	1	1
S3	315	464	437	0.2	0.3	0.3
Seeq Technology	27	32	31	0	0	0
Semtech	48	66	100	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Solitron	8	9	6	0	0	0
Spectra Diode Labs	15	17	17	0	0	0
Standard Microsystems	150	153	175	0	0.1	0.1
Sun Microsystems	0	170	550	0	0.1	0.4
Supertex	35	33	34	0	0	0
Symbios	395	458	418	0.3	0.3	0.3
Symphony Laboratories	15	17	19	0	0	0
Teccor Electronics	68	83	92	0	0	0
Telcom-	17	18	56	0	0	0
Texas Instruments	7,831	7,064	7,352	5.2	5	5
Trident Microsystems	139	180	144	0	0.1	0
TriQuint	0	0	72	0	0	0
Tseng Labs	105	26	8	0	0	0
Unitrode	103	98	118	0	0	0
Vitesse	0	0	118	0	0	0
VLSI Technology	672	672	713	0.4	0.5	0.5
VTC	155	172	110	0.1	0.1	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0	0	0
Xilinx	520	566	612	0.3	0.4	0.4
Zilog	265	286	262	0.2	0.2	0.2
Zoran	0	29	34	0	0	0
Other Americas Companies	33	40	53	0	0	0
Japanese Companies	**60,599**	**50,884**	**47,825**	**40.1**	**35.8**	**32.5**
Fuji Electric	566	486	417	0.4	0.3	0.3
Fujitsu	5,535	4,427	4,622	3.7	3.1	3.1
Hitachi	9,135	8,071	6,298	6	5.7	4.3
Matsushita	3,474	3,003	2,847	2.3	2.1	1.9
Mitsubishi	5,274	4,100	3,925	3.5	2.9	2.7
NEC	11,314	10,428	10,222	7.5	7.3	6.9
New JRC	237	200	230	0.2	0.1	0.2
Nippon Steel Semiconductor	549	198	145	0.4	0.1	0
Oki	2,028	1,177	1,062	1.3	0.8	0.7
Ricoh	213	168	163	0.1	0.1	0.1
Rohm	1,934	1,731	2,053	1.3	1.2	1.4
Sanken	733	622	540	0.5	0.4	0.4
SANYO	2,714	2,491	2,471	1.8	1.8	1.7
Seiko Epson	313	256	205	0.2	0.2	0.1
Sharp	2,592	2,124	2,145	1.7	1.5	1.5
Shindengen Electric	329	298	266	0.2	0.2	0.2
Sony	2,333	1,983	1,974	1.5	1.4	1.3
Stanley	301	0	294	0.2	0	0.2
Toshiba	10,076	8,065	7,253	6.7	5.7	4.9
Yamaha	444	295	239	0.3	0.2	0.2
Other Japanese Companies	392	667	454	0.3	0.5	0.3
European Companies	**12,837**	**13,682**	**14,809**	**8.5**	**9.6**	**10.1**
Alcatel Microelectronics	179	190	215	0.1	0.1	0.1
Austria Mikro Systeme	149	140	130	0	0	0
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	77	85	89	0	0	0
Ericsson	120	170	180	0	0.1	0.1
Eupec	120	160	111	0	0.1	0
Fagor	38	0	32	0	0	0
GEC Plessey	368	338	295	0.2	0.2	0.2
Melexis	33	34	22	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Micronas	43	33	285	0	0	0.2
Philips	3,900	4,220	4,440	2.6	3	3
Power Innovations	0	0	29	0	0	0
Robert Bosch	0	0	240	0	0	0.2
Semikron	125	109	116	0	0	0
SGS-Thomson	3,398	4,112	4,019	2.2	2.9	2.7
Siemens	3,063	3,029	3,441	2	2.1	2.3
TCS	100	83	123	0	0	0
TEMIC	773	813	856	0.5	0.6	0.6
Zetex	56	54	93	0	0	0
Other European Companies	105	105	84	0	0	0
Asia/Pacific Companies	**17,805**	**13,508**	**12,192**	**11.8**	**9.5**	**8.3**
Acer	80	50	115	0	0	0
Daewoo	49	45	50	0	0	0
Holtek	87	99	117	0	0	0
Hualon Microelectronics Corp.	107	47	46	0	0	0
Hyundai	4,132	2,247	1,939	2.7	1.6	1.3
Korean Electronic Co.	287	268	300	0.2	0.2	0.2
LG Semicon	2,863	2,243	1,792	1.9	1.6	1.2
Macronix	271	354	365	0.2	0.2	0.2
Mosel Vitelic	502	398	316	0.3	0.3	0.2
Samsung	8,332	6,464	5,856	5.5	4.5	4
Silicon Integrated Systems	127	127	110	0	0	0
United Microelectronics	477	492	378	0.3	0.3	0.3
Vanguard	0	225	334	0	0.2	0.2
VIA	0	110	151	0	0	0.1
Winbond Electronics	491	339	323	0.3	0.2	0.2

Source: Dataquest (April 1998)

Table 2-2
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**132,136**	**123,761**	**127,571**	**100**	**100**	**100**
Americas Companies	**55,754**	**59,836**	**67,952**	**42.2**	**48.3**	**53.3**
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0	0.2	0.2
Advanced Micro Devices	2,337	1,947	2,341	1.8	1.6	1.8
Allegro MicroSystems	156	181	153	0.1	0.1	0.1
Alliance Semiconductor	220	76	120	0.2	0	0
Altera	402	497	631	0.3	0.4	0.5
Anadigics	0	0	97	0	0	0
Analog Devices	983	1,260	1,370	0.7	1	1.1
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	49	56	36	0	0	0
ATI Technologies	0	130	260	0	0.1	0.2
Atmel	589	1,024	950	0.4	0.8	0.7
Burr-Brown	186	207	165	0.1	0.2	0.1
C-Cube	0	150	171	0	0.1	0.1
California Micro Devices	13	8	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	87	100	112	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0.1	0.1	0.1
Cirrus Logic	1,003	891	880	0.8	0.7	0.7
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.4	0.4	0.4
Dallas Semiconductor	228	277	304	0.2	0.2	0.2
Digital	0	271	359	0	0.2	0.3
DSP Group	60	67	76	0	0	0
Elantec	25	35	36	0	0	0
Electronic Designs	43	51	10	0	0	0
ESS	0	0	245	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	147	96	102	0.1	0	0
Fairchild	0	0	307	0	0	0.2
G-Link USA	14	15	34	0	0	0
Gennum	34	37	39	0	0	0
Gould AMI	72	95	194	0	0	0.2

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Harris Semiconductor	457	397	467	0.3	0.3	0.4
Hewlett-Packard	342	380	466	0.3	0.3	0.4
Honeywell	27	30	30	0	0	0
Hughes	36	39	38	0	0	0
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	2.7	2.6	2.7
IMI	35	39	36	0	0	0
IMP	54	35	19	0	0	0
Integrated Circuit Systems	97	79	95	0	0	0
Integrated Device Technology	617	554	536	0.5	0.4	0.4
Integrated Silicon Solution	158	111	125	0.1	0	0
Intel	13,172	17,781	21,746	10	14.4	17
International CMOS Technology	16	12	5	0	0	0
International Rectifier	18	27	31	0	0	0
Lattice	186	200	242	0.1	0.2	0.2
Level One Communications	78	112	127	0	0	0
Linear Technology	305	365	419	0.2	0.3	0.3
Linfinity	50	51	53	0	0	0
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	1	1	1
Lucent Technologies	1,534	2,020	2,489	1.2	1.6	2
Maxim	189	387	463	0.1	0.3	0.4
Micrel	26	24	104	0	0	0
Micro Linear	54	54	62	0	0	0
Microchip Technology	271	330	422	0.2	0.3	0.3
Micron Technology	2,601	1,558	1,704	2	1.3	1.3
Mitel	88	123	143	0	0	0.1
Motorola	7,022	6,584	6,585	5.3	5.3	5.2
National Semiconductor	2,244	2,223	2,624	1.7	1.8	2.1
NeoMagic	0	0	120	0	0	0
Oak Technology	84	172	163	0	0.1	0.1
Optek	8	9	20	0	0	0
OPTi	167	119	68	0.1	0	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	143	188	214	0.1	0.2	0.2
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
QuickLogic	16	25	29	0	0	0

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Ramtron	25	14	15	0	0	0
Raytheon	112	118	113	0	0	0
Rockwell	744	1,351	1,487	0.6	1.1	1.2
S3	315	464	437	0.2	0.4	0.3
Seeq Technology	27	32	31	0	0	0
Semtech	19	42	90	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Solitron	2	4	1	0	0	0
Standard Microsystems	150	153	175	0.1	0.1	0.1
Sun Microsystems	0	170	550	0	0.1	0.4
Supertex	19	17	17	0	0	0
Symbios	395	458	418	0.3	0.4	0.3
Symphony Laboratories	15	17	19	0	0	0
Telcom-	17	18	56	0	0	0
Texas Instruments	7,772	6,974	7,292	5.9	5.6	5.7
Trident Microsystems	139	180	144	0.1	0.1	0.1
TriQuint	0	0	72	0	0	0
Tseng Labs	105	26	8	0	0	0
Unitrode	103	98	118	0	0	0
Vitesse	0	0	118	0	0	0
VLSI Technology	672	672	713	0.5	0.5	0.6
VTC	155	172	110	0.1	0.1	0
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0	0	0
Xilinx	520	566	612	0.4	0.5	0.5
Zilog	265	286	262	0.2	0.2	0.2
Zoran	0	29	34	0	0	0
Other Americas Companies	0	40	53	0	0	0
Japanese Companies	**49,722**	**40,568**	**36,882**	**37.6**	**32.8**	**28.9**
Fuji Electric	98	85	61	0	0	0
Fujitsu	5,084	3,986	4,135	3.8	3.2	3.2
Hitachi	8,162	6,973	5,233	6.2	5.6	4.1
Matsushita	2,347	1,988	1,882	1.8	1.6	1.5
Mitsubishi	4,644	3,504	3,280	3.5	2.8	2.6
NEC	10,281	9,354	9,014	7.8	7.6	7.1
New JRC	223	188	227	0.2	0.2	0.2
Nippon Steel Semiconductor	549	198	145	0.4	0.2	0.1
Oki	1,988	1,138	1,018	1.5	0.9	0.8

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Ricoh	213	168	163	0.2	0.1	0.1
Rohm	877	757	869	0.7	0.6	0.7
Sanken	283	254	70	0.2	0.2	0
SANYO	2,059	1,902	1,818	1.6	1.5	1.4
Seiko Epson	313	256	205	0.2	0.2	0.2
Sharp	1,956	1,507	1,430	1.5	1.2	1.1
Shindengen Electric	28	21	0	0	0	0
Sony	1,898	1,567	1,541	1.4	1.3	1.2
Toshiba	8,025	6,204	5,340	6.1	5	4.2
Yamaha	444	295	239	0.3	0.2	0.2
Other Japanese Companies	205	184	212	0.2	0.1	0.2
European Companies	**9,418**	**10,381**	**11,152**	**7.1**	**8.4**	**8.7**
Alcatel Microelectronics	179	190	215	0.1	0.2	0.2
Austria Mikro Systeme	149	140	130	0.1	0.1	0.1
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	77	85	89	0	0	0
Ericsson	84	119	130	0	0	0.1
GEC Plessey	332	303	268	0.3	0.2	0.2
Melexis	31	34	22	0	0	0
Micronas	43	33	230	0	0	0.2
Philips	2,844	3,279	3,416	2.2	2.6	2.7
Robert Bosch	0	0	155	0	0	0.1
SGS-Thomson	2,807	3,526	3,447	2.1	2.8	2.7
Siemens	2,314	2,238	2,503	1.8	1.8	2
TCS	65	58	70	0	0	0
TEMIC	342	347	461	0.3	0.3	0.4
Zetex	4	1	7	0	0	0
Other European Companies	25	21	0	0	0	0
Asia/Pacific Companies	**17,242**	**12,976**	**11,585**	**13**	**10.5**	**9.1**
Acer	80	50	115	0	0	0
Daewoo	49	45	50	0	0	0
Holtek	87	99	117	0	0	0
Hualon Microelectronics Corp.	107	47	46	0	0	0
Hyundai	4,132	2,247	1,939	3.1	1.8	1.5
Korean Electronic Co.	45	51	60	0	0	0
LG Semicon	2,863	2,243	1,792	2.2	1.8	1.4
Macronix	271	354	365	0.2	0.3	0.3
Mosel Vitelic	502	398	316	0.4	0.3	0.2

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Samsung	8,011	6,149	5,489	6.1	5	4.3
Silicon Integrated Systems	127	127	110	0	0.1	0
United Microelectronics	477	492	378	0.4	0.4	0.3
Vanguard	0	225	334	0	0.2	0.3
VIA	0	110	151	0	0	0.1
Winbond Electronics	491	339	323	0.4	0.3	0.3

Source: Dataquest (April 1998)

Table 2-3
Each Company's Vendor Revenue from Shipments of Bipolar Digital Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**2,455**	**1,849**	**1,239**	**100**	**100**	**100**
Americas Companies	**1,295**	**953**	**609**	**52.7**	**51.5**	**49.2**
Advanced Micro Devices	100	62	28	4.1	3.4	2.3
Applied Micro Circuits Corp.	19	30	0	0.8	1.6	0
Harris Semiconductor	4	4	0	0.2	0.2	0
Lucent Technologies	50	70	10	2	3.8	0.8
Motorola	381	271	264	15.5	14.7	21.3
National Semiconductor	209	161	14	8.5	8.7	1.1
Raytheon	19	15	0	0.8	0.8	0
Texas Instruments	513	340	293	20.9	18.4	23.6
Japanese Companies	**972**	**752**	**485**	**39.6**	**40.7**	**39.1**
Fujitsu	203	90	63	8.3	4.9	5.1
Hitachi	442	451	262	18	24.4	21.1
Matsushita	29	19	19	1.2	1	1.5
Mitsubishi	37	25	24	1.5	1.4	1.9
NEC	109	90	82	4.4	4.9	6.6
Oki	36	4	3	1.5	0.2	0.2
Toshiba	116	73	32	4.7	3.9	2.6
European Companies	**174**	**134**	**117**	**7.1**	**7.2**	**9.4**
GEC Plessey	10	12	0	0.4	0.6	0
Philips	123	90	80	5	4.9	6.5
SGS-Thomson	6	0	0	0.2	0	0
Siemens	31	32	37	1.3	1.7	3
Other European Companies	4	0	0	0.2	0	0
Asia/Pacific Companies	14	10	28	0.6	0.5	2.3
LG Semicon	14	10	8	0.6	0.5	0.6
Mosel Vitelic	0	0	20	0	0	1.6

Source: Dataquest (April 1998)

Table 2-4
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**110,410**	**102,209**	**104,680**	**100**	**100**	**100**
Americas Companies	**46,979**	**50,721**	**57,414**	**42.5**	**49.6**	**54.8**
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0.1	0.2	0.2
Advanced Micro Devices	2,064	1,770	2,123	1.9	1.7	2
Allegro MicroSystems	0	7	9	0	0	0
Alliance Semiconductor	220	76	120	0.2	0	0.1
Altera	402	497	631	0.4	0.5	0.6
Analog Devices	116	272	306	0.1	0.3	0.3
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	25	23	33	0	0	0
ATI Technologies	0	130	260	0	0.1	0.2
Atmel	573	1,024	919	0.5	1	0.9
C-Cube	0	150	171	0	0.1	0.2
California Micro Devices	6	5	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	0	0	11	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0.1	0.1	0.1
Cirrus Logic	887	741	604	0.8	0.7	0.6
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.5	0.5	0.5
Dallas Semiconductor	228	230	251	0.2	0.2	0.2
Digital	0	271	359	0	0.3	0.3
DSP Group	60	67	76	0	0	0
Electronic Designs	43	51	10	0	0	0
ESS	0	0	240	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	16	24	33	0	0	0
Fairchild	0	0	307	0	0	0.3
G-Link USA	14	15	34	0	0	0
Gennum	0	0	9	0	0	0
Gould AMI	72	95	194	0	0	0.2
Harris Semiconductor	193	198	209	0.2	0.2	0.2
Hewlett-Packard	342	380	466	0.3	0.4	0.4
Hughes	20	39	38	0	0	0

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	3.2	3.1	3.2
IMI	30	39	36	0	0	0
IMP	12	5	0	0	0	0
Integrated Circuit Systems	52	63	77	0	0	0
Integrated Device Technology	617	554	536	0.6	0.5	0.5
Integrated Silicon Solution	158	111	125	0.1	0.1	0.1
Intel	13,163	17,781	21,746	11.9	17.4	20.8
International CMOS Technology	16	12	5	0	0	0
Lattice	186	200	242	0.2	0.2	0.2
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	1.1	1.2	1.2
Lucent Technologies	1,200	1,715	2,374	1.1	1.7	2.3
Micrel	7	6	0	0	0	0
Micro Linear	0	3	11	0	0	0
Microchip Technology	271	330	422	0.2	0.3	0.4
Micron Technology	2,601	1,558	1,704	2.4	1.5	1.6
Mitel	0	24	15	0	0	0
Motorola	5,610	5,113	4,903	5.1	5	4.7
National Semiconductor	993	1,047	1,252	0.9	1	1.2
NeoMagic	0	0	120	0	0	0.1
Oak Technology	84	172	163	0	0.2	0.2
OPTi	167	119	68	0.2	0.1	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	47	87	98	0	0	0
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
QuickLogic	16	25	29	0	0	0
Ramtron	25	14	15	0	0	0
Raytheon	0	7	28	0	0	0
Rockwell	744	1,230	1,356	0.7	1.2	1.3
S3	315	464	437	0.3	0.5	0.4
Seeq Technology	27	12	19	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Standard Microsystems	150	153	175	0.1	0.1	0.2
Sun Microsystems	0	170	550	0	0.2	0.5
Supertex	6	5	5	0	0	0
Symbios	293	458	418	0.3	0.4	0.4

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Symphony Laboratories	15	17	19	0	0	0
Texas Instruments	6,325	4,950	4,804	5.7	4.8	4.6
Trident Microsystems	139	180	144	0.1	0.2	0.1
Tseng Labs	105	26	8	0	0	0
Vitesse	0	0	53	0	0	0
VLSI Technology	672	672	713	0.6	0.7	0.7
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0.1	0.1	0.1
Xilinx	520	566	612	0.5	0.6	0.6
Zilog	265	286	262	0.2	0.3	0.3
Zoran	0	29	34	0	0	0
Other Americas Companies	0	40	53	0	0	0
Japanese Companies	**41,677**	**33,361**	**30,597**	**37.7**	**32.6**	**29.2**
Fuji Electric	46	41	37	0	0	0
Fujitsu	4,417	3,471	3,745	4	3.4	3.6
Hitachi	7,228	5,995	4,595	6.5	5.9	4.4
Matsushita	1,679	1,422	1,308	1.5	1.4	1.2
Mitsubishi	3,954	2,895	2,812	3.6	2.8	2.7
NEC	9,401	8,515	8,320	8.5	8.3	7.9
New JRC	40	28	29	0	0	0
Nippon Steel Semiconductor	549	198	145	0.5	0.2	0.1
Oki	1,911	1,103	998	1.7	1.1	1
Ricoh	175	118	103	0.2	0.1	0
Rohm	376	327	334	0.3	0.3	0.3
SANYO	972	945	968	0.9	0.9	0.9
Seiko Epson	297	242	191	0.3	0.2	0.2
Sharp	1,851	1,415	1,332	1.7	1.4	1.3
Sony	1,303	1,050	1,028	1.2	1	1
Toshiba	6,920	5,186	4,288	6.3	5.1	4.1
Yamaha	416	289	237	0.4	0.3	0.2
Other Japanese Companies	142	121	127	0.1	0.1	0.1
European Companies	**4,931**	**5,596**	**5,645**	**4.5**	**5.5**	**5.4**
Alcatel Microelectronics	35	179	204	0	0.2	0.2
Austria Mikro Systeme	68	133	124	0	0.1	0.1
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	2	29	30	0	0	0
Ericsson	19	19	30	0	0	0
GEC Plessey	164	196	197	0.1	0.2	0.2

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Melexis	23	22	16	0	0	0
Micronas	0	33	220	0	0	0.2
Philips	1,418	1,858	1,619	1.3	1.8	1.5
Robert Bosch	0	0	15	0	0	0
SGS-Thomson	1,318	1,651	1,556	1.2	1.6	1.5
Siemens	1,591	1,226	1,384	1.4	1.2	1.3
TCS	41	49	68	0	0	0
TEMIC	165	194	171	0.1	0.2	0.2
Zetex	0	0	2	0	0	0
Asia/Pacific Companies	**16,823**	**12,531**	**11,024**	**15.2**	**12.3**	**10.5**
Acer	80	50	115	0	0	0.1
Daewoo	27	21	21	0	0	0
Holtek	87	99	117	0	0	0.1
Hualon Microelectronics Corp.	98	43	41	0	0	0
Hyundai	4,130	2,246	1,936	3.7	2.2	1.8
LG Semicon	2,807	2,193	1,736	2.5	2.1	1.7
Macronix	271	354	365	0.2	0.3	0.3
Mosel Vitelic	502	398	296	0.5	0.4	0.3
Samsung	7,775	5,889	5,167	7	5.8	4.9
Silicon Integrated Systems	127	127	110	0.1	0.1	0.1
United Microelectronics	477	492	378	0.4	0.5	0.4
Vanguard	0	225	334	0	0.2	0.3
VIA	0	110	151	0	0.1	0.1
Winbond Electronics	442	284	257	0.4	0.3	0.2

Source: Dataquest (April 1998)

Table 2-5
Each Company's Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**55,287**	**38,064**	**30,978**	**100**	**100**	**100**
Americas Companies	**13,641**	**9,656**	**8,375**	**24.7**	**25.4**	**27**
Advanced Micro Devices	719	711	708	1.3	1.9	2.3
Alliance Semiconductor	210	66	111	0.4	0.2	0.4
Atmel	478	793	670	0.9	2.1	2.2
Catalyst	48	54	70	0	0.1	0.2
Cypress Semiconductor	424	382	314	0.8	1	1
Dallas Semiconductor	56	0	0	0.1	0	0
Electronic Designs	43	51	10	0	0.1	0
Fairchild	0	0	80	0	0	0.3
G-Link USA	14	15	34	0	0	0.1
Harris Semiconductor	18	9	17	0	0	0
IBM	2,100	1,253	990	3.8	3.3	3.2
Integrated Device Technology	444	378	365	0.8	1	1.2
Integrated Silicon Solution	158	111	125	0.3	0.3	0.4
Intel	766	950	850	1.4	2.5	2.7
Logic Devices	5	2	2	0	0	0
Lucent Technologies	3	0	0	0	0	0
Microchip Technology	102	117	126	0.2	0.3	0.4
Micron Technology	2,601	1,558	1,704	4.7	4.1	5.5
Motorola	1,237	827	435	2.2	2.2	1.4
National Semiconductor	188	127	2	0.3	0.3	0
Paradigm	55	23	11	0	0	0
Quality Semiconductor	14	1	2	0	0	0
Ramtron	25	14	15	0	0	0
Seeq Technology	6	0	0	0	0	0
Silicon Storage Technology	35	91	75	0	0.2	0.2
Texas Instruments	3,754	1,984	1,524	6.8	5.2	4.9
WaferScale Integration	17	16	3	0	0	0
Xicor	114	123	122	0.2	0.3	0.4
Other Americas Companies	0	0	10	0	0	0
Japanese Companies	**24,062**	**15,708**	**11,827**	**43.5**	**41.3**	**38.2**
Fujitsu	2,589	1,656	1,508	4.7	4.4	4.9
Hitachi	5,132	3,514	2,209	9.3	9.2	7.1
Matsushita	492	300	315	0.9	0.8	1
Mitsubishi	2,547	1,614	1,435	4.6	4.2	4.6
NEC	5,353	3,913	3,215	9.7	10.3	10.4
Nippon Steel Semiconductor	549	198	145	1	0.5	0.5

Table 2-5 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Oki	1,228	541	448	2.2	1.4	1.4
Ricoh	6	3	8	0	0	0
Rohm	61	51	48	0.1	0.1	0.2
SANYO	257	302	162	0.5	0.8	0.5
Seiko Epson	41	19	15	0	0	0
Sharp	1,030	727	624	1.9	1.9	2
Sony	489	330	193	0.9	0.9	0.6
Toshiba	4,264	2,513	1,485	7.7	6.6	4.8
Yamaha	1	1	1	0	0	0
Other Japanese Companies	23	26	16	0	0	0
European Companies	**2,023**	**1,669**	**1,621**	**3.7**	**4.4**	**5.2**
Philips	0	0	73	0	0	0.2
SGS-Thomson	646	738	502	1.2	1.9	1.6
Siemens	1,353	911	1,028	2.4	2.4	3.3
TEMIC	24	20	18	0	0	0
Asia/Pacific Companies	**15,561**	**11,031**	**9,155**	**28.1**	**29**	**29.6**
Holtek	0	2	5	0	0	0
Hualon Microelectronics Corp.	54	23	20	0	0	0
Hyundai	4,116	2,236	1,931	7.4	5.9	6.2
LG Semicon	2,635	2,021	1,489	4.8	5.3	4.8
Macronix	236	288	300	0.4	0.8	1
Mosel Vitelic	502	398	296	0.9	1	1
Samsung	7,498	5,501	4,623	13.6	14.5	14.9
United Microelectronics	203	177	22	0.4	0.5	0
Vanguard	0	225	334	0	0.6	1.1
Winbond Electronics	317	160	135	0.6	0.4	0.4

Source: Dataquest (April 1998)

Table 2-6
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**34,504**	**41,469**	**48,945**	**100**	**100**	**100**
Americas Companies	**24,204**	**30,450**	**36,974**	**70.1**	**73.4**	**75.5**
8x8	44	51	60	0.1	0.1	0.1
ACC Microelectronics	40	45	50	0.1	0.1	0.1
Adaptec	124	214	238	0.4	0.5	0.5
Advanced Micro Devices	925	624	1,106	2.7	1.5	2.3
Alliance Semiconductor	10	10	9	0	0	0
Analog Devices	116	258	287	0.3	0.6	0.6
Appian Technology	9	10	11	0	0	0
ATI Technologies	0	130	260	0	0.3	0.5
Atmel	28	49	65	0	0.1	0.1
C-Cube	0	150	171	0	0.4	0.3
California Micro Devices	6	5	1	0	0	0
Chips & Technologies	138	150	131	0.4	0.4	0.3
Cirrus Logic	887	741	604	2.6	1.8	1.2
Cypress Semiconductor	50	64	6	0.1	0.2	0
Dallas Semiconductor	35	113	126	0.1	0.3	0.3
Digital	0	271	359	0	0.7	0.7
DSP Group	60	67	76	0.2	0.2	0.2
ESS	0	0	240	0	0	0.5
Harris Semiconductor	67	49	46	0.2	0.1	0
Hughes	3	3	0	0	0	0
IBM	703	889	803	2	2.1	1.6
IMP	1	0	0	0	0	0
Integrated Device Technology	63	70	64	0.2	0.2	0.1
Intel	12,397	16,831	20,896	35.9	40.6	42.7
LSI Logic	107	103	108	0.3	0.2	0.2
Lucent Technologies	510	635	888	1.5	1.5	1.8
Microchip Technology	169	213	296	0.5	0.5	0.6
Motorola	2,987	3,153	3,530	8.7	7.6	7.2
National Semiconductor	542	627	1,101	1.6	1.5	2.2
NeoMagic	0	0	120	0	0	0.2
Oak Technology	84	172	163	0.2	0.4	0.3
OPTi	167	119	68	0.5	0.3	0.1
PMC Sierra Semiconductor	47	62	70	0.1	0.1	0.1
Q Logic	61	67	73	0.2	0.2	0.1
Rockwell	738	1,226	1,351	2.1	3	2.8
S3	315	464	437	0.9	1.1	0.9

Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Seeq Technology	21	12	19	0	0	0
Standard Microsystems	150	153	175	0.4	0.4	0.4
Sun Microsystems	0	170	550	0	0.4	1.1
Supertex	1	0	0	0	0	0
Symbios	85	102	129	0.2	0.2	0.3
Symphony Laboratories	15	17	19	0	0	0
Texas Instruments	1,254	1,550	1,728	3.6	3.7	3.5
Trident Microsystems	139	180	144	0.4	0.4	0.3
Tseng Labs	105	26	8	0.3	0	0
VLSI Technology	193	57	46	0.6	0.1	0
WaferScale Integration	18	30	46	0	0	0
Zilog	265	286	262	0.8	0.7	0.5
Zoran	0	29	34	0	0	0
Japanese Companies	**8,093**	**8,115**	**8,817**	**23.5**	**19.6**	**18**
Fuji Electric	3	3	3	0	0	0
Fujitsu	650	677	967	1.9	1.6	2
Hitachi	1,441	1,629	1,683	4.2	3.9	3.4
Matsushita	555	534	457	1.6	1.3	0.9
Mitsubishi	982	901	936	2.8	2.2	1.9
NEC	2,061	2,179	2,404	6	5.3	4.9
New JRC	4	5	5	0	0	0
Oki	233	175	164	0.7	0.4	0.3
Ricoh	75	76	75	0.2	0.2	0.2
Rohm	71	66	22	0.2	0.2	0
SANYO	187	164	229	0.5	0.4	0.5
Seiko Epson	28	22	24	0	0	0
Sharp	221	184	207	0.6	0.4	0.4
Sony	233	189	173	0.7	0.5	0.4
Toshiba	1,094	1,197	1,336	3.2	2.9	2.7
Yamaha	245	107	123	0.7	0.3	0.3
Other Japanese Companies	10	7	9	0	0	0
European Companies	**1,433**	**1,977**	**1,899**	**4.2**	**4.8**	**3.9**
EM Microelectronics Marin	2	4	4	0	0	0
GEC Plessey	10	10	11	0	0	0
Melexis	23	13	7	0	0	0
Micronas	0	0	50	0	0	0.1
Philips	662	1,085	791	1.9	2.6	1.6
SGS-Thomson	437	482	616	1.3	1.2	1.3

Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Siemens	209	284	333	0.6	0.7	0.7
TCS	22	21	28	0	0	0
TEMIC	68	78	59	0.2	0.2	0.1
Asia/Pacific Companies	**774**	**927**	**1,255**	**2.2**	**2.2**	**2.6**
Acer	77	50	115	0.2	0.1	0.2
Daewoo	23	18	18	0	0	0
Holtek	34	44	24	0	0.1	0
Hyundai	1	1	1	0	0	0
LG Semicon	56	59	121	0.2	0.1	0.2
Macronix	35	20	29	0.1	0	0
Samsung	87	99	237	0.3	0.2	0.5
Silicon Integrated Systems	127	127	110	0.4	0.3	0.2
United Microelectronics	274	315	356	0.8	0.8	0.7
VIA	0	110	151	0	0.3	0.3
Winbond Electronics	60	84	93	0.2	0.2	0.2

Source: Dataquest (April 1998)

Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**20,619**	**22,676**	**24,757**	**100**	**100**	**100**
Americas Companies	**9,134**	**10,615**	**12,065**	**44.3**	**46.8**	**48.7**
Actel	109	149	156	0.5	0.7	0.6
Advanced Micro Devices	420	435	309	2	1.9	1.2
Allegro MicroSystems	0	7	9	0	0	0
Altera	402	497	631	1.9	2.2	2.5
Analog Devices	0	14	19	0	0	0
Applied Micro Circuits Corp.	25	23	33	0.1	0.1	0.1
Atmel	67	182	184	0.3	0.8	0.7
Cherry Semiconductor	0	0	11	0	0	0
Chip Express	0	25	31	0	0.1	0.1
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	79	70	176	0.4	0.3	0.7
Dallas Semiconductor	137	117	125	0.7	0.5	0.5
Eteq Microsystems	7	4	4	0	0	0
Exar	16	24	33	0	0.1	0.1
Fairchild	0	0	227	0	0	0.9
Gennum	0	0	9	0	0	0
Gould AMI	72	95	194	0.3	0.4	0.8
Harris Semiconductor	108	140	146	0.5	0.6	0.6
Hewlett-Packard	342	380	466	1.7	1.7	1.9
Hughes	17	36	38	0	0.2	0.2
ISD	0	0	48	0	0	0.2
IBM	719	1,058	1,598	3.5	4.7	6.5
IMI	30	39	36	0.1	0.2	0.1
IMP	11	5	0	0	0	0
Integrated Circuit Systems	52	63	77	0.3	0.3	0.3
Integrated Device Technology	110	106	107	0.5	0.5	0.4
International CMOS Technology	16	12	5	0	0	0
Lattice	186	200	242	0.9	0.9	1
Logic Devices	12	12	12	0	0	0
LSI Logic	1,162	1,136	1,182	5.6	5	4.8
Lucent Technologies	687	1,080	1,486	3.3	4.8	6
Micrel	7	6	0	0	0	0
Micro Linear	0	3	11	0	0	0
Mitel	0	24	15	0	0.1	0
Motorola	1,386	1,133	938	6.7	5	3.8
National Semiconductor	263	293	149	1.3	1.3	0.6

Table 2-7 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
PMC Sierra Semiconductor	0	25	28	0	0.1	0.1
Quality Semiconductor	32	44	45	0.2	0.2	0.2
QuickLogic	16	25	29	0	0.1	0.1
Raytheon	0	7	28	0	0	0.1
Rockwell	6	4	5	0	0	0
Supertex	5	5	5	0	0	0
Symbios	208	356	289	1	1.6	1.2
Texas Instruments	1,317	1,416	1,552	6.4	6.2	6.3
Vitesse	0	0	53	0	0	0.2
VLSI Technology	479	615	667	2.3	2.7	2.7
WaferScale Integration	1	2	1	0	0	0
Xilinx	520	566	612	2.5	2.5	2.5
Other Americas Companies	0	40	43	0	0.2	0.2
Japanese Companies	**9,522**	**9,538**	**9,953**	**46.2**	**42.1**	**40.2**
Fuji Electric	43	38	34	0.2	0.2	0.1
Fujitsu	1,178	1,138	1,270	5.7	5	5.1
Hitachi	655	852	703	3.2	3.8	2.8
Matsushita	632	588	536	3.1	2.6	2.2
Mitsubishi	425	380	441	2.1	1.7	1.8
NEC	1,987	2,423	2,701	9.6	10.7	10.9
New JRC	36	23	24	0.2	0.1	0
Oki	450	387	386	2.2	1.7	1.6
Ricoh	94	39	20	0.5	0.2	0
Rohm	244	210	264	1.2	0.9	1.1
SANYO	528	479	577	2.6	2.1	2.3
Seiko Epson	228	201	152	1.1	0.9	0.6
Sharp	600	504	501	2.9	2.2	2
Sony	581	531	662	2.8	2.3	2.7
Toshiba	1,562	1,476	1,467	7.6	6.5	5.9
Yamaha	170	181	113	0.8	0.8	0.5
Other Japanese Companies	109	88	102	0.5	0.4	0.4
European Companies	**1,475**	**1,950**	**2,125**	**7.2**	**8.6**	**8.6**
Alcatel Microelectronics	35	179	204	0.2	0.8	0.8
Austria Mikro Systeme	68	133	124	0.3	0.6	0.5
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	0	25	26	0	0.1	0.1
Ericsson	19	19	30	0	0	0.1
GEC Plessey	154	186	186	0.7	0.8	0.8

Table 2-7 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Melexis	0	9	9	0	0	0
Micronas	0	33	170	0	0.1	0.7
Philips	756	773	755	3.7	3.4	3
Robert Bosch	0	0	15	0	0	0
SGS-Thomson	235	431	438	1.1	1.9	1.8
Siemens	29	31	23	0.1	0.1	0
TCS	19	28	40	0	0.1	0.2
TEMIC	73	96	94	0.4	0.4	0.4
Zetex	0	0	2	0	0	0
Asia/Pacific Companies	**488**	**573**	**614**	**2.4**	**2.5**	**2.5**
Acer	3	0	0	0	0	0
Daewoo	4	3	3	0	0	0
Holtek	53	53	88	0.3	0.2	0.4
Hualon Microelectronics Corp.	44	20	21	0.2	0	0
Hyundai	13	9	4	0	0	0
LG Semicon	116	113	126	0.6	0.5	0.5
Macronix	0	46	36	0	0.2	0.1
Samsung	190	289	307	0.9	1.3	1.2
Winbond Electronics	65	40	29	0.3	0.2	0.1

Source: Dataquest (April 1998)

Table 2-8
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**17,616**	**18,235**	**21,652**	**100**	**100**	**100**
Americas Companies	**7,294**	**8,013**	**9,929**	**41.4**	**43.9**	**45.9**
Advanced Micro Devices	173	115	190	1	0.6	0.9
Allegro MicroSystems	144	159	144	0.8	0.9	0.7
Anadigics	0	0	97	0	0	0.4
Analog Devices	809	946	1,064	4.6	5.2	4.9
Applied Micro Circuits Corp.	5	3	3	0	0	0
Atmel	16	0	31	0	0	0.1
Burr-Brown	126	157	165	0.7	0.9	0.8
California Micro Devices	7	3	0	0	0	0
Cherry Semiconductor	87	100	101	0.5	0.5	0.5
Cirrus Logic	116	150	276	0.7	0.8	1.3
Dallas Semiconductor	0	47	53	0	0.3	0.2
Elantec	22	32	36	0.1	0.2	0.2
ESS	0	0	5	0	0	0
Exar	131	72	69	0.7	0.4	0.3
Gennum	32	37	30	0.2	0.2	0.1
Harris Semiconductor	260	195	258	1.5	1.1	1.2
Honeywell	27	30	30	0.2	0.2	0.1
Hughes	16	0	0	0	0	0
IMI	5	0	0	0	0	0
IMP	42	30	19	0.2	0.2	0
Integrated Circuit Systems	45	16	18	0.3	0	0
Intel	9	0	0	0	0	0
International Rectifier	18	27	31	0.1	0.1	0.1
Level One Communications	78	112	127	0.4	0.6	0.6
Linear Technology	305	365	419	1.7	2	1.9
Linfinity	47	48	53	0.3	0.3	0.2
Lucent Technologies	284	235	105	1.6	1.3	0.5
Maxim	185	383	463	1.1	2.1	2.1
Micrel	19	18	104	0.1	0	0.5
Micro Linear	54	51	51	0.3	0.3	0.2
Mitel	68	83	128	0.4	0.5	0.6
Motorola	1,031	1,200	1,418	5.9	6.6	6.5
National Semiconductor	1,034	1,015	1,358	5.9	5.6	6.3
Optek	8	9	20	0	0	0
PMC Sierra Semiconductor	96	101	116	0.5	0.6	0.5
Raytheon	93	96	85	0.5	0.5	0.4

Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Rockwell	0	121	131	0	0.7	0.6
Seeq Technology	0	20	12	0	0.1	0
Semtech	19	42	90	0.1	0.2	0.4
Solitron	0	1	1	0	0	0
Supertex	13	12	12	0	0	0
Symbios	102	0	0	0.6	0	0
Telcom-	17	18	56	0	0	0.3
Texas Instruments	934	1,684	2,195	5.3	9.2	10.1
TriQuint	0	0	72	0	0	0.3
Unitrode	103	98	118	0.6	0.5	0.5
Vitesse	0	0	65	0	0	0.3
VTC	155	172	110	0.9	0.9	0.5
Japanese Companies	**5,704**	**5,210**	**5,800**	**32.4**	**28.6**	**26.8**
Fuji Electric	29	23	24	0.2	0.1	0.1
Fujitsu	315	291	327	1.8	1.6	1.5
Hitachi	355	409	376	2	2.2	1.7
Matsushita	639	547	555	3.6	3	2.6
Mitsubishi	455	397	444	2.6	2.2	2.1
NEC	641	624	612	3.6	3.4	2.8
New JRC	183	160	198	1	0.9	0.9
Oki	28	18	17	0.2	0	0
Ricoh	38	50	60	0.2	0.3	0.3
Rohm	423	357	535	2.4	2	2.5
Sanken	0	0	70	0	0	0.3
SANYO	894	780	850	5.1	4.3	3.9
Seiko Epson	16	14	14	0	0	0
Sharp	105	92	98	0.6	0.5	0.5
Sony	554	452	513	3.1	2.5	2.4
Toshiba	915	909	1,020	5.2	5	4.7
Yamaha	28	6	2	0.2	0	0
Other Japanese Companies	49	50	85	0.3	0.3	0.4
European Companies	**4,213**	**4,577**	**5,390**	**23.9**	**25.1**	**24.9**
Alcatel Microelectronics	144	11	11	0.8	0	0
Austria Mikro Systeme	81	7	6	0.5	0	0
EM Microelectronics Marin	75	56	59	0.4	0.3	0.3
Ericsson	50	87	100	0.3	0.5	0.5
GEC Plessey	155	95	71	0.9	0.5	0.3
Melexis	8	12	6	0	0	0

Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Micronas	33	0	10	0.2	0	0
Philips	1,257	1,291	1,717	7.1	7.1	7.9
Robert Bosch	0	0	140	0	0	0.6
SGS-Thomson	1,483	1,875	1,891	8.4	10.3	8.7
Siemens	692	980	1,082	3.9	5.4	5
TCS	24	9	2	0.1	0	0
TEMIC	177	153	290	1	0.8	1.3
Zetex	4	1	5	0	0	0
Asia/Pacific Companies	**405**	**435**	**533**	**2.3**	**2.4**	**2.5**
Daewoo	22	24	29	0.1	0.1	0.1
Hualon Microelectronics Corp.	9	4	5	0	0	0
Hyundai	2	1	3	0	0	0
Korean Electronic Co.	45	51	60	0.3	0.3	0.3
LG Semicon	42	40	48	0.2	0.2	0.2
Samsung	236	260	322	1.3	1.4	1.5
Winbond Electronics	49	55	66	0.3	0.3	0.3

Source: Dataquest (April 1998)

Table 2-9
Each Company's Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**14,314**	**13,474**	**14,255**	**100**	**100**	**100**
Americas Companies	**3,720**	**3,416**	**3,391**	**26**	**25.4**	**23.8**
Allegro MicroSystems	29	19	2	0.2	0.1	0
Fairchild	0	0	141	0	0	1
General Semiconductor	413	362	370	2.9	2.7	2.6
Harris Semiconductor	228	232	230	1.6	1.7	1.6
Hewlett-Packard	146	140	126	1	1	0.9
International Rectifier	468	493	480	3.3	3.7	3.4
Ixys	65	66	69	0.5	0.5	0.5
Microsemi	118	146	156	0.8	1.1	1.1
Motorola	1,650	1,452	1,446	11.5	10.8	10.1
National Semiconductor	164	157	135	1.1	1.2	0.9
Optek	1	1	0	0	0	0
Powerex	98	98	98	0.7	0.7	0.7
Raytheon	13	13	14	0	0	0
Semtech	29	24	10	0.2	0.2	0
Solitron	6	5	5	0	0	0
Supertex	16	16	17	0.1	0.1	0.1
Teccor Electronics	68	83	92	0.5	0.6	0.6
Texas Instruments	16	28	0	0.1	0.2	0
Japanese Companies	**7,142**	**6,774**	**7,187**	**49.9**	**50.3**	**50.4**
Fuji Electric	468	401	356	3.3	3	2.5
Fujitsu	283	290	319	2	2.2	2.2
Hitachi	889	977	949	6.2	7.3	6.7
Matsushita	631	565	577	4.4	4.2	4
Mitsubishi	479	452	460	3.3	3.4	3.2
NEC	831	818	885	5.8	6.1	6.2
New JRC	2	3	3	0	0	0
Oki	12	11	12	0	0	0
Rohm	771	681	827	5.4	5.1	5.8
Sanken	398	328	434	2.8	2.4	3
SANYO	488	441	478	3.4	3.3	3.4
Shindengen Electric	301	277	266	2.1	2.1	1.9
Sony	53	43	39	0.4	0.3	0.3
Toshiba	1,428	1,390	1,484	10	10.3	10.4
Other Japanese Companies	40	42	98	0.3	0.3	0.7

Table 2-9 (Continued)
Each Company's Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
European Companies	**2,915**	**2,784**	**3,102**	**20.4**	**20.7**	**21.8**
Ericsson	20	28	30	0.1	0.2	0.2
Eupec	120	160	111	0.8	1.2	0.8
Fagor	38	0	32	0.3	0	0.2
GEC Plessey	36	35	27	0.3	0.3	0.2
Melexis	2	0	0	0	0	0
Micronas	0	0	55	0	0	0.4
Philips	1,056	941	1,024	7.4	7	7.2
Power Innovations	0	0	29	0	0	0.2
Robert Bosch	0	0	85	0	0	0.6
Semikron	125	109	116	0.9	0.8	0.8
SGS-Thomson	591	586	572	4.1	4.3	4
Siemens	435	452	554	3	3.4	3.9
TCS	1	0	31	0	0	0.2
TEMIC	321	353	281	2.2	2.6	2
Zetex	51	52	86	0.4	0.4	0.6
Other European Companies	65	68	69	0.5	0.5	0.5
Asia/Pacific Companies	**537**	**500**	**575**	**3.8**	**3.7**	**4**
Korean Electronic Co.	220	193	220	1.5	1.4	1.5
Samsung	317	307	355	2.2	2.3	2.5

Source: Dataquest (April 1998)

Table 2-10
Each Company's Vendor Revenue from Shipments of Total Optical Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**4,812**	**4,915**	**5,339**	**100**	**100**	**100**
Americas Companies	**547**	**824**	**996**	**11.4**	**16.8**	**18.7**
CID Technologies	5	6	6	0.1	0.1	0.1
Eastman Kodak	3	3	3	0	0	0
Hewlett-Packard	160	425	433	3.3	8.6	8.1
Honeywell	37	41	38	0.8	0.8	0.7
IC Sensors	6	7	7	0.1	0.1	0.1
Lucent Technologies	81	90	273	1.7	1.8	5.1
Mitel	0	22	16	0	0.4	0.3
Motorola	50	40	36	1	0.8	0.7
Optek	53	59	53	1.1	1.2	1
Quality Technologies	61	52	54	1.3	1.1	1
Spectra Diode Labs	15	17	17	0.3	0.3	0.3
Texas Instruments	43	62	60	0.9	1.3	1.1
Other Americas Companies	33	0	0	0.7	0	0
Japanese Companies	**3,735**	**3,542**	**3,756**	**77.6**	**72.1**	**70.4**
Fujitsu	168	151	168	3.5	3.1	3.1
Hitachi	84	121	116	1.7	2.5	2.2
Matsushita	496	450	388	10.3	9.2	7.3
Mitsubishi	151	144	185	3.1	2.9	3.5
NEC	202	256	323	4.2	5.2	6
New JRC	12	9	0	0.2	0.2	0
Oki	28	28	32	0.6	0.6	0.6
Rohm	286	293	357	5.9	6	6.7
Sanken	52	40	36	1.1	0.8	0.7
SANYO	167	148	175	3.5	3	3.3
Sharp	636	617	715	13.2	12.6	13.4
Sony	382	373	394	7.9	7.6	7.4
Stanley	301	0	294	6.3	0	5.5
Toshiba	623	471	429	12.9	9.6	8
Other Japanese Companies	147	441	144	3.1	9	2.7
European Companies	**504**	**517**	**555**	**10.5**	**10.5**	**10.4**
Ericsson	16	23	20	0.3	0.5	0.4
Siemens	314	339	384	6.5	6.9	7.2
TCS	34	25	22	0.7	0.5	0.4
TEMIC	110	113	114	2.3	2.3	2.1
Zetex	1	1	0	0	0	0
Other European Companies	15	16	15	0.3	0.3	0.3
Asia/Pacific Companies	**26**	**32**	**32**	**0.5**	**0.7**	**0.6**
Korean Electronic Co.	22	24	20	0.5	0.5	0.4
Samsung	4	8	12	0	0.2	0.2

Source: Dataquest (April 1998)

Table 2-11
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	14.8
2	2	NEC	10,428	10,222	-2	6.9
3	3	Motorola	8,076	8,067	-0.1	5.5
6	4	Texas Instruments	7,064	7,352	4.1	5
5	5	Toshiba	8,065	7,253	-10.1	4.9
4	6	Hitachi	8,071	6,298	-22	4.3
7	7	Samsung	6,464	5,856	-9.4	4
8	8	Fujitsu	4,427	4,622	4.4	3.1
9	9	Philips	4,220	4,440	5.2	3
10	10	SGS-Thomson	4,112	4,019	-2.3	2.7
11	11	Mitsubishi	4,100	3,925	-4.3	2.7
13	12	Siemens	3,029	3,441	13.6	2.3
12	13	IBM	3,200	3,391	6	2.3
14	14	Matsushita	3,003	2,847	-5.2	1.9
20	15	Lucent Technologies	2,110	2,762	30.9	1.9
16	16	National Semiconductor	2,380	2,759	15.9	1.9
15	17	SANYO	2,491	2,471	-0.8	1.7
22	18	Advanced Micro Devices	1,947	2,341	20.2	1.6
19	19	Sharp	2,124	2,145	1	1.5
23	20	Rohm	1,731	2,053	18.6	1.4
21	21	Sony	1,983	1,974	-0.5	1.3
17	22	Hyundai	2,247	1,939	-13.7	1.3
18	23	LG Semicon	2,243	1,792	-20.1	1.2
24	24	Micron Technology	1,558	1,704	9.4	1.2
25	25	Rockwell	1,351	1,487	10.1	1
26	26	Analog Devices	1,260	1,370	8.7	0.9
27	27	LSI Logic	1,239	1,290	4.1	0.9
28	28	Oki	1,177	1,062	-9.8	0.7
30	29	Hewlett-Packard	945	1,025	8.5	0.7
29	30	Atmel	1,024	950	-7.2	0.6
31	31	Cirrus Logic	891	880	-1.2	0.6
32	32	TEMIC	813	856	5.3	0.6
33	33	VLSI Technology	672	713	6.1	0.5
34	34	Harris Semiconductor	629	697	10.8	0.5
40	35	Altera	497	631	27	0.4
36	36	Xilinx	566	612	8.1	0.4
73	37	Sun Microsystems	170	550	223.5	0.4
35	38	Sanken	622	540	-13.2	0.4

Table 2-11 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
37	39	Integrated Device Technology	554	536	-3.2	0.4
38	40	International Rectifier	520	511	-1.7	0.3
		All Others	16,366	18,036	10.2	12.3
		Americas Companies	**64,076**	**72,339**	**12.9**	**49.2**
		Japanese Companies	**50,884**	**47,825**	**-6**	**32.5**
		European Companies	**13,682**	**14,809**	**8.2**	**10.1**
		Asia/Pacific Companies	**13,508**	**12,192**	**-9.7**	**8.3**
		Total Market	**142,150**	**147,165**	**3.5**	**100**

Source: Dataquest (April 1998)

Table 2-12
Top 40 Total Market Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	17
2	2	NEC	9,354	9,014	-3.6	7.1
3	3	Texas Instruments	6,974	7,292	4.6	5.7
5	4	Motorola	6,584	6,585	0	5.2
7	5	Samsung	6,149	5,489	-10.7	4.3
6	6	Toshiba	6,204	5,340	-13.9	4.2
4	7	Hitachi	6,973	5,233	-25	4.1
8	8	Fujitsu	3,986	4,135	3.7	3.2
9	9	SGS-Thomson	3,526	3,447	-2.2	2.7
11	10	Philips	3,279	3,416	4.2	2.7
12	11	IBM	3,200	3,391	6	2.7
10	12	Mitsubishi	3,504	3,280	-6.4	2.6
16	13	National Semiconductor	2,223	2,624	18	2.1
15	14	Siemens	2,238	2,503	11.8	2
17	15	Lucent Technologies	2,020	2,489	23.2	2
19	16	Advanced Micro Devices	1,947	2,341	20.2	1.8
13	17	Hyundai	2,247	1,939	-13.7	1.5
18	18	Matsushita	1,988	1,882	-5.3	1.5
20	19	SANYO	1,902	1,818	-4.4	1.4
14	20	LG Semicon	2,243	1,792	-20.1	1.4
22	21	Micron Technology	1,558	1,704	9.4	1.3
21	22	Sony	1,567	1,541	-1.7	1.2
24	23	Rockwell	1,351	1,487	10.1	1.2
23	24	Sharp	1,507	1,430	-5.1	1.1
25	25	Analog Devices	1,260	1,370	8.7	1.1
26	26	LSI Logic	1,239	1,290	4.1	1
27	27	Oki	1,138	1,018	-10.5	0.8
28	28	Atmel	1,024	950	-7.2	0.7
29	29	Cirrus Logic	891	880	-1.2	0.7
30	30	Rohm	757	869	14.8	0.7
31	31	VLSI Technology	672	713	6.1	0.6
35	32	Altera	497	631	27	0.5
32	33	Xilinx	566	612	8.1	0.5
68	34	Sun Microsystems	170	550	223.5	0.4
33	35	Integrated Device Technology	554	536	-3.2	0.4
34	36	Cypress Semiconductor	516	496	-3.9	0.4
40	37	Harris Semiconductor	397	467	17.6	0.4
42	38	Hewlett-Packard	380	466	22.6	0.4

Table 2-12 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
41	39	Maxim	387	463	19.6	0.4
45	40	TEMIC	347	461	32.9	0.4
		All Others	12,661	13,881	9.6	10.9
		Americas Companies	**59,836**	**67,952**	**13.6**	**53.3**
		Japanese Companies	**40,568**	**36,882**	**-9.1**	**28.9**
		European Companies	**10,381**	**11,152**	**7.4**	**8.7**
		Asia/Pacific Companies	**12,976**	**11,585**	**-10.7**	**9.1**
		Total Market	**123,761**	**127,571**	**3.1**	**100**

Source: Dataquest (April 1998)

Table 2-13
Top 20 Total Market Vendor Revenue from Shipments of Bipolar Digital Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Texas Instruments	340	293	-13.8	23.6
3	2	Motorola	271	264	-2.6	21.3
1	3	Hitachi	451	262	-41.9	21.1
5	4	NEC	90	82	-8.9	6.6
7	5	Philips	90	80	-11.1	6.5
6	6	Fujitsu	90	63	-30	5.1
11	7	Siemens	32	37	15.6	3
8	8	Toshiba	73	32	-56.2	2.6
10	9	Advanced Micro Devices	62	28	-54.8	2.3
13	10	Mitsubishi	25	24	-4	1.9
NA	11	Mosel Vitelic	0	20	NA	1.6
14	12	Matsushita	19	19	0	1.5
4	13	National Semiconductor	161	14	-91.3	1.1
9	14	Lucent Technologies	70	10	-85.7	0.8
17	15	LG Semicon	10	8	-20	0.6
18	16	Oki	4	3	-25	0.2
12	17	Applied Micro Circuits Corp.	30	0	-100	0
15	18	Raytheon	15	0	-100	0
16	19	GEC Plessey	12	0	-100	0
19	20	Harris Semiconductor	4	0	-100	0
		All Others	-	-	NA	0
		Americas Companies	**953**	**609**	**-36.1**	**49.2**
		Japanese Companies	**752**	**485**	**-35.5**	**39.1**
		European Companies	**134**	**117**	**-12.7**	**9.4**
		Asia/Pacific Companies	**10**	**28**	**180**	**2.3**
		Total Market	**1,849**	**1,239**	**-33**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-14
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	20.8
2	2	NEC	8,515	8,320	-2.3	7.9
4	3	Samsung	5,889	5,167	-12.3	4.9
6	4	Motorola	5,113	4,903	-4.1	4.7
7	5	Texas Instruments	4,950	4,804	-2.9	4.6
3	6	Hitachi	5,995	4,595	-23.4	4.4
5	7	Toshiba	5,186	4,288	-17.3	4.1
8	8	Fujitsu	3,471	3,745	7.9	3.6
9	9	IBM	3,200	3,391	6	3.2
10	10	Mitsubishi	2,895	2,812	-2.9	2.7
15	11	Lucent Technologies	1,715	2,374	38.4	2.3
14	12	Advanced Micro Devices	1,770	2,123	19.9	2
11	13	Hyundai	2,246	1,936	-13.8	1.8
12	14	LG Semicon	2,193	1,736	-20.8	1.7
17	15	Micron Technology	1,558	1,704	9.4	1.6
13	16	Philips	1,858	1,619	-12.9	1.5
16	17	SGS-Thomson	1,651	1,556	-5.8	1.5
22	18	Siemens	1,226	1,384	12.9	1.3
21	19	Rockwell	1,230	1,356	10.2	1.3
19	20	Sharp	1,415	1,332	-5.9	1.3
18	21	Matsushita	1,422	1,308	-8	1.2
20	22	LSI Logic	1,239	1,290	4.1	1.2
25	23	National Semiconductor	1,047	1,252	19.6	1.2
24	24	Sony	1,050	1,028	-2.1	1
23	25	Oki	1,103	998	-9.5	1
27	26	SANYO	945	968	2.4	0.9
26	27	Atmel	1,024	919	-10.3	0.9
29	28	VLSI Technology	672	713	6.1	0.7
33	29	Altera	497	631	27	0.6
30	30	Xilinx	566	612	8.1	0.6
28	31	Cirrus Logic	741	604	-18.5	0.6
60	32	Sun Microsystems	170	550	223.5	0.5
31	33	Integrated Device Technology	554	536	-3.2	0.5
32	34	Cypress Semiconductor	516	496	-3.9	0.5
38	35	Hewlett-Packard	380	466	22.6	0.4
35	36	S3	464	437	-5.8	0.4
40	37	Microchip Technology	330	422	27.9	0.4
36	38	Symbios	458	418	-8.7	0.4

Table 2-14 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
34	39	United Microelectronics	492	378	-23.2	0.4
39	40	Macronix	354	365	3.1	0.3
		All Others	8,328	9,398	12.8	9
		Americas Companies	**50,721**	**57,414**	**13.2**	**54.8**
		Japanese Companies	**33,361**	**30,597**	**-8.3**	**29.2**
		European Companies	**5,596**	**5,645**	**0.9**	**5.4**
		Asia/Pacific Companies	**12,531**	**11,024**	**-12**	**10.5**
		Total Market	**102,209**	**104,680**	**2.4**	**100**

Source: Dataquest (April 1998)

Table 2-15
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Samsung	5,501	4,623	-16	14.9
2	2	NEC	3,913	3,215	-17.8	10.4
3	3	Hitachi	3,514	2,209	-37.1	7.1
5	4	Hyundai	2,236	1,931	-13.6	6.2
10	5	Micron Technology	1,558	1,704	9.4	5.5
7	6	Texas Instruments	1,984	1,524	-23.2	4.9
8	7	Fujitsu	1,656	1,508	-8.9	4.9
6	8	LG Semicon	2,021	1,489	-26.3	4.8
4	9	Toshiba	2,513	1,485	-40.9	4.8
9	10	Mitsubishi	1,614	1,435	-11.1	4.6
13	11	Siemens	911	1,028	12.8	3.3
11	12	IBM	1,253	990	-21	3.2
12	13	Intel	950	850	-10.5	2.7
18	14	Advanced Micro Devices	711	708	-0.4	2.3
15	15	Atmel	793	670	-15.5	2.2
17	16	Sharp	727	624	-14.2	2
16	17	SGS-Thomson	738	502	-32	1.6
19	18	Oki	541	448	-17.2	1.4
14	19	Motorola	827	435	-47.4	1.4
22	20	Integrated Device Technology	378	365	-3.4	1.2
27	21	Vanguard	225	334	48.4	1.1
25	22	Matsushita	300	315	5	1
21	23	Cypress Semiconductor	382	314	-17.8	1
26	24	Macronix	288	300	4.2	1
20	25	Mosel Vitelic	398	296	-25.6	1
23	26	Sony	330	193	-41.5	0.6
24	27	SANYO	302	162	-46.4	0.5
28	28	Nippon Steel Semiconductor	198	145	-26.8	0.5
30	29	Winbond Electronics	160	135	-15.6	0.4
33	30	Microchip Technology	117	126	7.7	0.4
34	31	Integrated Silicon Solution	111	125	12.6	0.4
32	32	Xicor	123	122	-0.8	0.4
36	33	Alliance Semiconductor	66	111	68.2	0.4
NA	34	Fairchild	0	80	NA	0.3
35	35	Silicon Storage Technology	91	75	-17.6	0.2
NA	36	Philips	0	73	NA	0.2
37	37	Catalyst	54	70	29.6	0.2
38	38	Rohm	51	48	-5.9	0.2

Table 2-15 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
45	39	G-Link USA	15	34	126.7	0.1
29	40	United Microelectronics	177	22	-87.6	0
		All Others	337	155	-54	0.5
		Americas Companies	**9,656**	**8,375**	**-13.3**	**27**
		Japanese Companies	**15,708**	**11,827**	**-24.7**	**38.2**
		European Companies	**1,669**	**1,621**	**-2.9**	**5.2**
		Asia/Pacific Companies	**11,031**	**9,155**	**-17**	**29.6**
		Total Market	**38,064**	**30,978**	**-18.6**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-16
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	16,831	20,896	24.2	42.7
2	2	Motorola	3,153	3,530	12	7.2
3	3	NEC	2,179	2,404	10.3	4.9
5	4	Texas Instruments	1,550	1,728	11.5	3.5
4	5	Hitachi	1,629	1,683	3.3	3.4
6	6	Rockwell	1,226	1,351	10.2	2.8
7	7	Toshiba	1,197	1,336	11.6	2.7
15	8	Advanced Micro Devices	624	1,106	77.2	2.3
14	9	National Semiconductor	627	1,101	75.6	2.2
12	10	Fujitsu	677	967	42.8	2
9	11	Mitsubishi	901	936	3.9	1.9
13	12	Lucent Technologies	635	888	39.8	1.8
10	13	IBM	889	803	-9.7	1.6
8	14	Philips	1,085	791	-27.1	1.6
17	15	SGS-Thomson	482	616	27.8	1.3
11	16	Cirrus Logic	741	604	-18.5	1.2
31	17	Sun Microsystems	170	550	223.5	1.1
16	18	Matsushita	534	457	-14.4	0.9
18	19	S3	464	437	-5.8	0.9
22	20	Digital	271	359	32.5	0.7
19	21	United Microelectronics	315	356	13	0.7
21	22	Siemens	284	333	17.3	0.7
25	23	Microchip Technology	213	296	39	0.6
23	24	Analog Devices	258	287	11.2	0.6
20	25	Zilog	286	262	-8.4	0.5
37	26	ATI Technologies	130	260	100	0.5
NA	27	ESS	0	240	NA	0.5
24	28	Adaptec	214	238	11.2	0.5
45	29	Samsung	99	237	139.4	0.5
32	30	SANYO	164	229	39.6	0.5
27	31	Sharp	184	207	12.5	0.4
34	32	Standard Microsystems	153	175	14.4	0.4
26	33	Sony	189	173	-8.5	0.4
35	34	C-Cube	150	171	14	0.3
29	35	Oki	175	164	-6.3	0.3
30	36	Oak Technology	172	163	-5.2	0.3
41	37	VIA	110	151	37.3	0.3
28	38	Trident Microsystems	180	144	-20	0.3

Table 2-16 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
36	39	Chips & Technologies	150	131	-12.7	0.3
44	40	Symbios	102	129	26.5	0.3
		All Others	2,076	2,056	-1	4.2
		Americas Companies	**30,450**	**36,974**	**21.4**	**75.5**
		Japanese Companies	**8,115**	**8,817**	**8.7**	**18**
		European Companies	**1,977**	**1,899**	**-3.9**	**3.9**
		Asia/Pacific Companies	**927**	**1,255**	**35.4**	**2.6**
		Total Market	**41,469**	**48,945**	**18**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-17
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	2,423	2,701	11.5	10.9
8	2	IBM	1,058	1,598	51	6.5
3	3	Texas Instruments	1,416	1,552	9.6	6.3
7	4	Lucent Technologies	1,080	1,486	37.6	6
2	5	Toshiba	1,476	1,467	-0.6	5.9
4	6	Fujitsu	1,138	1,270	11.6	5.1
5	7	LSI Logic	1,136	1,182	4	4.8
6	8	Motorola	1,133	938	-17.2	3.8
10	9	Philips	773	755	-2.3	3
9	10	Hitachi	852	703	-17.5	2.8
11	11	VLSI Technology	615	667	8.5	2.7
14	12	Sony	531	662	24.7	2.7
16	13	Altera	497	631	27	2.5
13	14	Xilinx	566	612	8.1	2.5
17	15	SANYO	479	577	20.5	2.3
12	16	Matsushita	588	536	-8.8	2.2
15	17	Sharp	504	501	-0.6	2
22	18	Hewlett-Packard	380	466	22.6	1.9
21	19	Mitsubishi	380	441	16.1	1.8
19	20	SGS-Thomson	431	438	1.6	1.8
20	21	Oki	387	386	-0.3	1.6
18	22	Advanced Micro Devices	435	309	-29	1.2
25	23	Samsung	289	307	6.2	1.2
23	24	Symbios	356	289	-18.8	1.2
26	25	Rohm	210	264	25.7	1.1
28	26	Lattice	200	242	21	1
NA	27	Fairchild	0	227	NA	0.9
32	28	Alcatel Microelectronics	179	204	14	0.8
41	29	Gould AMI	95	194	104.2	0.8
29	30	GEC Plessey	186	186	0	0.8
30	31	Atmel	182	184	1.1	0.7
42	32	Cypress Semiconductor	70	176	151.4	0.7
52	33	Micronas	33	170	415.2	0.7
33	34	Actel	149	156	4.7	0.6
27	35	Seiko Epson	201	152	-24.4	0.6
24	36	National Semiconductor	293	149	-49.1	0.6
34	37	Harris Semiconductor	140	146	4.3	0.6
38	38	LG Semicon	113	126	11.5	0.5

Table 2-17 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
37	39	Dallas Semiconductor	117	125	6.8	0.5
36	40	Austria Mikro Systeme	133	124	-6.8	0.5
		All Others	1,452	1,458	0.4	5.9
		Americas Companies	**10,615**	**12,065**	**13.7**	**48.7**
		Japanese Companies	**9,538**	**9,953**	**4.4**	**40.2**
		European Companies	**1,950**	**2,125**	**9**	**8.6**
		Asia/Pacific Companies	**573**	**614**	**7.2**	**2.5**
		Total Market	**22,676**	**24,757**	**9.2**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-18
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Texas Instruments	1,684	2,195	30.3	10.1
1	2	SGS-Thomson	1,875	1,891	0.9	8.7
3	3	Philips	1,291	1,717	33	7.9
4	4	Motorola	1,200	1,418	18.2	6.5
5	5	National Semiconductor	1,015	1,358	33.8	6.3
6	6	Siemens	980	1,082	10.4	5
7	7	Analog Devices	946	1,064	12.5	4.9
8	8	Toshiba	909	1,020	12.2	4.7
9	9	SANYO	780	850	9	3.9
10	10	NEC	624	612	-1.9	2.8
11	11	Matsushita	547	555	1.5	2.6
17	12	Rohm	357	535	49.9	2.5
12	13	Sony	452	513	13.5	2.4
15	14	Maxim	383	463	20.9	2.1
14	15	Mitsubishi	397	444	11.8	2.1
16	16	Linear Technology	365	419	14.8	1.9
13	17	Hitachi	409	376	-8.1	1.7
18	18	Fujitsu	291	327	12.4	1.5
19	19	Samsung	260	322	23.8	1.5
26	20	TEMIC	153	290	89.5	1.3
27	21	Cirrus Logic	150	276	84	1.3
21	22	Harris Semiconductor	195	258	32.3	1.2
23	23	New JRC	160	198	23.8	0.9
29	24	Advanced Micro Devices	115	190	65.2	0.9
25	25	Burr-Brown	157	165	5.1	0.8
24	26	Allegro MicroSystems	159	144	-9.4	0.7
NA	27	Robert Bosch	0	140	NA	0.6
28	28	Rockwell	121	131	8.3	0.6
38	29	Mitel	83	128	54.2	0.6
30	30	Level One Communications	112	127	13.4	0.6
33	31	Unitrode	98	118	20.4	0.5
31	32	PMC Sierra Semiconductor	101	116	14.9	0.5
22	33	VTC	172	110	-36	0.5
20	34	Lucent Technologies	235	105	-55.3	0.5
59	35	Micrel	18	104	477.8	0.5
32	36	Cherry Semiconductor	100	101	1	0.5
37	37	Ericsson	87	100	14.9	0.5
36	38	Sharp	92	98	6.5	0.5

Table 2-18 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
NA	39	Anadigics	0	97	NA	0.4
47	40	Semtech	42	90	114.3	0.4
		All Others	1,120	1,405	25.4	6.5
		Americas Companies	**8,013**	**9,929**	**23.9**	**45.9**
		Japanese Companies	**5,210**	**5,800**	**11.3**	**26.8**
		European Companies	**4,577**	**5,390**	**17.8**	**24.9**
		Asia/Pacific Companies	**435**	**533**	**22.5**	**2.5**
		Total Market	**18,235**	**21,652**	**18.7**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-19
Top 40 Total Market Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Toshiba	1,390	1,484	6.8	10.4
1	2	Motorola	1,452	1,446	-0.4	10.1
4	3	Philips	941	1,024	8.8	7.2
3	4	Hitachi	977	949	-2.9	6.7
5	5	NEC	818	885	8.2	6.2
6	6	Rohm	681	827	21.4	5.8
8	7	Matsushita	565	577	2.1	4
7	8	SGS-Thomson	586	572	-2.4	4
10	9	Siemens	452	554	22.6	3.9
9	10	International Rectifier	493	480	-2.6	3.4
12	11	SANYO	441	478	8.4	3.4
11	12	Mitsubishi	452	460	1.8	3.2
16	13	Sanken	328	434	32.3	3
14	14	General Semiconductor	362	370	2.2	2.6
13	15	Fuji Electric	401	356	-11.2	2.5
17	16	Samsung	307	355	15.6	2.5
18	17	Fujitsu	290	319	10	2.2
15	18	TEMIC	353	281	-20.4	2
19	19	Shindengen Electric	277	266	-4	1.9
20	20	Harris Semiconductor	232	230	-0.9	1.6
21	21	Korean Electronic Co.	193	220	14	1.5
24	22	Microsemi	146	156	6.8	1.1
NA	23	Fairchild	0	141	NA	1
23	24	National Semiconductor	157	135	-14	0.9
25	25	Hewlett-Packard	140	126	-10	0.9
26	26	Semikron	109	116	6.4	0.8
22	27	Eupec	160	111	-30.6	0.8
27	28	Powerex	98	98	0	0.7
28	29	Teccor Electronics	83	92	10.8	0.6
32	30	Zetex	52	86	65.4	0.6
NA	31	Robert Bosch	0	85	NA	0.6
30	32	Ixys	66	69	4.5	0.5
NA	33	Micronas	0	55	NA	0.4
33	34	Sony	43	39	-9.3	0.3
NA	35	Fagor	0	32	NA	0.2
NA	36	TCS	0	31	NA	0.2
36	37	Ericsson	28	30	7.1	0.2
NA	38	Power Innovations	0	29	NA	0.2

Table 2-19 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
34	39	GEC Plessey	35	27	-22.9	0.2
39	40	Supertex	16	17	6.3	0.1
		All Others	350	213	-39.1	1.5
		Americas Companies	**3,416**	**3,391**	**-0.7**	**23.8**
		Japanese Companies	**6,774**	**7,187**	**6.1**	**50.4**
		European Companies	**2,784**	**3,102**	**11.4**	**21.8**
		Asia/Pacific Companies	**500**	**575**	**15**	**4**
		Total Market	**13,474**	**14,255**	**5.8**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-20
Top 33 Total Market Vendor Revenue from Shipments of Total Optical Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Sharp	617	715	15.9	13.4
4	2	Hewlett-Packard	425	433	1.9	8.1
2	3	Toshiba	471	429	-8.9	8
5	4	Sony	373	394	5.6	7.4
3	5	Matsushita	450	388	-13.8	7.3
6	6	Siemens	339	384	13.3	7.2
7	7	Rohm	293	357	21.8	6.7
8	8	NEC	256	323	26.2	6
NA	9	Stanley	0	294	NA	5.5
14	10	Lucent Technologies	90	273	203.3	5.1
11	11	Mitsubishi	144	185	28.5	3.5
10	12	SANYO	148	175	18.2	3.3
9	13	Fujitsu	151	168	11.3	3.1
12	14	Hitachi	121	116	-4.1	2.2
13	15	TEMIC	113	114	0.9	2.1
15	16	Texas Instruments	62	60	-3.2	1.1
17	17	Quality Technologies	52	54	3.8	1
16	18	Optek	59	53	-10.2	1
18	19	Honeywell	41	38	-7.3	0.7
19	20	Motorola	40	36	-10	0.7
20	21	Sanken	40	36	-10	0.7
21	22	Oki	28	32	14.3	0.6
22	23	TCS	25	22	-12	0.4
23	24	Korean Electronic Co.	24	20	-16.7	0.4
24	25	Ericsson	23	20	-13	0.4
26	26	Spectra Diode Labs	17	17	0	0.3
25	27	Mitel	22	16	-27.3	0.3
28	28	Samsung	8	12	50	0.2
29	29	IC Sensors	7	7	0	0.1
30	30	CID Technologies	6	6	0	0.1
31	31	Eastman Kodak	3	3	0	0
27	32	New JRC	9	0	-100	0
32	33	Zetex	1	0	-100	0
		All Others	457	159	-65.2	3
		Americas Companies	**824**	**996**	**20.9**	**18.7**
		Japanese Companies	**3,542**	**3,756**	**6**	**70.4**
		European Companies	**517**	**555**	**7.4**	**10.4**
		Asia/Pacific Companies	**32**	**32**	**0**	**0.6**
		Total Market	**4,915**	**5,339**	**8.6**	**100**

NA = Not available
Source: Dataquest (April 1998)

For More Information...
Inquiry Hotline +1-408-468-8423
Internet address scndinquiry@dataquest.com
Via fax +1-408-954-1780
Dataquest Interactive http://www.dataquest.com

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Research Center
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

EUROPE

European Headquarters
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431 611
Facsimile: +44 1784 488 980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49 89 42 70 4-0
Facsimile: +49 89 42 70 4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153
Japan
Phone: 81-3-3481-3670
Facsimile: 81-3-3481-3644

ASIA/PACIFIC

Asia/Pacific Headquarters
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

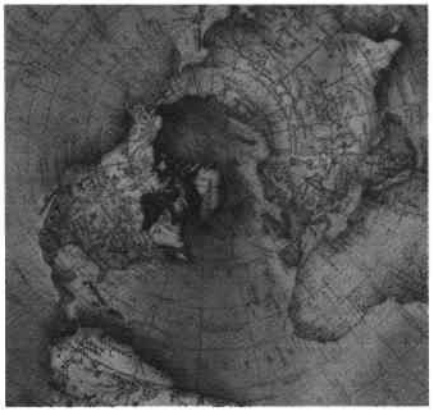
Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-2756-0389
Facsimile: 8862-2756-0663

Dataquest Singapore
6 Temasek Boulevard, #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: 65-333-6773
Facsimile: 65-333-6768

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Dataquest Australia
80 Alfred Street
Milsons Point NSW 2061
Australia
Phone: 61-2-9941-4860
Facsimile: 61-2-9941-4868

Dataquest
A Gartner Group Company



Dataquest

North American Semiconductor Price Outlook, Second Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9801
Publication Date: March 23, 1998
Filing: Market Statistics

North American Semiconductor Price Outlook, Second Quarter 1998

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9801
Publication Date: March 23, 1998
Filing: Market Statistics

Table of Contents

List of Tables

Chapter 1

North American Semiconductor Prices, Second Quarter 1998

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 (SSPS) 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 SSPS clients that use the SSPS online service through CompuServe, the prices presented here correlate with the quarterly and long-range price tables dated March 1998 in the SSPS online service. Clients who want to access the information on the World Wide Web can pay extra for a Dataquest on Gartner Group Interactive subscription, which allows users to access all their deliverables at their desktops. 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.

Chapter 2
Market Statistics Tables

Tables 2-1 through 2-16 show statistics on North American semiconductor prices.

Table 2-1
Estimated Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q1	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
74LS TTL											
74LS00	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	3-8
74LS74	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	3-8
74LS138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74LS244	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.21	3-8
74AC TTL											
74AC00	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	3-8
74AC74	0.18	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	3-8
74AC138	0.28	0.28	0.28	0.28	0.28	0.26	0.26	0.26	0.26	0.26	3-8
74AC244	0.36	0.36	0.36	0.36	0.36	0.33	0.33	0.33	0.33	0.33	3-8
74F TTL											
74F00	0.12	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11	3-8
74F74	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	3-8
74F138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74F244	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.21	3-8
74HC CMOS											
74HC00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	3-8
74HC74	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	3-8
74HC138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74HC244	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.22	0.21	3-8
74ALS TTL											
74ALS00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	3-8
74ALS74	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	3-8
74ALS138	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	3-8
74ALS244	0.27	0.27	0.27	0.27	0.27	0.26	0.28	0.26	0.26	0.26	3-8

Table 2-1 (Continued)
Estimated Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q1	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
74AS TTL											
74AS00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS74	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS138	0.40	0.39	0.39	0.39	0.39	0.37	0.37	0.37	0.37	0.37	3-8
74AS244	0.61	0.61	0.61	0.61	0.61	0.60	0.60	0.59	0.59	0.60	3-8
74BC*											
74BC00	0.19	0.19	0.18	0.18	0.19	0.17	0.17	0.17	0.17	0.17	3-8
74BC244	0.48	0.48	0.46	0.46	0.47	0.44	0.44	0.40	0.40	0.42	3-8
74BC373	0.50	0.50	0.46	0.46	0.48	0.44	0.44	0.42	0.42	0.43	3-8
74ACT244	0.38	0.38	0.36	0.36	0.37	0.35	0.35	0.33	0.33	0.34	3-8
74ACT245	0.40	0.40	0.37	0.37	0.39	0.36	0.36	0.34	0.34	0.35	3-8
74ABT244	0.49	0.49	0.48	0.48	0.49	0.46	0.46	0.44	0.44	0.45	3-8
74ABT245	0.52	0.52	0.51	0.51	0.52	0.49	0.49	0.46	0.46	0.48	3-8

*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 1998)

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

Product	1998	1999	2000	2001	2002
74LS TTL					
74LS00	0.13	0.13	0.13	0.14	0.15
74LS74	0.16	0.16	0.16	0.16	0.17
74LS138	0.17	0.17	0.17	0.17	0.18
74LS244	0.22	0.21	0.20	0.20	0.20
74AC TTL					
74AC00	0.15	0.14	0.13	0.13	0.13
74AC74	0.17	0.16	0.15	0.15	0.15
74AC138	0.28	0.26	0.23	0.22	0.22
74AC244	0.36	0.33	0.31	0.30	0.30
74F TTL					
74F00	0.12	0.11	0.10	0.10	0.10
74F74	0.14	0.14	0.14	0.14	0.15
74F138	0.17	0.17	0.17	0.17	0.18
74F244	0.21	0.21	0.22	0.22	0.22
74HC CMOS					
74HC00	0.11	0.11	0.11	0.11	0.12
74HC74	0.15	0.15	0.15	0.15	0.16
74HC138	0.17	0.17	0.17	0.18	0.18
74HC244	0.21	0.21	0.22	0.22	0.23
74ALS TTL					
74ALS00	0.14	0.14	0.11	0.11	0.12
74ALS74	0.15	0.16	0.16	0.16	0.16
74ALS138	0.20	0.20	0.20	0.20	0.20
74ALS244	0.27	0.26	0.26	0.26	0.26
74AS TTL					
74AS00	0.19	0.19	0.19	0.19	0.19
74AS74	0.19	0.19	0.19	0.19	0.19
74AS138	0.39	0.37	0.35	0.34	0.34
74AS244	0.61	0.60	0.58	0.57	0.57
74BC*					
74BC00	0.19	0.17	0.16	0.16	0.16
74BC244	0.47	0.42	0.40	0.39	0.39
74BC373	0.48	0.43	0.31	0.40	0.40
74ACT244	0.37	0.34	0.30	0.29	0.29
74ACT245	0.39	0.35	0.34	0.33	0.32
74ABT244	0.49	0.45	0.40	0.37	0.37
74ABT245	0.52	0.48	0.42	0.40	0.40

*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 1998)

Table 2-3
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
68EC020-25 PQFP	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	2-4
68040-25	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
68LC040-25 CQFP 184	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
Pentium 166 MHz 3.3V PGA	85.00	80.00	78.00	75.00	79.50	EOL	EOL	EOL	EOL	EOL	2-4
Pentium 200 MHz 3.3V PGA	110.00	100.00	90.00	85.00	96.25	EOL	EOL	EOL	EOL	EOL	2-4
Pentium MMX 166 MHz 2.8V PGA	90.00	85.00	83.00	80.00	84.50	EOL	EOL	EOL	EOL	EOL	2-4
Pentium MMX 200 MHz 2.8V PGA	110.00	100.00	90.00	85.00	96.25	80.00	80.00	80.00	80.00	80.00	2-4
Pentium MMX 233 MHz 2.8V PGA	175.00	125.00	100.00	90.00	122.50	85.00	85.00	85.00	85.00	85.00	2-4
Pentium II 233 MHz 512K Cache	260.00	190.00	190.00	150.00	197.50	150.00	150.00	150.00	150.00	150.00	2-4
Pentium II 266 MHz 512K Cache	350.00	250.00	200.00	150.00	237.50	150.00	150.00	150.00	150.00	150.00	2-4
Pentium II 300 MHz 512K Cache	500.00	350.00	225.00	200.00	318.75	175.00	175.00	150.00	150.00	162.50	2-4
Pentium II 350 MHz 512K Cache	NA	600.00	400.00	350.00	450.00	275.00	225.00	175.00	145.00	205.00	2-4
Pentium II 400 MHz 512K Cache	NA	800.00	550.00	450.00	600.00	350.00	300.00	250.00	200.00	275.00	2-4
Pentium II 450 MHz 512K Cache	NA	NA	NA	800.00	800.00	700.00	450.00	350.00	275.00	443.75	2-4
Pentium II 266 MHz 0K Cache	NA	140.00	99.00	90.00	109.67	90.00	90.00	90.00	90.00	90.00	2-4
Pentium II 300 MHz 128K intCache	NA	NA	150.00	125.00	137.50	115.00	105.00	95.00	90.00	101.25	2-4
Pentium Pro 166 512K Cache	380	380	380	380	380.00	380	380	380	380	380.00	2-4
Pentium Pro 200 512K Cache	940	940	940	940	940.00	940	940	940	940	940.00	2-4
Pentium Pro 200 1M Cache	2,350	2,350	2,350	2,350	2,350.00	2,350	2,350	2,350	2,350	2,350.00	2-4
Pentium II/2 400 MHz 512K Cache	NA	NA	1,050	1,050	1,050.00	990	950	900	875	928.75	2-4
Pentium II/2 400 MHz 1,024K Cache	NA	NA	2,550	2,550	2,550.00	2,500	2,400	2,300	2,200	2,350.00	2-4
Pentium II/2 400 MHz 2,048K Cache	NA	NA	3,850	3,850	3,850.00	3,700	3,600	3,500	3,500	3,575.00	2-4

Table 2-3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
PowerPC 603e-100	34.00	33.32	32.65	32.00	32.99	31.36	30.73	30.12	29.52	30.43	2-4
Power PC 603e-133	135.00	132.30	129.65	127.06	131.00	124.52	122.03	119.59	117.20	120.83	2-4
PowerPC 604e-250	375.00	367.50	360.15	352.95	363.90	345.89	338.97	332.19	325.55	335.65	2-4
Power PC 604e-300	424.00	415.52	407.21	399.07	411.45	391.08	383.26	375.60	368.09	379.51	2-4
Power PC 604e-350	475.00	465.50	456.19	447.07	460.94	438.12	429.36	420.78	412.36	425.16	2-4
PowerPC 740-200	150.00	147.00	144.06	141.18	145.56	138.36	135.59	132.88	130.22	134.26	2-4
PowerPC 740-233	175.00	171.50	168.07	164.71	169.82	161.41	158.19	155.02	151.92	156.64	2-4
PowerPC 740-266	275.00	269.50	264.11	258.83	266.86	253.65	248.58	243.61	238.73	246.14	2-4
PowerPC 750-233	200.00	196.00	192.08	188.24	194.08	184.47	180.78	177.17	173.63	179.01	2-4
PowerPC 750-266	300.00	294.00	288.12	282.36	291.12	276.71	271.18	265.75	260.44	268.52	2-4

EOL = End of life
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1998)

Table 2-4
Estimated Long-Range Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 32/64 Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1998	1999	2000	2001	2002
68EC020-25 PQFP	16.88	16.88	14.34	12.19	EOL
68040-25	24.20	24.20	20.57	17.48	EOL
68LC040-25 CQFP 184	24.20	24.20	20.57	17.48	EOL
Pentium 166 MHz 3.3V PGA	79.50	EOL	EOL	EOL	EOL
Pentium 200 MHz 3.3V PGA	96.25	EOL	EOL	EOL	EOL
Pentium MMX 166 MHz 2.8V PGA	84.50	EOL	EOL	EOL	EOL
Pentium MMX 200 MHz 2.8V PGA	96.25	80.00	68.00	57.80	EOL
Pentium MMX 233 MHz 2.8V PGA	122.50	85.00	72.25	61.41	EOL
Pentium II 233 MHz 512K Cache	197.50	150.00	127.50	108.38	92.12
Pentium II 266 MHz 512K Cache	237.50	150.00	127.50	108.38	92.12
Pentium II 300 MHz 512K Cache	318.75	162.50	138.13	117.41	99.80
Pentium II 350 MHz 512K Cache	450.00	205.00	174.25	148.11	125.90
Pentium II 400 MHz 512K Cache	600.00	275.00	233.75	198.69	168.88
Pentium II 450 MHz 512K Cache	800.00	443.75	377.19	320.61	272.52
Pentium II 266 MHz 0K Cache	109.67	90.00	76.50	65.03	55.27
Pentium II 300 MHz 128K intCache	137.50	101.25	86.06	73.15	62.18
Pentium Pro 166 512K Cache	380.00	380.00	323.00	274.55	233.37
Pentium Pro 200 512K Cache	940.00	940.00	705.00	528.75	396.56
Pentium Pro 200 1M Cache	2,350.00	2,350.00	1,762.50	1,321.88	991.41
Pentium II/2 400 MHz 512K Cache	1,050.00	928.75	696.56	522.42	391.82
Pentium II/2 400 MHz 1,024K Cache	2,550.00	2,350.00	1,762.50	1,321.88	991.41
Pentium II/2 400 MHz 2,048K Cache	3,850.00	3,575.00	2,681.25	2,010.94	1,508.20
PowerPC 603e-100	32.99	30.43	25.87	EOL	EOL
Power PC 603e-133	131.00	120.83	102.71	EOL	EOL
PowerPC 604e-250	363.90	335.65	285.30	242.51	206.13
Power PC 604e-300	411.45	379.51	322.58	274.19	233.06
Power PC 604e-350	460.94	425.16	361.38	307.17	261.10
PowerPC 740-200	145.56	134.26	114.12	97.00	82.45
PowerPC 740-233	169.82	156.64	133.14	113.17	96.19
PowerPC 740-266	266.86	246.14	209.22	177.84	151.16
PowerPC 750-233	194.08	179.01	152.16	129.34	109.94
PowerPC 750-266	291.12	268.52	228.24	194.01	164.90

EOL = End of life
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1998)

Table 2-5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
4Mbx1 DRAM 70ns SOJ 5V	2.17	2.11	2.09	2.04	2.10	2.01	1.96	1.93	1.90	1.95	2-8
1Mbx4 DRAM 60ns SOJ 5V FPM	1.80	1.76	1.74	1.70	1.75	1.67	1.62	1.60	1.59	1.62	2-8
1Mbx4 DRAM 60ns SOJ 5V EDO	1.80	1.76	1.74	1.70	1.75	1.67	1.62	1.60	1.59	1.62	2-8
256Kx16 DRAM 70ns SOJ 5V	2.64	2.59	2.53	2.48	2.56	2.41	2.37	2.32	2.29	2.35	2-8
4Mbx4 DRAM 60ns SOJ 5V FPM	3.50	3.35	3.27	3.16	3.32	3.10	3.05	3.05	3.05	3.06	2-8
4Mbx4 DRAM 60ns SOJ 5V EDO	3.50	3.35	3.27	3.16	3.32	3.10	3.05	3.05	3.05	3.06	2-8
1Mbx16 DRAM 60ns TSOP 5V FPM	3.50	3.35	3.27	3.16	3.32	3.10	3.05	3.05	3.05	3.06	2-8
1Mbx16 DRAM 60ns TSOP 5V EDO	3.50	3.35	3.27	3.16	3.32	3.10	3.05	3.05	3.05	3.06	2-8
1Mbx16 3.3V SDRAM	4.97	4.86	4.41	4.23	4.62	4.04	3.84	3.56	3.44	3.72	2-8
2Mbx8 DRAM 60ns TSOP 5V FPM	3.50	3.35	3.27	3.16	3.32	3.10	3.05	3.05	3.05	3.06	2-8
2Mbx8 DRAM SDRAM 3.3V	4.97	4.86	4.41	4.23	4.62	4.04	3.84	3.56	3.44	3.72	2-8
16Mbx4 DRAM SOJ 60ns 3.3V EDO	23.97	21.33	19.10	18.55	20.74	17.86	16.92	16.22	15.99	16.75	2-8
16Mbx4 DRAM SOJ 3.3V SDRAM	24.02	22.10	20.36	19.03	21.38	17.98	17.00	16.33	16.00	16.83	2-8
8Mbx8 DRAM SOJ 60ns 3.3V EDO	23.97	21.33	19.10	18.55	20.74	17.86	16.92	16.22	15.99	16.75	2-8
8Mbx8 DRAM SOJ 3.3V SDRAM	24.02	22.10	20.36	19.03	21.38	17.98	17.00	16.33	16.00	16.83	2-8
4Mbx16 DRAM SOJ60ns 3.3V EDO	23.97	21.33	19.10	18.55	20.74	17.86	16.92	16.22	15.99	16.75	2-8
4Mbx16 DRAM SOJ 3.3V SDRAM	24.02	22.10	20.36	19.03	21.38	17.98	17.00	16.33	16.00	16.83	2-8
1Mbx32 SIMM 60ns 5V FPM	10.23	9.93	9.77	9.55	9.87	9.43	9.33	9.33	9.33	9.36	2-8
1Mbx36 SIMM 60ns 5V FPM	12.69	12.35	12.17	11.91	12.28	11.76	11.61	11.59	11.58	11.64	2-8
2Mbx32 SIMM 60ns 5V FPM	17.32	16.72	16.40	15.95	16.60	15.72	15.52	15.52	15.52	15.57	2-8
2Mbx36 SIMM 60ns 5V FPM	22.49	21.81	21.45	20.92	21.67	20.63	20.33	20.29	20.27	20.38	2-8
4Mbx32 SIMM 60ns 5V FPM	32.57	31.37	30.73	29.83	31.13	29.37	28.97	28.97	28.97	29.07	2-8
4Mbx36 SIMM 60ns 5V FPM	40.57	39.07	38.27	37.15	38.77	36.57	36.07	36.07	36.07	36.20	2-8
8Mbx32 SIMM 60ns 5V FPM	60.90	58.50	57.22	55.43	58.01	54.50	53.70	53.70	53.70	53.90	2-8
8Mbx36 SIMM 60ns 5V FPM	75.69	72.69	71.09	68.85	72.08	67.69	66.69	66.69	66.69	66.94	2-8
1Mbx32 SIMM 60ns 5V EDO	9.71	9.41	9.25	9.03	9.35	8.91	8.81	8.81	8.81	8.84	2-8
1Mbx36 SIMM 60ns 5V EDO	12.51	12.17	11.99	11.73	12.10	11.58	11.43	11.41	11.40	11.46	2-8
2Mbx32 SIMM 60ns 5V EDO	17.12	16.52	16.20	15.75	16.40	15.52	15.32	15.32	15.32	15.37	2-8

Table 2-5 (Continued)
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
2Mbx36 SIMM 60ns 5V EDO	22.31	21.63	21.27	20.74	21.49	20.45	20.15	20.11	20.09	20.20	2-8
4Mbx32 SIMM 60ns 5V EDO	32.07	30.87	30.23	29.33	30.63	28.87	28.47	28.47	28.47	28.57	2-8
4Mbx36 SIMM 60ns 5V EDO	40.11	53.71	49.21	47.41	47.61	45.51	43.51	40.71	39.51	42.31	2-8
8Mbx32 SIMM 60ns 5V EDO	60.71	58.31	57.03	55.24	57.82	54.31	53.51	53.51	53.51	53.71	2-8
8Mbx36 SIMM 60ns 5V EDO	75.21	72.21	70.61	68.37	71.60	67.21	66.21	66.21	66.21	66.46	2-8
1Mbx64 60ns 3.3V EDO	22.66	22.23	20.46	19.75	21.28	19.01	18.22	17.12	16.65	17.75	2-8
2Mbx64 60ns 3.3V EDO	52.65	47.37	42.91	41.81	46.19	40.43	38.55	37.15	36.69	38.21	2-8
4Mbx64 60ns 3.3V EDO	101.10	90.54	81.62	79.42	88.17	76.66	72.90	70.10	69.18	72.21	2-8
1Mbx64 3.3V SDRAM	23.21	22.77	20.97	20.25	21.80	19.49	18.69	17.57	17.09	18.21	2-8
2Mbx64 3.3V SDRAM	52.75	48.91	45.43	42.77	47.47	40.67	38.71	37.37	36.71	38.37	2-8
4Mbx64 3.3V SDRAM	101.09	77.43	76.69	75.51	82.68	73.98	72.56	71.21	68.59	71.58	2-8
256Kx32 SGRAM 66 MHz 3.3V	5.17	5.03	4.80	4.61	4.90	4.87	4.85	4.82	4.81	4.84	2-8
512Kx32 SGRAM 66 MHz 3.3V	11.44	10.85	10.24	9.23	10.44	9.98	9.94	9.68	9.86	9.87	2-8

*Contract volume is at least 100,000 per order.
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 1998)

Table 2-6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1998	1999	2000	2001	2002
4Mbx1 DRAM 70ns SOJ 5V	2.10	1.95	1.99	2.06	2.06
1Mbx4 DRAM 60ns SOJ 5V FPM	1.75	1.62	1.65	1.75	1.99
1Mbx4 DRAM 60ns SOJ 5V EDO	1.75	1.62	1.65	1.75	1.99
256Kx16 DRAM 70ns SOJ 5V	2.56	2.35	2.49	2.55	2.79
4Mbx4 DRAM 60ns SOJ 5V FPM	3.32	3.06	2.97	2.94	3.10
4Mbx4 DRAM 60ns SOJ 5V EDO	3.32	3.06	2.97	2.94	3.10
1Mbx16 DRAM 60ns TSOP 5V FPM	3.32	3.06	2.97	2.94	3.10
1Mbx16 DRAM 60ns TSOP 5V EDO	3.32	3.06	2.97	2.94	3.10
1Mbx16 3.3V SDRAM	4.62	3.72	3.33	3.17	3.07
2Mbx8 DRAM 60ns TSOP 5V FPM	3.32	3.06	2.97	2.94	3.10
2Mbx8 DRAM SDRAM 3.3V	4.62	3.72	3.33	3.17	3.07
16Mbx4 DRAM SOJ 60ns 3.3V EDO	20.74	16.75	14.95	12.50	12.12
16Mbx4 DRAM SOJ 3.3V SDRAM	21.38	16.83	14.88	12.31	12.01
8Mbx8 DRAM SOJ 60ns 3.3V EDO	20.74	16.75	14.95	12.50	12.12
8Mbx8 DRAM SOJ 3.3V SDRAM	21.38	16.83	14.88	12.31	12.01
4Mbx16 DRAM SOJ60ns 3.3V EDO	20.74	16.75	14.95	12.50	12.12
4Mbx16 DRAM SOJ 3.3V SDRAM	21.38	16.83	14.88	12.31	12.01
1Mbx32 SIMM 60ns 5V FPM	9.87	9.36	9.17	9.11	9.43
1Mbx36 SIMM 60ns 5V FPM	12.28	11.64	11.48	11.52	12.08
2Mbx32 SIMM 60ns 5V FPM	16.60	15.57	15.20	15.08	15.72
2Mbx36 SIMM 60ns 5V FPM	21.67	20.38	20.07	20.15	21.27
4Mbx32 SIMM 60ns 5V FPM	31.13	29.07	28.33	28.09	29.37
4Mbx36 SIMM 60ns 5V FPM	38.77	36.20	35.27	34.97	36.57
8Mbx32 SIMM 60ns 5V FPM	58.01	53.90	52.42	51.94	54.50
8Mbx36 SIMM 60ns 5V FPM	72.08	66.94	65.09	64.49	67.69
1Mbx32 SIMM 60ns 5V EDO	9.35	8.84	8.65	8.59	8.91
1Mbx36 SIMM 60ns 5V EDO	12.10	11.46	11.30	11.34	11.90
2Mbx32 SIMM 60ns 5V EDO	16.40	15.37	15.00	14.88	15.52
2Mbx36 SIMM 60ns 5V EDO	21.49	20.20	19.89	19.97	21.09
4Mbx32 SIMM 60ns 5V EDO	30.63	28.57	27.83	27.59	28.87
4Mbx36 SIMM 60ns 5V EDO	47.61	42.31	38.41	36.81	35.81
8Mbx32 SIMM 60ns 5V EDO	57.82	53.71	52.23	51.75	54.31
8Mbx36 SIMM 60ns 5V EDO	71.60	66.46	64.61	64.01	67.21
1Mbx64 60ns 3.3V EDO	21.28	17.75	16.22	15.59	15.20
2Mbx64 60ns 3.3V EDO	46.19	38.21	34.61	29.71	28.95
4Mbx64 60ns 3.3V EDO	88.17	72.21	65.02	55.22	53.70
1Mbx64 3.3V SDRAM	21.80	18.21	16.65	16.01	15.61
2Mbx64 3.3V SDRAM	47.47	38.37	34.47	29.33	28.73
4Mbx64 3.3V SDRAM	82.68	71.58	68.59	68.59	68.59
256Kx32 SGRAM 66 MHz 3.3V	4.90	4.84	4.64	4.55	4.41
512Kx32 SGRAM 66 MHz 3.3V	10.44	9.87	9.24	8.88	8.67

*Contract volume is at least 100,000 per order.
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 1998)

Table 2-7
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	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
16Kx4 35ns	2.07	2.09	2.09	2.11	2.09	2.11	2.11	2.13	2.13	2.12	2-4
8Kx8 25ns	0.94	0.89	0.88	0.88	0.90	0.83	0.83	0.83	0.83	0.83	2-4
8Kx8 100-120ns	1.12	1.10	1.08	1.08	1.09	1.03	1.03	1.03	1.03	1.03	2-4
64Kx4 10ns	5.03	4.85	4.78	4.77	4.86	4.75	4.68	4.65	4.60	4.67	2-4
64Kx4 25ns	1.60	1.60	1.55	1.55	1.58	1.53	1.53	1.51	1.51	1.52	2-4
32Kx8 12ns	1.25	1.23	1.23	1.23	1.24	1.25	1.25	1.25	1.25	1.25	2-4
32Kx9 12ns Burst	3.27	3.25	3.23	3.21	3.24	3.19	3.19	3.17	3.17	3.18	2-4
32Kx8 15ns 5V	1.10	1.10	1.10	1.10	1.10	1.13	1.13	1.13	1.13	1.13	2-4
32Kx8 15ns 3.3V	1.02	1.02	1.05	1.08	1.04	1.15	1.15	1.15	1.15	1.15	2-4
32Kx8 25ns	1.12	1.12	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.13	2-4
32Kx8 70-100ns SOJ	1.21	1.21	1.20	1.19	1.20	1.19	1.19	1.19	1.19	1.19	2-4
64Kx8 12ns Burst	13.35	12.20	11.80	11.35	12.18	11.25	11.17	11.03	10.95	11.10	2-4
256Kx4 20ns	3.31	3.27	3.24	3.22	3.26	3.05	3.03	3.01	2.98	3.02	2-4
256Kx4 12ns 3.3V	4.19	4.14	3.85	3.77	3.99	3.46	3.30	3.17	2.98	3.23	3-6
256Kx8 12ns 3.3V	4.02	3.72	3.54	3.36	3.66	3.24	3.11	3.05	3.00	3.10	3-6
128Kx8 15ns	3.32	3.25	3.16	3.13	3.21	2.91	2.90	2.88	2.86	2.89	2-4
128Kx8 20ns	3.16	3.19	3.10	3.06	3.13	2.91	2.90	2.88	2.86	2.89	2-4
128Kx8 25ns	3.16	3.19	3.10	3.06	3.13	2.91	2.90	2.88	2.86	2.89	2-4
128Kx8 70-100ns SOJ	2.79	2.75	2.68	2.66	2.72	2.62	2.60	2.57	2.57	2.59	2-4
32Kx32 15ns, 3.3V PQFP	3.18	3.13	3.08	3.04	3.11	3.00	3.00	2.96	2.96	2.98	3-6
32Kx32 8ns 3.3V PBSynch	2.76	2.71	2.68	2.66	2.70	2.64	2.61	2.60	2.59	2.61	3-6
64Kx32 8ns 3.3V PBSynch	5.17	5.04	4.89	4.62	4.93	4.57	4.52	4.48	4.46	4.51	3-6
64Kx32 5ns 3.3V PBSynch	7.00	6.76	6.22	5.75	6.43	5.55	5.40	5.19	5.00	5.29	3-6
256Kx16 70-100ns	13.53	13.00	12.48	12.27	12.82	12.15	12.02	12.00	11.95	12.03	3-6
256Kx16 25ns	16.79	16.26	15.51	15.06	15.90	14.60	14.33	13.80	13.69	14.11	3-8
512Kx8 70ns	13.06	12.60	12.26	11.85	12.44	11.70	11.60	11.29	11.11	11.43	3-8
512Kx8 25ns	16.91	16.04	14.75	14.04	15.44	13.80	13.30	13.00	12.81	13.23	3-8

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 1998)

Table 2-8
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	1998	1999	2000	2001	2002
16Kx4 35ns	2.09	2.12	2.14	2.16	2.17
8Kx8 25ns	0.90	0.83	0.83	0.85	0.85
8Kx8 100-120ns	1.09	1.03	1.00	1.00	1.05
64Kx4 10ns	4.86	4.67	4.52	4.50	4.50
64Kx4 25ns	1.58	1.52	1.51	1.51	1.51
32Kx8 12ns	1.24	1.25	1.28	1.38	1.50
32Kx9 12ns Burst	3.24	3.18	3.16	3.15	3.15
32Kx8 15ns 5V	1.10	1.13	1.18	1.25	1.50
32Kx8 15ns 3.3V	1.04	1.15	1.18	1.25	1.50
32Kx8 25ns	1.12	1.13	1.18	1.25	1.50
32Kx8 70-100ns SOJ	1.20	1.19	1.19	1.19	1.19
64Kx8 12ns Burst	12.18	11.10	10.55	10.39	10.21
256Kx4 20ns	3.26	3.02	2.84	2.81	2.74
256Kx4 12ns 3.3V	3.99	3.23	2.84	2.81	2.75
256Kx8 12ns 3.3V	3.66	3.10	2.90	2.85	2.79
128Kx8 15ns	3.21	2.89	2.81	2.75	2.70
128Kx8 20ns	3.13	2.89	2.81	2.75	2.70
128Kx8 25ns	3.13	2.89	2.81	2.75	2.70
128Kx8 70-100ns SOJ	2.72	2.59	2.54	2.51	2.50
32Kx32 15ns, 3.3V PQFP	3.11	2.98	2.92	3.06	3.25
32Kx32 8ns 3.3V PBSynch	2.70	2.61	2.69	3.12	3.39
64Kx32 8ns 3.3V PBSynch	4.93	4.51	4.28	4.85	5.30
64Kx32 5ns 3.3V PBSynch	6.43	5.29	4.75	4.85	5.30
256Kx16 70-100ns	12.82	12.03	11.70	11.06	11.70
256Kx16 25ns	15.90	14.11	13.50	12.70	11.90
512Kx8 70ns	12.44	11.43	11.00	10.88	10.77
512Kx8 25ns	15.44	13.23	12.39	11.90	11.09

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 1998)

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

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
128Kx8 ROM	1.58	1.55	1.51	1.51	1.54	1.48	1.46	1.45	1.54	1.48	4-8
64Kx16 ROM	1.73	1.70	1.66	1.66	1.69	1.61	1.59	1.59	1.69	1.62	4-8
256Kx8 ROM	2.10	2.08	2.05	2.05	2.07	2.00	1.98	1.97	2.07	2.01	4-8
512Kx8 ROM	2.70	2.68	2.55	2.62	2.64	2.57	2.53	2.50	2.64	2.56	4-8
256Kx16 ROM[1]	2.70	2.68	2.55	2.62	2.64	2.57	2.53	2.50	2.64	2.56	4-8
1Mbx8 ROM[2]	3.62	3.58	3.53	3.49	3.56	3.40	3.38	3.35	3.56	3.42	4-8
1Mbx16 ROM	5.55	5.50	5.46	5.46	5.49	5.35	5.30	5.30	5.49	5.36	4-8
2Mbx8 ROM	5.55	5.50	5.46	5.46	5.49	5.35	5.30	5.30	5.49	5.36	4-8
2Mbx16 ROM	11.00	11.00	10.70	10.45	10.79	10.35	10.20	10.20	10.79	10.38	4-8
4Mbx8 ROM	11.00	11.00	10.70	10.45	10.79	10.35	10.20	10.20	10.79	10.38	4-8
4Mbx16 ROM	14.50	14.50	14.00	14.00	14.25	13.85	13.60	13.55	14.25	13.81	4-9
8Mbx8 ROM	14.40	14.40	13.90	13.90	14.15	13.75	13.50	13.35	14.15	13.69	4-9

[1]256Kx16 ROM: 150ns and above; 40-pin PDIP
[2]1Mbx8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (March 1998)

Table 2-10
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	1998	1999	2000	2001	2002
128Kx8 ROM	1.54	1.48	1.45	1.43	1.42
64Kx16 ROM	1.69	1.62	1.57	1.55	1.54
256Kx8 ROM	2.07	2.01	1.96	1.94	1.92
512Kx8 ROM	2.64	2.56	2.47	2.42	2.4
256Kx16 ROM[1]	2.64	2.56	2.47	2.42	2.4
1Mbx8 ROM[2]	3.56	3.42	3.30	3.28	2.27
1Mbx16 ROM	5.49	5.36	5.26	5.22	5.18
2Mbx8 ROM	5.49	5.36	5.26	5.22	5.18
2Mbx16 ROM	10.79	10.38	10.11	9.89	9.49
4Mbx8 ROM	10.79	10.38	10.11	9.89	9.49
4Mbx16 ROM	14.25	13.81	13.44	13.13	12.86
8Mbx8 ROM	14.15	13.69	13.21	12.97	12.56

[1]256Kx16 ROM: 150ns and above; 40-pin PDIP
[2]1Mbx8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (March 1998)

Table 2-11
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
32Kx8 EPROM	1.26	1.23	1.22	1.21	1.23	1.21	1.19	1.18	1.13	1.18	2-3
64Kx8 EPROM	1.31	1.29	1.27	1.26	1.28	1.25	1.23	1.22	1.16	1.21	2-3
128Kx8 EPROM	1.65	1.65	1.60	1.59	1.62	1.56	1.55	1.52	1.52	1.54	2-3
256Kx8 EPROM	2.68	2.66	2.52	2.50	2.59	2.45	2.45	2.42	2.42	2.44	2-3
128Kx16 EPROM	3.08	3.03	2.82	2.80	2.93	2.75	2.75	2.71	2.71	2.73	2-3
512Kx8 EPROM	4.06	4.03	3.95	3.91	3.99	3.86	3.86	3.79	3.77	3.82	2-3
256Kx16 EPROM	5.33	5.14	4.94	4.74	5.03	4.65	4.60	4.48	4.43	4.54	2-3
1Mbx8 EPROM	7.38	7.33	7.18	6.65	7.13	6.63	6.68	6.35	6.25	6.48	2-3
512Kx16 EPROM	8.25	8.13	8.00	7.88	8.06	7.55	7.55	7.20	7.05	7.34	2-3

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 1998)

Table 2-12
Estimated Long-Range EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

Product	1998	1999	2000	2001	2002
32Kx8 EPROM	1.23	1.18	1.12	1.11	1.10
64Kx8 EPROM	1.28	1.21	1.15	1.13	1.11
128Kx8 EPROM	1.62	1.54	1.49	1.48	1.47
256Kx8 EPROM	2.59	2.44	2.40	2.37	2.36
128Kx16 EPROM	2.93	2.73	2.67	2.65	2.62
512Kx8 EPROM	3.99	3.82	3.72	3.64	3.60
256Kx16 EPROM	5.03	4.54	4.37	4.32	4.29
1Mbx8 EPROM	7.13	6.48	6.16	6.07	5.98
512Kx16 EPROM	8.06	7.34	6.96	6.82	6.77

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 1998)

Table 2-13
Estimated Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	Q1	Q2	Q3	1998 Q4	1998 Year	Q21	Q2	Q3	1999 Q4	1999 Year	Lead Times (Weeks)
64Kx8 PDIP/PLCC	2.18	2.15	2.05	2.03	2.10	1.98	1.98	1.95	1.95	1.96	5
64Kx8 TSOP	2.12	2.09	2.09	2.08	2.10	2.05	2.00	1.95	1.95	1.99	5
128Kx8 PDIP/PLCC	2.14	2.16	2.12	2.11	2.14	2.12	2.10	2.11	2.10	2.11	3
128Kx8 TSOP 12V	2.16	2.19	2.18	2.18	2.18	2.17	2.17	2.17	2.17	2.17	4
128Kx8 TSOP 5V	2.50	2.43	2.36	2.32	2.40	2.28	2.26	2.26	2.24	2.26	4
256Kx8 TSOP 12V	4.13	3.88	3.76	3.69	3.86	3.63	3.59	3.53	3.49	3.56	4
256Kx8 TSOP 5V	3.70	3.50	3.45	3.40	3.51	3.35	3.33	3.32	3.32	3.33	4
256Kx8 PDIP/PLCC	3.65	3.40	3.35	3.32	3.43	3.30	3.26	3.23	3.21	3.27	4
512Kx8 PDIP/PLCC	3.80	3.50	3.35	3.30	3.49	3.25	3.21	3.17	3.13	3.34	4
512Kx8 TSOP 12V	4.52	4.20	4.17	4.10	4.25	4.05	4.00	3.95	3.90	3.98	4
512Kx8 TSOP 5V	4.06	3.59	3.56	3.40	3.65	3.37	3.30	3.27	3.25	3.30	4
512Kx8 SSOP 3V	3.75	3.52	3.47	3.35	3.52	3.33	3.26	3.20	3.19	3.36	4
1Mx8 TSOP 12V	7.02	6.85	6.69	6.40	6.74	6.23	6.10	5.99	5.83	6.04	4
1Mx8 TSOP 5V	6.97	6.75	6.50	6.20	6.60	5.96	5.80	5.65	5.53	5.73	4
1Mx8 TSOP 3V	6.94	6.60	5.31	5.20	6.01	5.04	4.93	4.49	4.40	4.71	4
2Mx8 TSOP 12V	13.09	13.10	12.55	11.96	12.67	11.60	11.24	11.08	10.95	11.22	4
2Mx8 TSOP 5V	12.12	11.30	11.00	10.90	11.33	10.70	10.30	10.20	10.20	10.35	4
2Mx8 TSOP 3V	12.14	11.02	10.94	10.30	11.10	9.71	9.49	9.10	9.03	9.33	4
1Mx16 TSOP 12V	15.37	14.10	13.50	12.95	13.98	12.35	11.85	11.55	11.40	11.79	4
1Mbx16 TSOP 5V	16.79	15.47	14.23	13.21	14.92	11.41	11.07	10.77	11.56	11.20	4
1Mx16 TSOP 3V	17.01	14.74	11.55	10.88	13.54	10.28	10.03	9.63	9.55	9.87	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 price guidelines.
Source: Dataquest (March 1998)

Table 2-14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1998	1999	2000	2001	2002
64Kx8 PDIP/PLCC	2.10	1.96	1.94	1.95	2.00
64Kx8 TSOP	2.10	1.99	1.94	1.95	2.00
128Kx8 PDIP/PLCC	2.14	2.11	2.05	2.00	1.96
128Kx8 TSOP 12V	2.18	2.17	2.10	2.04	2.00
128Kx8 TSOP 5V	2.40	2.26	2.15	2.07	2.00
256Kx8 TSOP 12V	3.86	3.56	3.31	3.24	3.18
256Kx8 TSOP 5V	3.51	3.33	3.25	3.16	3.11
256Kx8 PDIP/PLCC	3.43	3.27	3.17	3.10	3.07
512Kx8 PDIP/PLCC	3.49	3.34	3.07	3.00	2.92
512Kx8 TSOP 12V	4.25	3.98	3.59	3.22	3.02
512Kx8 TSOP 5V	3.65	3.30	3.13	3.05	2.97
512Kx8 SSOP 3V	3.52	3.36	3.09	3.03	2.95
1Mx8 TSOP 12V	6.74	6.04	5.31	5.11	4.98
1Mx8 TSOP 5V	6.60	5.73	5.25	5.01	4.80
1Mx8 TSOP 3V	6.01	4.71	4.25	4.11	4.04
2Mx8 TSOP 12V	12.67	11.22	10.44	9.60	9.09
2Mx8 TSOP 5V	11.33	10.35	9.56	9.12	8.77
2Mx8 TSOP 3V	11.10	9.33	8.89	8.64	8.35
1Mx16 TSOP 12V	13.98	11.79	10.18	9.35	8.80
1Mbx16 TSOP 5V	14.92	11.20	9.67	8.88	8.36
1Mx16 TSOP 3V	13.54	9.87	8.94	8.84	8.35

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 1998)

Table 2-15
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	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	Lead Time (Weeks)
CMOS										Production:
0.8 Micron	20.00	19.00	19.00	16.00	15.00	14.00	14.00	13.00	12.00	4-10
0.6 Micron	22.00	21.00	20.00	15.00	14.00	13.00	16.00	15.00	13.00	4-10
0.5 Micron	25.00	24.00	23.00	21.00	20.00	20.00	18.00	17.00	15.00	4-10
0.35 Micron	34.00	34.00	34.00	28.00	26.00	26.00	20.00	19.00	17.00	4-10
										Prototype:
NRE CMOS Average Charge ($K)	43.00	43.00	43.00	53.00	51.00	51.00	73.00	72.00	72.00	1-4

Gate Count	100-299.99K Gates			>300K Gates			
Technology	1998	1999	2000	1998	1999	2000	Lead Time (Weeks)
CMOS							Production:
0.8 Micron	22.00	21.00	19.00	NA	NA	NA	4-10
0.6 Micron	22.00	21.00	19.00	30.00	29.00	29.00	4-10
0.5 Micron	24.00	22.00	20.00	32.00	32.00	32.00	4-10
0.35 Micron	31.00	30.00	29.00	38.00	38.00	38.00	4-10
							Prototype:
NRE CMOS Average Charge ($K)	105.00	103.00	103.00	125.00	120.00	120.00	1-4

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors.
Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (March 1998)

Table 2-16
Estimated CBIC Pricing—North American Production Bookings (Volume: 20,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype; Millicents per Gate)

Gate Count	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			
Technology	1998	1999	2000	1998	1999	2000	1998	1999	2000	Lead Time (Weeks)
CMOS										Production:
0.8 Micron	24.00	22.00	21.00	16.00	14.00	13.00	11.00	10.00	9.00	6-14
0.6 Micron	25.00	24.00	23.00	16.00	15.00	14.00	12.00	10.00	9.00	6-14
0.5 Micron	27.00	26.00	26.00	24.00	22.00	20.00	19.00	17.00	14.00	6-14
0.35 Micron	39.00	37.00	37.00	35.00	34.00	32.00	24.00	22.00	19.00	6-14
										Prototype:
NRE CMOS Average Charge ($K)	66.00	65.00	65.00	72.00	71.00	71.00	82.00	82.00	82.00	3-6

Gate Count	100-299.99K Gates			>300K Gates			
Technology	1998	1999	2000	1998	1999	2000	Lead Time (Weeks)
CMOS							Production:
0.8 Micron	15.00	14.00	12.00	NA	NA	NA	6-14
0.6 Micron	14.00	13.00	10.00	18.00	17.00	15.00	6-14
0.5 Micron	12.00	10.00	9.00	15.00	14.00	12.00	6-14
0.35 Micron	11.00	10.00	9.00	9.00	8.00	7.00	6-14
							Prototype:
NRE CMOS Average Charge ($K)	133.00	131.00	131.00	161.00	160.00	158.00	3-6

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors.
Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (March 1998)

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@dataquest.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

Dataquest
A Gartner Group Company

60254

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Research Center
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

EUROPE

European Headquarters
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431 611
Facsimile: +44 1784 488 980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49 89 42 70 4-0
Facsimile: +49 89 42 70 4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153
Japan
Phone: 81-3-3481-3670
Facsimile: 81-3-3481-3644

ASIA/PACIFIC

Asia/Pacific Headquarters
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

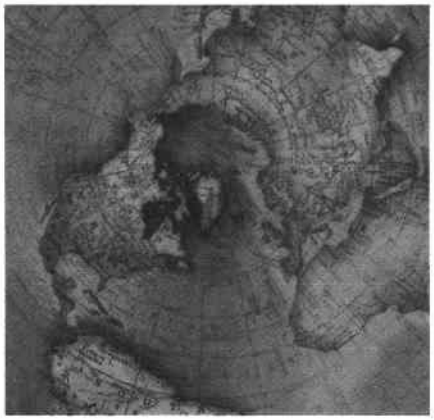
Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-2756-0389
Facsimile: 8862-2756-0663

Dataquest Singapore
6 Temasek Boulevard, #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: 65-333-6773
Facsimile: 65-333-6768

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Dataquest Australia
80 Alfred Street
Milsons Point NSW 2061
Australia
Phone: 61-2-9941-4860
Facsimile: 61-2-9941-4868

Dataquest
A Gartner Group Company



Dataquest

North American Semiconductor Pricing: First Quarter 1999

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9805
Publication Date: February 1, 1999
Filing: Market Statistics

North American Semiconductor Pricing: First Quarter 1999

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-MS-9805
Publication Date: February 1, 1999
Filing: Market Statistics

Table of Contents

List of Tables

Chapter 1
North American Semiconductor Prices, First Quarter 1999

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 (SSPS) 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.

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.

Chapter 2
Market Statistics Tables

Tables 2-1 through 2-16 show statistics on North American semiconductor prices.

Table 2-1
Estimated Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
74LS TTL												
74LS00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	3-8
74LS74	0.14	0.13	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	3-8
74LS138	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74LS244	0.20	0.19	0.19	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0.18	3-8
74AC TTL												
74AC00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	3-8
74AC74	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	3-8
74AC138	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.23	0.22	0.23	3-8
74AC244	0.32	0.29	0.29	0.29	0.29	0.29	0.29	0.27	0.27	0.27	0.28	3-8
74F TTL												
74F00	0.10	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08	3-8
74F74	0.11	0.11	0.11	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.10	3-8
74F138	0.16	0.15	0.15	0.15	0.14	0.15	0.14	0.14	0.14	0.14	0.14	3-8
74F244	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74HC CMOS												
74HC00	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	3-8
74HC74	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.13	3-8
74HC138	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.13	0.13	0.14	3-8
74HC244	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.18	0.19	3-8
74ALS TTL												
74ALS00	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	3-8
74ALS74	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	3-8
74ALS138	0.20	0.19	0.19	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0.18	3-8
74ALS244	0.24	0.23	0.23	0.22	0.22	0.22	0.21	0.21	0.20	0.20	0.20	3-8
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	3-8
74AS74	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	3-8
74AS138	0.39	0.38	0.38	0.38	0.38	0.38	0.37	0.37	0.36	0.36	0.37	3-8
74AS244	0.61	0.57	0.57	0.56	0.56	0.57	0.56	0.55	0.55	0.54	0.55	3-8

Table 2-1 (Continued)
Estimated Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package: PLCC; Dollars)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
74BC*												
74BC00	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	3-8
74BC244	0.46	0.44	0.44	0.40	0.40	0.42	0.39	0.37	0.35	0.34	0.36	3-8
74BC373	0.46	0.44	0.44	0.42	0.42	0.43	0.40	0.40	0.37	0.36	0.38	3-8
74ACT244	0.34	0.31	0.31	0.27	0.27	0.29	0.26	0.26	0.24	0.24	0.25	3-8
74ACT245	0.30	0.27	0.27	0.26	0.26	0.27	0.26	0.26	0.24	0.24	0.25	3-8
74ABT244	0.39	0.34	0.34	0.33	0.33	0.34	0.33	0.33	0.31	0.30	0.32	3-8
74ABT245	0.39	0.34	0.34	0.33	0.33	0.34	0.33	0.33	0.31	0.30	0.32	3-8

*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 (January 1999)

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

	1999	2000	2001	2002	2003
74LS TTL					
74LS00	0.12	0.12	0.13	0.13	0.13
74LS74	0.13	0.12	0.12	0.13	0.13
74LS138	0.17	0.17	0.17	0.18	0.18
74LS244	0.19	0.18	0.18	0.20	0.20
74AC TTL					
74AC00	0.14	0.14	0.14	0.16	0.17
74AC74	0.15	0.15	0.15	0.16	0.18
74AC138	0.24	0.23	0.22	0.24	0.26
74AC244	0.29	0.28	0.27	0.27	0.30
74F TTL					
74F00	0.09	0.08	0.08	0.09	0.10
74F74	0.11	0.10	0.10	0.10	0.11
74F138	0.15	0.14	0.14	0.14	0.16
74F244	0.17	0.17	0.17	0.18	0.19
74HC CMOS					
74HC00	0.11	0.10	0.10	0.12	0.13
74HC74	0.13	0.13	0.12	0.14	0.15
74HC138	0.14	0.14	0.13	0.13	0.16
74HC244	0.19	0.19	0.18	0.20	0.22
74ALS TTL					
74ALS00	0.13	0.13	0.13	0.14	0.14
74ALS74	0.13	0.13	0.13	0.14	0.14
74ALS138	0.19	0.18	0.17	0.19	0.20
74ALS244	0.22	0.20	0.20	0.22	0.22
74AS TTL					
74AS00	0.19	0.19	0.21	0.21	0.22
74AS74	0.19	0.19	0.21	0.21	0.22
74AS138	0.38	0.37	0.35	0.32	0.31
74AS244	0.57	0.55	0.52	0.50	0.49
74BC*					
74BC00	0.17	0.17	0.17	0.18	0.19
74BC244	0.42	0.36	0.34	0.32	0.32
74BC373	0.43	0.38	0.35	0.34	0.34
74ACT244	0.29	0.25	0.24	0.22	0.22
74ACT245	0.27	0.25	0.24	0.23	0.23
74ABT244	0.34	0.32	0.29	0.27	0.26
74ABT245	0.34	0.32	0.29	0.27	0.26

*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 (January 1999)

Table 2-3
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998			1999					2000			Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
68EC020-25 PQFP	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	16.88	2-4
68040-25	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
68LC040-25 CQFP 184	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	2-4
Celeron 300A (Mendocino)	100.00	65.00	60.00	60.00	60.00	61.25	60.00	60.00	60.00	60.00	60.00	2-4
Celeron 333 (Mendocino)	110.00	85.00	75.00	70.00	70.00	75.00	70.00	70.00	70.00	70.00	70.00	2-4
Celeron 366 (Mendocino)	NA	115.00	110.00	105.00	105.00	108.75	105.00	105.00	105.00	105.00	105.00	2-4
Celeron 400 (Mendocino)	NA	NA	150.00	130.00	115.00	131.67	115.00	115.00	115.00	115.00	115.00	2-4
Pentium II 266 MHz 512KB Cache	155.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00 180.00	2-4
Pentium II 333MHz 512KB Cache	185.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	180.00	150.00	
Pentium II 350 MHz 512KB Cache	210.00	200.00	195.00	180.00	175.00	187.50	150.00	150.00	150.00	150.00	195.00	2-4
Pentium II 400 MHz 512KB Cache	370.00	350.00	285.00	235.00	195.00	266.25	195.00	195.00	195.00	195.00	300.00 800.00	2-4
Pentium II 450 MHz 512KB Cache	550.00	525.00	450.00	350.00	300.00	406.25	300.00	300.00	300.00	300.00		2-4
Pentium II Xeon 400 MHz 512KB Cache	895.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00		2-4
Pentium II Xeon 400 MHz 1024KB Cache	1,950.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	2-4
Pentium II Xeon 450 MHz 512KB Cache	850.00	800.00	775.00	775.00	775.00	781.25	775.00	775.00	775.00	775.00	775.00	2-4
Pentium II Xeon 450 MHz 1024KB Cache	1,950.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	1,895.00	2-4
Pentium II Xeon 450 MHz 2048KB Cache	3,750.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	3,500.00	2-4
PowerPC 603e-200	47.66	43.85	43.85	41.66	41.66	42.76	40.41	39.60	39.60	39.60	39.80	2-4
PowerPC 603e-233	67.07	53.66	53.66	50.97	50.97	52.32	49.44	48.70	48.70	48.70	48.89	2-4
PowerPC 603e-266	84.37	67.50	67.50	64.12	64.12	65.81	62.20	60.64	60.64	60.64	61.03	2-4
PowerPC 603e-300	98.45	88.61	88.61	84.17	84.17	86.39	82.07	80.02	80.02	80.02	80.53	2-4
PowerPC 740-200	83.87	76.32	76.32	68.69	68.69	72.51	65.25	63.25	61.99	61.99	63.12	2-4
PowerPC 740-233	95.68	87.07	87.07	76.62	76.62	81.85	72.79	72.79	69.15	69.15	70.97	2-4
PowerPC 740-266	119.38	102.66	102.66	93.42	93.42	98.04	88.75	88.75	84.31	84.31	86.53	2-4
PowerPC 740-300	182.00	164.00	164.00	140.00	140.00	152.00	125.00	113.00	113.00	113.00	116.00	2-4
PowerPC 750-200	92.52	84.19	84.19	75.77	75.77	79.98	71.98	69.82	69.82	69.82	70.36	2-4

Table 2-3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
PowerPC 750-233	104.42	95.02	95.02	85.52	85.52	90.27	81.25	81.25	78.81	78.81	80.03	2-4
PowerPC 750-266	121.67	110.72	110.72	100.75	100.75	105.74	95.72	95.72	92.84	92.84	94.28	2-4
PowerPC 750-300	193.00	174.00	174.00	158.00	148.00	163.50	133.00	120.00	120.00	120.00	123.25	2-4
PowerPC 750-333	333.00	247.00	247.00	186.00	186.00	216.50	167.00	150.00	150.00	150.00	154.25	2-4
PowerPC 750-366	440.00	330.00	330.00	264.00	264.00	297.00	238.00	214.00	214.00	214.00	220.00	2-4

EOL = end of life
NA = Not available
*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 (January 1999)

Table 2-4
Estimated Long-Range Microprocessor Price Trends—North American Bookings (Volume: 25,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32/64-Bit Devices—Ceramic PGA; Exceptions Noted)

	1999	2000	2001	2002	2003
68EC020-25 PQFP	16.88	16.88	16.88	EOL	EOL
68040-25	24.20	24.20	24.20	EOL	EOL
68LC040-25 CQFP 184	24.20	24.20	24.20	EOL	EOL
Celeron 300A (Mendocino)	61.25	60.00	60.00	EOL	EOL
Celeron 333 (Mendocino)	75.00	70.00	70.00	EOL	EOL
Celeron 366 (Mendocino)	108.75	105.00	105.00	EOL	EOL
Celeron 400 (Mendocino)	131.67	115.00	115.00	EOL	EOL
Pentium II 266 MHz 512KB Cache	150.00	150.00	150.00	EOL	EOL
Pentium II 333MHz 512KB Cache	180.00	180.00	180.00	EOL	EOL
Pentium II 350 MHz 512KB Cache	187.50	150.00	150.00	EOL	EOL
Pentium II 400 MHz 512KB Cache	266.25	195.00	195.00	EOL	EOL
Pentium II 450 MHz 512KB Cache	406.25	300.00	300.00	EOL	EOL
Pentium II Xeon 400 MHz 512KB Cache	800.00	800.00	800.00	EOL	EOL
Pentium II Xeon 400 MHz 1024KB Cache	1,895.00	1,895.00	1,895.00	EOL	EOL
Pentium II Xeon 450 MHz 512KB Cache	781.25	775.00	775.00	EOL	EOL
Pentium II Xeon 450 MHz 1024KB Cache	1,895.00	1,895.00	1,895.00	EOL	EOL
Pentium II Xeon 450 MHz 2048KB Cache	3,500.00	3,500.00	3,500.00	EOL	EOL
PowerPC 603e-200	42.76	39.80	39.80	EOL	EOL
PowerPC 603e-233	52.32	48.89	48.89	EOL	EOL
PowerPC 603e-266	65.81	61.03	61.03	EOL	EOL
PowerPC 603e-300	86.39	80.53	80.53	EOL	EOL
PowerPC 740-200	72.51	48.62	61.99	61.99	EOL
PowerPC 740-233	81.85	70.97	69.15	69.15	EOL
PowerPC 740-266	98.04	86.53	84.31	84.31	EOL
PowerPC 740-300	152.00	116.00	113.00	113	EOL
PowerPC 750-200	79.98	70.36	69.82	69.82	EOL
PowerPC 750-233	90.27	80.03	78.81	78.81	EOL
PowerPC 750-266	105.74	94.28	92.84	92.84	EOL
PowerPC 750-300	163.50	123.25	120.00	120	EOL
PowerPC 750-333	216.50	154.25	150.00	150	EOL
PowerPC 750-366	297.00	220.00	214.00	214	EOL

EOL = End of life
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 1998)

Table 2-5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
4Mbx1 DRAM 70ns SOJ 5V	2.00	2.08	2.11	2.15	2.17	2.13	2.50	2.50	2.60	2.65	2.56	3-8
1Mbx4 DRAM 60ns SOJ 5V FPM	1.62	1.70	1.72	1.76	1.76	1.74	1.95	1.95	2.15	2.35	2.10	3-8
1Mbx4 DRAM 60ns SOJ 5V EDO	1.62	1.70	1.72	1.76	1.76	1.74	1.95	1.95	2.15	2.35	2.10	3-8
256Kx16 DRAM 70ns SOJ 5V	2.20	2.25	2.27	2.30	2.30	2.28	2.40	2.40	2.40	2.40	2.40	3-8
4Mbx4 DRAM 60ns SOJ 5V FPM	2.60	3.40	3.55	3.60	3.95	3.63	4.00	4.25	4.55	4.70	4.38	3-8
4Mbx4 DRAM 60ns SOJ 5V EDO	2.55	3.35	3.40	3.45	3.85	3.51	4.00	4.20	4.48	4.67	4.34	3-8
1Mbx16 DRAM 60ns TSOP 5V FPM	2.57	3.15	3.20	3.22	3.27	3.21	3.65	3.75	3.95	4.10	3.86	3-8
1Mbx16 DRAM 60ns TSOP 5V EDO	2.53	3.05	3.15	3.20	3.25	3.16	3.45	3.55	3.78	4.05	3.71	3-8
1Mbx16 3.3V SDRAM	2.75	2.90	3.00	3.10	3.15	3.04	3.20	3.30	3.40	3.45	3.34	3-8
2Mbx8 DRAM 60ns TSOP 5V FPM	2.57	3.00	3.10	3.20	3.24	3.14	3.55	3.67	3.85	4.00	3.77	3-8
2Mbx8 DRAM SDRAM 3.3V	2.46	2.80	2.85	2.98	3.07	2.93	3.11	3.20	3.26	3.34	3.23	3-8
16Mbx4 DRAM 60ns SOJ 3.3V EDO	9.16	9.05	8.88	8.76	8.73	8.86	8.70	8.67	8.62	8.60	8.65	3-8
16Mbx4 DRAM SOJ 3.3V SDRAM	9.06	8.95	8.80	8.68	8.57	8.75	8.54	8.52	8.49	8.48	8.51	3-8
16Mbx4 DRAM 3.3V PC100 SDRAM	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
8Mbx8 DRAM 60ns SOJ 3.3V EDO	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
8Mbx8 DRAM SOJ 3.3V SDRAM	9.16	9.05	8.88	8.76	8.73	8.86	8.70	8.67	8.62	8.60	8.65	3-8
8Mbx8 DRAM 3.3V PC100 SDRAM	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
4Mbx16 DRAM 60ns SOJ 3.3V EDO	9.06	8.95	8.80	8.68	8.57	8.75	8.54	8.52	8.49	8.48	8.51	3-8
4Mbx16 DRAM SOJ 3.3V SDRAM	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
4Mbx16 DRAM 3.3V PC100 SDRAM	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
1Mbx32 SIMM 60ns 5V FPM	9.16	9.05	8.88	8.76	8.73	8.86	8.70	8.67	8.62	8.60	8.65	3-8
2Mbx32 SIMM 60ns 5V FPM	9.85	9.10	8.95	8.78	8.60	8.86	8.47	8.43	8.45	8.35	8.43	3-8
4Mbx32 SIMM 60ns 5V FPM	12.08	14.40	14.60	14.68	14.88	14.64	16.40	16.80	17.60	18.20	17.25	3-8
8Mbx32 SIMM 60ns 5V FPM	44.22	53.50	54.30	54.62	55.42	54.46	61.50	63.10	66.30	68.70	64.90	3-8
1Mbx32 SIMM 60ns 5V EDO	11.92	14.00	14.40	14.60	14.80	14.45	15.60	16.00	16.92	18.00	16.63	3-8
2Mbx32 SIMM 60ns 5V EDO	43.58	51.90	53.50	54.30	55.10	53.70	58.30	59.90	63.58	67.90	62.42	3-8
4Mbx32 SIMM 60ns 5V EDO	45.68	45.26	44.57	44.11	43.98	44.48	43.85	43.73	43.53	43.45	43.64	3-8

Table 2-5 (Continued)
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
8Mbx32 SIMM 60ns 5V EDO	165.70	164.03	161.27	159.43	158.90	160.91	158.40	157.92	157.12	156.80	157.56	3-8
2Mbx64 60ns 3.3V EDO	45.30	44.85	44.26	43.77	43.33	44.05	43.21	43.13	43.01	42.97	43.08	3-8
4Mbx64 60ns 3.3V EDO	86.60	85.70	84.53	83.54	82.66	84.11	82.42	82.26	82.02	81.94	82.16	3-8
8Mbx64 60ns 3.3V EDO	164.20	162.40	160.05	158.08	156.32	159.21	155.84	155.52	155.04	154.88	155.32	3-8
16Mbx64 60ns 3.3V EDO	25.40	23.90	23.60	23.26	22.90	23.42	22.64	22.56	22.60	22.40	22.55	3-8
2Mbx64 3.3V SDRAM	48.45	45.45	44.85	44.17	43.45	44.48	42.93	42.77	42.85	42.45	42.75	3-8
4Mbx64 3.3V SDRAM	92.90	86.90	85.70	84.34	82.90	84.96	81.87	81.54	81.70	80.90	81.50	3-8
8Mbx64 3.3V SDRAM	176.80	164.80	162.40	159.68	156.80	160.92	154.73	154.08	154.40	152.80	154.00	3-8
16Mbx64 3.3V SDRAM	164.20	162.40	160.05	158.08	156.32	159.21	155.84	155.52	155.04	154.88	155.32	3-8
2Mbx64 3.3V PC100 SDRAM	25.40	23.90	23.60	23.26	22.90	23.42	22.64	22.56	22.60	22.40	22.55	3-8
4Mbx64 3.3V PC100 SDRAM	48.45	45.45	44.85	44.17	43.45	44.48	42.93	42.77	42.85	42.45	42.75	3-8
8Mbx64 3.3V PC100 SDRAM	92.90	86.90	85.70	84.34	82.90	84.96	81.87	81.54	81.70	80.90	81.50	3-8
16Mbx64 3.3V PC100 SDRAM	176.80	164.80	162.40	159.68	156.80	160.92	154.73	154.08	154.40	152.80	154.00	3-8
256Kx32 SGRAM 66 MHz 3.3V	2.91	2.83	2.77	2.72	2.68	2.75	2.62	2.57	2.53	2.50	2.56	3-8
512Kx32 SGRAM 66 MHz 3.3V	5.87	5.63	5.49	5.30	5.15	5.39	4.95	4.88	4.81	4.76	4.85	3-8

NA = Not available
*Contract volume is at least 100,000 per order.
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 (January 1999)

Table 2-6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

	1999	2000	2001	2002	2003
4Mbx1 DRAM 70ns SOJ 5V	2.13	2.56	3.50	4.00	4.90
1Mbx4 DRAM 60ns SOJ 5V FPM	1.74	2.10	3.75	4.00	4.89
1Mbx4 DRAM 60ns SOJ 5V EDO	1.74	2.10	3.75	4.00	4.89
256Kx16 DRAM 70ns SOJ 5V	2.28	2.40	3.10	3.85	4.45
4Mbx4 DRAM 60ns SOJ 5V FPM	3.63	4.38	5.80	6.50	7.10
4Mbx4 DRAM 60ns SOJ 5V EDO	3.51	4.34	5.75	6.50	7.10
1Mbx16 DRAM 60ns TSOP 5V FPM	3.21	3.86	5.20	6.05	6.85
1Mbx16 DRAM 60ns TSOP 5V EDO	3.16	3.71	5.18	6.00	6.85
1Mbx16 3.3V SDRAM	3.04	3.34	4.50	5.40	6.57
2Mbx8 DRAM 60ns TSOP 5V FPM	3.14	3.77	5.15	6.05	6.80
2Mbx8 DRAM SDRAM 3.3V	2.93	3.23	4.40	5.35	6.55
16Mbx4 DRAM 60ns SOJ 3.3V EDO	8.86	8.65	8.42	8.25	8.06
16Mbx4 DRAM SOJ 3.3V SDRAM	8.75	8.51	8.33	8.19	8.00
16Mbx4 DRAM 3.3V PC100 SDRAM	8.86	8.43	8.18	8.06	7.92
8Mbx8 DRAM 60ns SOJ 3.3V EDO	8.86	8.43	8.18	8.06	7.92
8Mbx8 DRAM SOJ 3.3V SDRAM	8.86	8.65	8.42	8.25	8.06
8Mbx8 DRAM 3.3V PC100 SDRAM	8.86	8.43	8.18	8.06	7.92
4Mbx16 DRAM 60ns SOJ 3.3V EDO	8.75	8.51	8.33	8.19	8.00
4Mbx16 DRAM SOJ 3.3V SDRAM	8.86	8.43	8.18	8.06	7.92
4Mbx16 DRAM 3.3V PC100 SDRAM	8.86	8.43	8.18	8.06	7.92
1Mbx32 SIMM 60ns 5V FPM	8.86	8.65	8.42	8.25	8.06
2Mbx32 SIMM 60ns 5V FPM	8.86	8.43	8.18	8.06	7.92
4Mbx32 SIMM 60ns 5V FPM	14.64	17.25	22.60	26.00	29.20
8Mbx32 SIMM 60ns 5V FPM	54.46	64.90	86.30	99.90	112.70
1Mbx32 SIMM 60ns 5V EDO	14.45	16.63	22.52	25.80	29.20
2Mbx32 SIMM 60ns 5V EDO	53.70	62.42	85.98	99.10	112.70
4Mbx32 SIMM 60ns 5V EDO	44.48	43.64	42.73	42.05	41.29
8Mbx32 SIMM 60ns 5V EDO	160.91	157.56	153.92	151.20	148.16
2Mbx64 60ns 3.3V EDO	44.05	43.08	42.37	41.81	41.05
4Mbx64 60ns 3.3V EDO	84.11	82.16	80.74	79.62	78.10
8Mbx64 60ns 3.3V EDO	159.21	155.32	152.48	150.24	147.20
16Mbx64 60ns 3.3V EDO	23.42	22.55	22.06	21.82	21.54
2Mbx64 3.3V SDRAM	44.48	42.75	41.77	41.29	40.73
4Mbx64 3.3V SDRAM	84.96	81.50	79.54	78.58	77.46
8Mbx64 3.3V SDRAM	160.92	154.00	150.08	148.16	145.92
16Mbx64 3.3V SDRAM	159.21	155.32	152.48	150.24	147.2
2Mbx64 3.3V PC100 SDRAM	23.42	22.55	22.06	21.82	21.54
4Mbx64 3.3V PC100 SDRAM	44.48	42.75	41.77	41.29	40.73
8Mbx64 3.3V PC100 SDRAM	84.96	81.50	79.54	78.58	77.46
16Mbx64 3.3V PC100 SDRAM	160.92	154.00	150.08	148.16	145.92
256Kx32 SGRAM 66 MHz 3.3V	2.75	2.56	2.36	2.15	2.06
512Kx32 SGRAM 66 MHz 3.3V	5.39	4.85	4.55	4.23	4.01

*Contract volume is at least 100,000 per order.

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 (January 1999)

Table 2-7
Estimated Static RAM Price Trends—North American Bookings (Volume: Slow SRAM—50,000 per Year; Fast SRAM—20,000 per Year; Package: PDIP; Dollars)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
16Kx4 35ns	2.11	2.11	2.11	2.13	2.13	2.12	2.25	2.30	2.35	2.35	2.31	2-6
8Kx8 25ns	0.94	0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	2-6
8Kx8 100-120ns	0.99	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	2-6
64Kx4 10ns	4.73	4.70	4.63	4.59	4.55	4.62	4.50	4.45	4.35	4.30	4.40	2-4
64Kx4 25ns	1.55	1.53	1.53	1.51	1.51	1.52	1.51	1.52	1.52	1.57	1.53	2-4
32Kx8 12ns	0.96	0.96	0.96	1.00	1.05	0.99	1.15	1.20	1.25	1.25	1.21	2-4
32Kx9 12ns Burst	3.21	3.19	3.19	3.17	3.17	3.18	3.17	3.17	3.17	3.17	3.17	2-4
32Kx8 15ns 5V	0.94	0.94	0.98	1.02	1.06	1.00	1.10	1.14	1.15	1.21	1.15	2-4
32Kx8 15ns 3.3V	0.94	0.94	0.97	1.03	1.08	1.01	1.12	1.16	1.19	1.23	1.18	2-4
32Kx8 25ns	0.95	0.96	0.97	1.03	1.08	1.01	1.14	1.16	1.20	1.22	1.18	2-4
32Kx8 70-100ns SOJ	0.95	0.95	0.98	0.98	1.05	0.99	1.10	1.11	1.13	1.14	1.12	2-4
64Kx8 12ns Burst	11.23	11.11	11.00	10.50	10.62	10.81	10.50	10.36	10.30	10.25	10.35	2-4
256Kx4 20ns	2.92	2.89	2.85	2.82	2.77	2.83	2.72	2.69	2.64	2.58	2.66	2-8
256Kx4 12ns 3.3V	3.69	3.39	3.23	3.10	2.87	3.15	2.82	2.78	2.74	2.71	2.76	3-8
256Kx8 12ns 3.3V	3.29	3.16	3.09	3.01	2.81	3.02	2.75	2.63	2.55	2.48	2.60	3-8
128Kx8 15ns	2.54	2.45	2.41	2.34	2.29	2.37	2.16	2.12	2.09	2.07	2.11	3-6
128Kx8 20ns	2.34	2.26	2.16	2.13	2.12	2.16	2.11	2.08	2.05	2.04	2.07	3-6
128Kx8 25ns	2.34	2.26	2.16	2.13	2.12	2.16	2.11	2.08	2.05	2.04	2.07	3-6
128Kx8 70-100ns SOJ	2.20	2.19	2.14	2.10	2.05	2.12	2.19	2.15	2.10	2.08	2.13	3-6
32Kx32 15ns 3.3V PQFP	2.87	2.75	2.75	2.72	2.72	2.74	2.72	2.78	2.80	2.85	2.79	2-6
32Kx32 8ns 3.3V PBSynch	2.49	2.34	2.29	2.29	2.29	2.30	2.40	2.45	2.45	2.45	2.44	2-6
64Kx32 8ns 3.3V PBSynch	4.55	4.40	4.30	4.25	4.20	4.29	4.16	4.10	4.00	3.92	4.05	2-6
64Kx32 5ns 3.3V PBSynch	5.69	5.50	5.35	5.05	4.87	5.19	4.65	4.30	4.01	3.95	4.23	2-6
256Kx16 70-100ns	12.15	12.02	11.92	11.65	11.31	11.73	11.22	11.00	10.97	10.85	11.01	3-6
256Kx16 25ns	13.53	13.29	13.13	13.00	12.54	12.99	12.22	12.02	11.74	11.54	11.88	3-6
512Kx8 70ns	11.80	11.60	11.25	11.01	10.95	11.20	10.75	10.69	10.60	10.56	10.65	3-6
512Kx8 25ns	14.02	13.69	13.08	12.88	12.45	13.03	12.18	11.98	11.69	11.51	11.84	3-6

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 (January 1999)

Table 2-8
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)

	1999	2000	2001	2002	2003
16Kx4 35ns	2.12	2.31	2.40	2.45	2.50
8Kx8 25ns	0.93	0.92	0.92	0.95	1.05
8Kx8 100-120ns	0.97	0.97	1.00	1.05	1.15
64Kx4 10ns	4.62	4.40	4.20	4.09	4.00
64Kx4 25ns	1.52	1.53	1.70	1.80	1.95
32Kx8 12ns	0.99	1.21	1.35	1.45	1.57
32Kx9 12ns Burst	3.18	3.17	3.35	3.40	3.52
32Kx8 15ns 5V	1.00	1.15	1.30	1.38	1.42
32Kx8 15ns 3.3V	1.01	1.18	1.31	1.37	1.42
32Kx8 25ns	1.01	1.18	1.30	1.37	1.42
32Kx8 70-100ns SOJ	0.99	1.12	1.25	1.35	1.40
64Kx8 12ns Burst	10.81	10.35	10.19	10.12	10.04
256Kx4 20ns	2.83	2.66	2.52	2.47	2.41
256Kx4 12ns 3.3V	3.15	2.76	2.65	2.57	2.50
256Kx8 12ns 3.3V	3.02	2.60	2.41	2.34	2.26
128Kx8 15ns	2.37	2.11	2.05	2.00	2.00
128Kx8 20ns	2.16	2.07	2.00	1.97	1.97
128Kx8 25ns	2.16	2.07	2.00	1.97	1.97
128Kx8 70-100ns SOJ	2.12	2.13	2.06	2.02	2.00
32Kx32 15ns 3.3V PQFP	2.74	2.79	2.90	3.10	3.35
32Kx32 8ns 3.3V PBSynch	2.30	2.44	2.75	2.95	3.20
64Kx32 8ns 3.3V PBSynch	4.29	4.05	3.71	3.44	3.12
64Kx32 5ns 3.3V PBSynch	5.19	4.23	3.74	3.45	3.13
256Kx16 70-100ns	11.73	11.01	10.30	10.05	9.85
256Kx16 25ns	12.99	11.88	11.42	11.21	10.95
512Kx8 70ns	11.20	10.65	10.25	10.02	9.82
512Kx8 25ns	13.03	11.84	11.45	11.25	11.01

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 (January 1999)

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

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
128Kx8 ROM	1.20	1.12	1.08	1.05	1.03	1.07	1.03	1.00	0.97	0.95	0.99	4-6
64Kx16 ROM	1.25	1.18	1.13	1.10	1.07	1.12	1.05	1.05	1.03	1.00	1.03	4-6
256Kx8 ROM	1.40	1.35	1.33	1.30	1.28	1.32	1.25	1.23	1.23	1.21	1.23	4-6
512Kx8 ROM	1.60	1.55	1.47	1.44	1.40	1.47	1.38	1.35	1.33	1.31	1.34	4-6
256Kx16 ROM[1]	1.60	1.55	1.47	1.44	1.40	1.47	1.37	1.35	1.33	1.31	1.34	4-6
1Mbx8 ROM[2]	2.00	1.90	1.85	1.80	1.75	1.83	1.65	1.60	1.55	1.50	1.58	4-6
1Mbx16 ROM	2.50	2.40	2.30	2.25	2.20	2.29	2.15	2.11	2.07	2.05	2.10	4-6
2Mbx8 ROM	2.50	2.40	2.30	2.25	2.20	2.29	2.15	2.11	2.07	2.05	2.10	4-6
2Mbx16 ROM	5.90	5.75	5.60	5.50	5.40	5.56	5.35	5.30	5.20	5.15	5.25	4-6
4Mbx8 ROM	5.90	5.75	5.60	5.50	5.40	5.56	5.35	5.30	5.20	5.15	5.25	4-6
4Mbx16 ROM	10.50	10.20	10.00	9.90	9.85	9.99	9.60	9.40	9.00	8.60	9.15	4-6
8Mbx8 ROM	10.50	10.20	10.00	9.90	9.85	9.99	9.60	9.40	9.00	8.60	9.15	4-6

[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 (January 1999)

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

	1999	2000	2001	2002	2003
128Kx8 ROM	1.07	0.99	0.96	1.05	1.10
64Kx16 ROM	1.12	1.03	1.00	1.09	1.16
256Kx8 ROM	1.32	1.23	1.15	1.26	1.32
512Kx8 ROM	1.47	1.34	1.30	1.28	1.28
256Kx16 ROM[1]	1.47	1.34	1.30	1.28	1.28
1Mbx8 ROM[2]	1.83	1.58	1.45	1.42	1.37
1Mbx16 ROM	2.29	2.10	2.00	1.97	1.94
2Mbx8 ROM	2.29	2.10	2.00	1.97	1.94
2Mbx16 ROM	5.56	5.25	4.90	4.60	4.50
4Mbx8 ROM	5.56	5.25	4.90	4.60	4.50
4Mbx16 ROM	9.99	9.15	8.00	7.60	7.40
8Mbx8 ROM	9.99	9.15	8.00	7.60	7.40

[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 (January 1999)

Table 2-11
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package Type: Plastic; Speed: 150ns and Above; Dollars)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
32Kx8 EPROM	1.18	1.16	1.13	1.11	1.10	1.13	1.10	1.10	1.10	1.10	1.10	2-3
64Kx8 EPROM	1.23	1.21	1.18	1.16	1.16	1.18	1.15	1.15	1.15	1.15	1.15	2-3
128Kx8 EPROM	1.53	1.49	1.47	1.47	1.45	1.47	1.44	1.42	1.42	1.39	1.42	2-3
256Kx8 EPROM	2.41	2.25	2.23	2.23	2.18	2.22	2.15	2.15	2.13	2.10	2.13	2-3
128Kx16 EPROM	2.63	2.60	2.60	2.57	2.56	2.58	2.54	2.52	2.50	2.47	2.51	2-3
512Kx8 EPROM	2.74	2.63	2.61	2.51	2.50	2.56	2.46	2.44	2.41	2.38	2.42	2-3
256Kx16 EPROM	2.95	2.88	2.75	2.67	2.67	2.74	2.65	2.64	2.59	2.54	2.61	2-3
1Mbx8 EPROM	5.45	5.15	4.95	4.82	4.75	4.92	4.66	4.54	4.32	4.10	4.41	2-3
512Kx16 EPROM	5.95	5.55	5.32	5.10	4.97	5.24	4.82	4.65	4.44	4.32	4.56	2-3
2Mbx8 EPROM	10.55	10.00	9.65	9.45	9.12	9.56	8.85	8.45	8.06	7.82	8.30	2-3
1Mbx16 EPROM	11.01	10.45	10.02	9.84	9.33	9.91	9.10	8.81	8.36	8.00	8.57	2-3
4Mbx8 EPROM	18.19	17.55	17.22	16.80	16.40	16.99	16.00	15.85	15.33	14.90	15.52	2-3
2Mbx16 EPROM	19.00	18.10	17.95	17.30	16.85	17.55	16.42	16.10	15.82	15.20	15.89	2-3

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 (January 1999)

Table 2-12
Estimated Long-Range EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Plastic; Speed: 150ns and Above; Dollars)

	1999	2000	2001	2002	2003
32Kx8 EPROM	1.13	1.10	1.10	1.15	1.21
64Kx8 EPROM	1.18	1.15	1.15	1.21	1.30
128Kx8 EPROM	1.47	1.42	1.32	1.46	1.60
256Kx8 EPROM	2.22	2.13	2.05	2.00	2.00
128Kx16 EPROM	2.58	2.51	2.43	2.40	2.40
512Kx8 EPROM	2.56	2.42	2.31	2.20	2.13
256Kx16 EPROM	2.74	2.61	2.38	2.25	2.17
1Mbx8 EPROM	4.92	4.41	3.90	3.70	3.65
512Kx16 EPROM	5.24	4.56	4.00	3.85	3.80
2Mbx8 EPROM	9.56	8.30	7.45	7.00	6.64
1Mbx16 EPROM	9.91	8.57	7.66	7.23	6.92
4Mbx8 EPROM	16.99	15.52	13.10	11.50	10.65
2Mbx16 EPROM	17.55	15.89	13.62	11.84	10.88

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (January 1999)

Table 2-13
Estimated Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1998	1999					2000					Lead Times
	Q4	Q1	Q2	Q3	Q4	1999	Q1	Q2	Q3	Q4	2000	(Weeks)
128Kx8 PDIP/PLCC	2.00	1.95	1.93	1.92	1.90	1.93	1.89	1.88	1.88	1.88	1.88	3
128Kx8 TSOP 12V	2.07	2.05	2.05	2.03	2.03	2.04	2.02	2.02	2.00	2.00	2.01	4
128Kx8 TSOP 5V	2.12	2.07	2.07	2.06	2.06	2.07	2.05	2.05	2.03	2.03	2.04	4
256Kx8 TSOP 12V	2.96	2.75	2.73	2.70	2.68	2.72	2.65	2.62	2.60	2.55	2.61	4-6
256Kx8 TSOP 5V	2.85	2.68	2.60	2.55	2.40	2.56	2.30	2.20	2.15	2.07	2.18	4-6
256Kx8 PDIP/PLCC	2.89	2.85	2.79	2.72	2.67	2.76	2.65	2.62	2.53	2.45	2.56	4-6
512Kx8 PDIP/PLCC	2.94	2.92	2.86	2.79	2.75	2.83	2.70	2.67	2.58	2.52	2.62	4
512Kx8 TSOP 12V	3.55	3.27	3.31	3.22	3.13	3.23	3.07	3.01	2.93	2.88	2.97	4
512Kx8 TSOP 5V	3.13	2.96	2.90	2.83	2.75	2.86	2.65	2.60	2.55	2.48	2.57	4
512Kx8 SSOP 3V	3.13	3.00	2.93	2.89	2.80	2.90	2.71	2.60	2.55	2.48	2.58	4
1Mbx8 TSOP 12V	5.21	4.76	4.55	4.45	4.35	4.53	4.30	4.25	4.15	4.05	4.19	3-4
1Mbx8 TSOP 5V	4.65	4.25	4.15	4.04	3.90	4.09	3.74	3.65	3.54	3.45	3.59	3-4
1Mbx8 TSOP 3V	4.63	4.25	4.15	3.95	3.79	4.04	3.69	3.60	3.50	3.40	3.55	3-4
2Mbx8 TSOP 12V	10.25	9.11	9.05	8.85	8.45	8.87	8.20	8.00	7.90	7.80	7.98	3-4
2Mbx8 TSOP 5V	8.75	8.00	7.86	7.50	7.23	7.65	7.00	6.80	6.48	6.20	6.62	3-4
2Mbx8 TSOP 3V	8.70	7.95	7.65	7.30	7.00	7.48	6.77	6.56	6.30	6.15	6.44	3-4
1Mbx16 TSOP 12V	10.95	9.85	9.59	9.28	8.86	9.39	8.60	8.32	8.15	7.92	8.25	3-4
1Mbx16 TSOP 5V	10.01	9.15	8.78	8.32	7.93	8.54	7.65	7.33	6.98	6.70	7.16	3-4
1Mbx16 TSOP 3V	9.45	8.88	8.54	8.15	7.83	8.35	7.56	7.21	6.84	6.62	7.06	3-4
2Mbx16 TSOP 5V	21.55	19.08	18.77	17.53	16.70	18.02	16.00	15.32	14.54	13.87	14.93	3-4
2Mbx16 TSOP 3V	20.42	18.62	18.14	17.17	16.44	17.59	15.89	15.05	14.34	13.46	14.69	3-4
4Mbx8 TSOP 5V	21.62	19.19	18.85	17.61	16.77	18.10	16.07	15.38	14.58	13.90	14.98	3-4
4Mbx8 TSOP 3V	20.53	18.74	18.23	17.22	16.61	17.70	15.88	15.13	14.41	13.69	14.78	3-4
4Mbx16 TSOP 5V	42.35	37.20	36.83	34.44	32.77	35.31	31.48	30.16	28.15	27.02	29.20	3-4
4Mbx16 TSOP 3V	40.01	36.31	35.78	33.77	32.18	34.51	30.30	29.90	27.96	26.88	28.76	3-4
8Mbx8 TSOP 5V	41.49	36.48	36.09	33.75	32.07	34.60	30.05	29.55	27.87	26.74	28.55	3-4
8Mbx8 TSOP 3V	38.89	35.33	34.78	32.81	31.46	33.60	29.88	29.04	27.61	26.44	28.24	3-4

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 price guidelines.
Source: Dataquest (January 1999)

Table 2-14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12V; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1999	2000	2001	2002	2003
128Kx8 PDIP/PLCC	1.93	1.88	1.82	2.05	2.20
128Kx8 TSOP 12V	2.04	2.01	1.94	2.20	2.34
128Kx8 TSOP 5V	2.07	2.04	1.97	2.25	2.40
256Kx8 TSOP 12V	2.72	2.61	2.48	2.65	2.88
256Kx8 TSOP 5V	2.56	2.18	2.02	2.15	2.35
256Kx8 PDIP/PLCC	2.76	2.56	2.38	2.32	2.50
512Kx8 PDIP/PLCC	2.83	2.62	2.47	2.41	2.65
512Kx8 TSOP 12V	3.23	2.97	2.73	2.67	2.84
512Kx8 TSOP 5V	2.86	2.57	2.34	2.28	2.55
512Kx8 SSOP 3V	2.90	2.58	2.34	2.28	2.55
1Mbx8 TSOP 12V	4.53	4.19	3.90	3.84	4.14
1Mbx8 TSOP 5V	4.09	3.59	3.33	3.24	3.51
1Mbx8 TSOP 3V	4.04	3.55	3.29	3.21	3.49
2Mbx8 TSOP 12V	8.87	7.98	7.59	7.40	7.31
2Mbx8 TSOP 5V	7.65	6.62	6.02	5.94	5.88
2Mbx8 TSOP 3V	7.48	6.44	5.95	5.84	5.76
1Mbx16 TSOP 12V	9.39	8.25	7.61	7.42	7.34
1Mbx16 TSOP 5V	8.54	7.16	6.35	6.02	5.91
1Mbx16 TSOP 3V	8.35	7.06	6.00	5.87	5.64
2Mbx16 TSOP 5V	18.02	14.93	12.55	12.01	11.81
2Mbx16 TSOP 3V	17.59	14.69	12.10	11.77	11.44
4Mbx8 TSOP 5V	18.10	14.98	12.60	12.05	11.89
4Mbx8 TSOP 3V	17.70	14.78	12.30	11.86	11.51
4Mbx16 TSOP 5V	35.31	29.20	22.01	21.11	20.07
4Mbx16 TSOP 3V	34.51	28.76	21.45	20.34	19.87
8Mbx8 TSOP 5V	34.60	28.55	21.88	21.05	20.03
8Mbx8 TSOP 3V	33.60	28.24	21.33	20.11	19.68

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 (January 1999)

Table 2-15
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 Times (Weeks)
	1999	2000	2001	1999	2000	2001	1999	2000	2001	
Technology										
CMOS										Production:
0.8 Micron	18.00	18.00	17.00	15.00	14.00	13.00	12.00	11.00	10.00	4-12
0.6 Micron	20.00	19.00	19.00	15.00	14.00	13.00	14.00	14.00	12.00	4-12
0.5 Micron	23.00	22.00	20.00	16.00	15.00	14.00	15.00	14.00	13.00	4-12
0.35 Micron	27.00	27.00	27.00	20.00	19.00	19.00	16.00	15.00	14.00	4-12
										Prototype:
NRE CMOS Average Charge ($K)	42.00	42.00	42.00	48.00	48.00	49.00	60.00	58.00	57.00	1-5

	100-299.99K Gates			300K or More Gates			Lead Times (Weeks)
	1999	2000	2001	1999	2000	2001	
Technology							
CMOS							Production:
0.8 Micron	18.00	17.00	17.00	NR	NR	NR	4-12
0.6 Micron	18.00	17.00	17.00	23.00	22.00	20.00	4-12
0.5 Micron	19.00	18.00	18.00	24.00	23.00	21.00	4-12
0.35 Micron	22.00	20.00	19.00	26.00	24.00	24.00	4-12
							Prototype:
NRE CMOS Average Charge ($K)	70.00	70.00	69.00	100.00	95.00	95.00	1-5

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors. Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (September 1998)

Table 2-16
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			
	1999	2000	2001	1999	2000	2001	1999	2000	2001	Lead Times (Weeks)
Technology										
CMOS										Production:
0.8 Micron	20.00	20.00	19.00	16.00	14.00	14.00	10.00	10.00	9.00	4-13
0.6 Micron	22.00	21.00	21.00	15.00	15.00	14.00	10.00	9.00	9.00	4-13
0.5 Micron	23.00	23.00	21.00	18.00	17.00	16.00	16.00	14.00	13.00	4-13
0.35 Micron	30.00	28.00	28.00	29.00	28.00	26.00	22.00	20.00	20.00	4-13
										Prototype:
NRE CMOS Average Charge ($K)	40.00	40.00	40.00	42.00	42.00	41.00	65.00	60.00	58.00	2-6

	100-299.99K Gates			300K or More Gates			
	1999	2000	2001	1999	2000	2001	Lead Times (Weeks)
Technology							
CMOS							Production:
0.8 Micron	14.00	13.00	12.00	NR	NR	NR	4-13
0.6 Micron	13.00	12.00	12.00	16.00	14.00	14.00	4-13
0.5 Micron	10.00	9.00	8.00	13.00	12.00	11.00	4-13
0.35 Micron	10.00	9.00	8.00	7.00	7.00	6.00	4-13
							Prototype:
NRE CMOS Average Charge ($K)	85.00	80.00	80.00	125.00	110.00	100.00	2-6

NR = Not relevant
NRE = Nonrecurring engineering charge
Notes: The actual NRE may vary from these because of device amortization, testing, intellectual property rights, and other factors. Actual negotiated market prices may vary substantially from these because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, pad or core constraints, and volume discount. For volumes of 1 million or greater, discount the above prices by a further 50 to 60 percent. For core-limited solutions with volumes greater than 10,000 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (January 1999)

For More Information...

Inquiry Hotline	+1-408-468-8423
Internet address	scndinquiry@gartner.com
Via fax	+1-408-954-1780
Dataquest Interactive	http://www.dataquest.com

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest/Gartner Group
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: +1-408-468-8000
Facsimile: +1-408-954-1780

East Coast Research Center
Gartner Group Lowell
900 Chelmsford Street
Tower Two, Floor Nine
Lowell, Massachusetts 01851
United States
Phone: +1-978-323-6914
Facsimile: +1-978-323-6933

EUROPE

European Headquarters
Gartner Group Ltd.
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44-1784-431-611
Facsimile: +44-1784-488-980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33-1-41-35-13-00
Facsimile: +33-1-41-35-13-13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49-89-42-70-4-0
Facsimile: +49-89-42-70-4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153-0042
Japan
Phone: +81-3-3481-3670
Facsimile: +81-3-3481-3644

ASIA/PACIFIC

Asia Headquarters
Gartner Group Hong Kong
Suite 5904-7, Central Plaza
18 Harbour Road
Wanchai
Hong Kong
Phone: +852-2824-6168
Facsimile: +852-2824-6138

Pacific Headquarters
Gartner Group Pacific
80 Alfred Street - 6th Floor
Milsons Point, NSW 2061
Australia
Phone: +61-2-9941-4860
Facsimile: +61-2-9941-4868

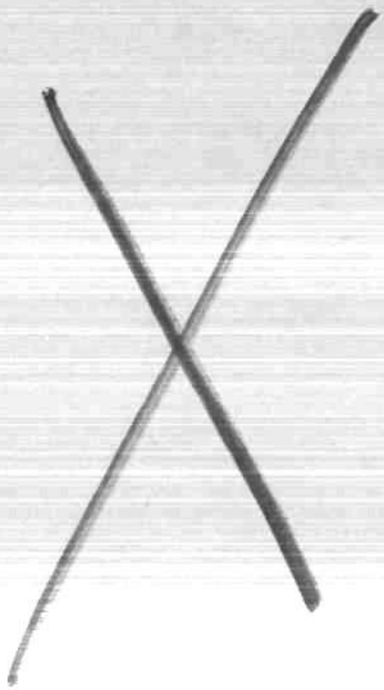
Korea
Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: +82-2-551-1331
Facsimile: +82-2-551-1330

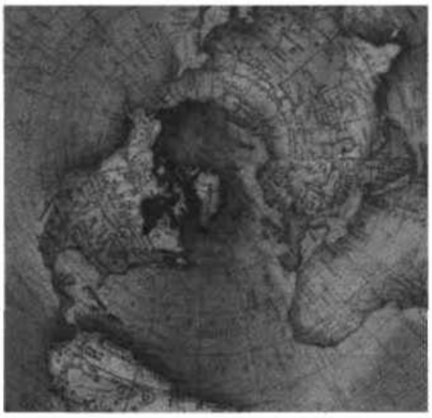
Taiwan
Gartner Group Taiwan Ltd.
11F-2, 188, Section 5
Nan King East Road
Taipei 105
Taiwan R.O.C.
Phone: +886-2-2756-0389
Facsimile: +886-2-2756-2663/4122

Thailand
Gartner Group Thailand Ltd.
29 Vanissa Building, 12F
Soi Chidlom, Ploenchit Road
Pathumwan, Bangkok 10330
Thailand
Phone: +662-655-0577
Facsimile: +662-655-0576

Singapore
Gartner Group Advisory (S) Pte Ltd.
6 Temasek Boulevard #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: +65-333-6773
Facsimile: +65-333-6787

Dataquest
A Gartner Group Company





Dataquest

Contract Manufacturers, 1998

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9803
Publication Date: December 14, 1998
Filing: Reports

Contract Manufacturers, 1998

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9803
Publication Date: December 14, 1998
Filing: Reports

Table of Contents

List of Figures

List of Tables

Chapter 1

Executive Summary

The contract manufacturing market is getting considerable attention at the moment. With many OEMs outsourcing their manufacturing, the contract manufacturing market will continue to grow. This report examines key commercial and technology issues for 80 small contract manufacturers.

For the purposes of this study, Dataquest focused on small contract manufacturers. This segment is often overlooked, as the merger mania of the larger ones gets much more media attention. This study examines how these small fry fare in comparison with the larger companies in areas such as package types, use of direct chip attachment (DCA), PCBs, procurement trends (of all products and semiconductors), and sourcing trends.

Chapter 2
Research Methodology

Dataquest's 1998 contract manufacturing Focus Report includes the results of a telephone survey conducted by Dataquest's Research Operations group. The survey questionnaire was developed by analysts from the Semiconductors group. The questionnaire comprises a total of 38 questions. Most of the questions allowed or required more than one response. There are 146 data points in the survey results database.

The telephone survey was conducted during regular business hours from late August 1998 through late September 1998. Survey data was collected by Dataquest's primary research centers in San Jose, California, and in the United Kingdom. All interviewers were extensively briefed on the goals and terminology of the project. Respondents' answers were entered into a computer-assisted telephone interviewing program that automatically records responses. About 15 percent of each interviewer's work was monitored for validation.

Respondents represented semiconductor contract manufacturers in the United States, Canada, and Europe. Dataquest obtained a total of 2,000 randomly selected names of marketing vice presidents/managers and sales vice presidents/managers from a Computer Intelligence (CI) database and the 1998 Contract Manufacturing Directory. Eligible respondents had to be familiar with the electronic contract manufacturing products. This familiarity was required to ensure that the views and facts conveyed by respondents were based on first-hand knowledge. The identities of the respondents are kept strictly confidential.

Dataquest placed a total of 820 calls to secure 80 completed interviews. The disposition of the sample is as follows:

- 80 calls resulted in completed interviews.
- 66 of those called refused to be interviewed.
- 193 of those called could not be contacted, were left a message, or otherwise did not produce an interview.
- 62 were bad numbers.
- 416 did not qualify to participate in the study.

Research Operations analysts tabulated the survey results using SPSS, a statistical analysis software package.

Report Summary

This report is broken into eight chapters. Chapter 1 provides the management summary of the total report; Chapter 2 covers both the research methodology used and report summary.

The third chapter looks at the area of sourcing, detailing contract manufacturer classifications, sourcing characteristics, and total products procured. Chapter 3 also examines exactly what types of semiconductor device families are bought by the group, going into further detail for memory and processors.

The fourth chapter gives information on inventory holding trends of the 80 small contract manufacturers. These trends are looked at from three perspectives: an overall view, a look at semiconductors only, and a comparison of both. In Chapter 5, package types (through-hole, surface mount, and advanced types) and DCA are examined.

Many seemingly different things are lumped together in Chapter 6. It covers PCB usage, including issues of selecting whether to make PCBs or to buy them through suppliers, and PCB layers and linewidths.

Chapter 7 contains information on exotic material adders plus three different PCB sourcing elements. These elements include pricing, lead times, and availability. Chapter 8 ends the report with a summary and conclusions.

Chapter 3
Sourcing

Overview

This chapter looks at many important facets of these contract manufacturers and their relationship with their customers. Dataquest wanted to know how the manufacturers classify themselves and whether they provide the service of component sourcing to their customers.

For those who do source products on behalf of their customers, Dataquest wanted to see what was bought. Anyone with any contract manufacturing experience knows that manufacturers potentially procure everything from screws to chassis to keep their clients happy.

However, as this report originates in the Semiconductor group of Dataquest, we obviously had a vested interest in any semiconductors procured. Therefore, the different semiconductor device families bought by the respondents are listed in this report with further granularity offered on the memory and processor device families.

Who Are You?

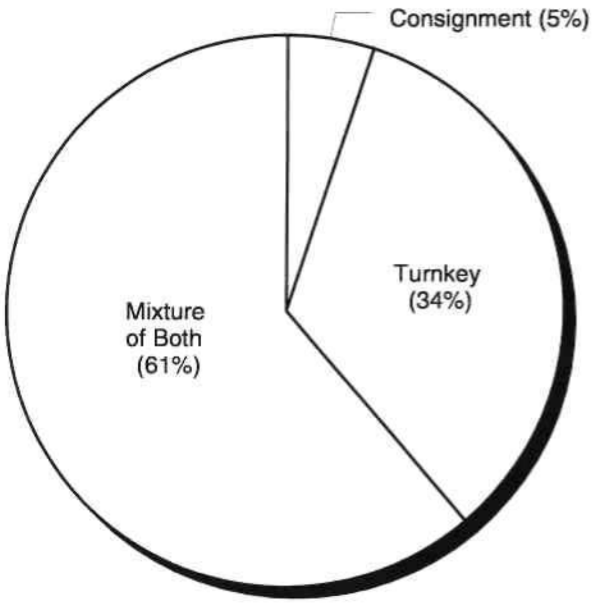
With contract manufacturers, as with everyone else, various classifications indicate the type of work performed. Dataquest asked those surveyed how they classify themselves. The results are graphed in Figure 3-1. By way of explanation, let us first look at what Dataquest means by "turnkey" and "consignment."

A turnkey contract manufacturer is a one-stop shop for its customers. It does all the work on behalf of its customers (from sourcing components and PCBs as required, to manufacture and assembly). A turnkey contract manufacturer therefore has the capability to provide a seamless external manufacturing service to the customer by taking care of as much of the process as the customer requires.

A consignment contract manufacturer performs certain specific, predefined functions for its customers. It neither does nor offers to do everything and is only one link in the production chain. For example, the customer might ship the consignment contract manufacturer raw materials, so that the manufacturer only does assembly.

A mere 5 percent of those surveyed catalogued themselves as purely consignment contract manufacturers, while just over a third referred to themselves as purely turnkey contract manufacturers. The vast majority of participants ticked the "mixture of both" box, classifying themselves as hybrids. In other words, they view themselves as capable of offering whichever class of service is required by a specific customer.

Figure 3-1
Respondents Split by Types of Contract Manufacturers



Source: Dataquest (November 1998)

Whom Do You Buy For?

Dataquest had already asked the participants to categorize themselves, and the vast majority described their services as either a mixture of turnkey and consignment work or just pure turnkey work. These folks generally offer the option of one-stop service to their customers and would be likely to play a strong role in the sourcing of the raw material and product required to fulfill the contract manufacture work. Therefore, Dataquest asked the group whether they bought products for any of their customers. The results are shown in Table 3-1.

Table 3-1
Do You Buy Products for Your Customers? (N = 80)

Responses	Frequency	Percent
Yes	75	93.8
No	4	5.0
For Some Customers	1	1.2
In Some Situations	0	0

Source: Dataquest (November 1998)

Table 3-1 shows that a whopping majority admit to sourcing products for their customers: All told, 96 percent buy products either for all customers or for some customers. Only 5 percent do not obtain products for their customers.

This question was an obvious follow-up to check the validity of the respondents' self-classification, and it worked. Figure 3-1 established that 5 percent of respondents merely offer a consignment manufacturing service to their customers. Likewise, in Table 3-1, this same 5 percent of respondents do not source products on their customers' behalf.

What Do You Buy?

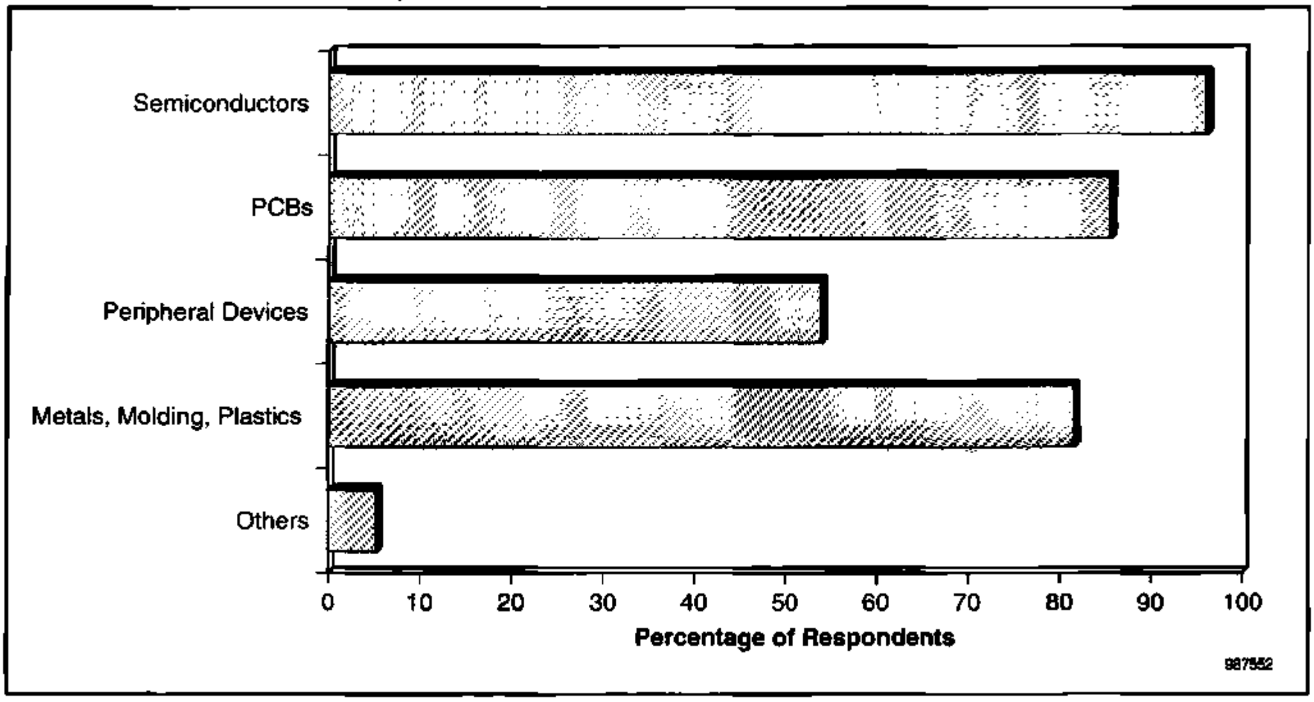
Next we wanted to determine what types of goods the contract manufacturers bought on their customers' behalf. The goods required by the manufacturers vary and are not limited exclusively to semiconductors. Dataquest listed different types of product families and asked each respondent to pick which goods from the list they bought. The results are graphed in Figure 3-2.

As was expected, the respondents buy a wide range of products to satisfy their customers' requirements. Figure 3-1 shows that they buy products that cover the technology scale—everything from metal, moldings, and plastics to semiconductors.

Just over half of those surveyed procure peripheral devices, making peripheral devices the product least selected. Metals, moldings, and plastics, and printed circuit boards (PCBs) were neck and neck, both scoring percentages well into the 80s. However, PCBs came out marginally ahead at 85.5 percent. The clear winner was semiconductors, with more than 96 percent of those surveyed purchasing them on behalf of their customers.

It is important to note that while only 65 out of the 76 respondents in this group *buy* PCBs directly for their customers, a considerably larger proportion *use* PCBs. In fact, 76 out of 80 respondents use PCBs (see Chapter 4).

Figure 3-2
What Products Do You Buy for Your Customers? (N = 76)



Note: Percentages do not total 100 as respondents could select more than one option.
Source: Dataquest (November 1998)

Semiconductors—More Detail, Please!

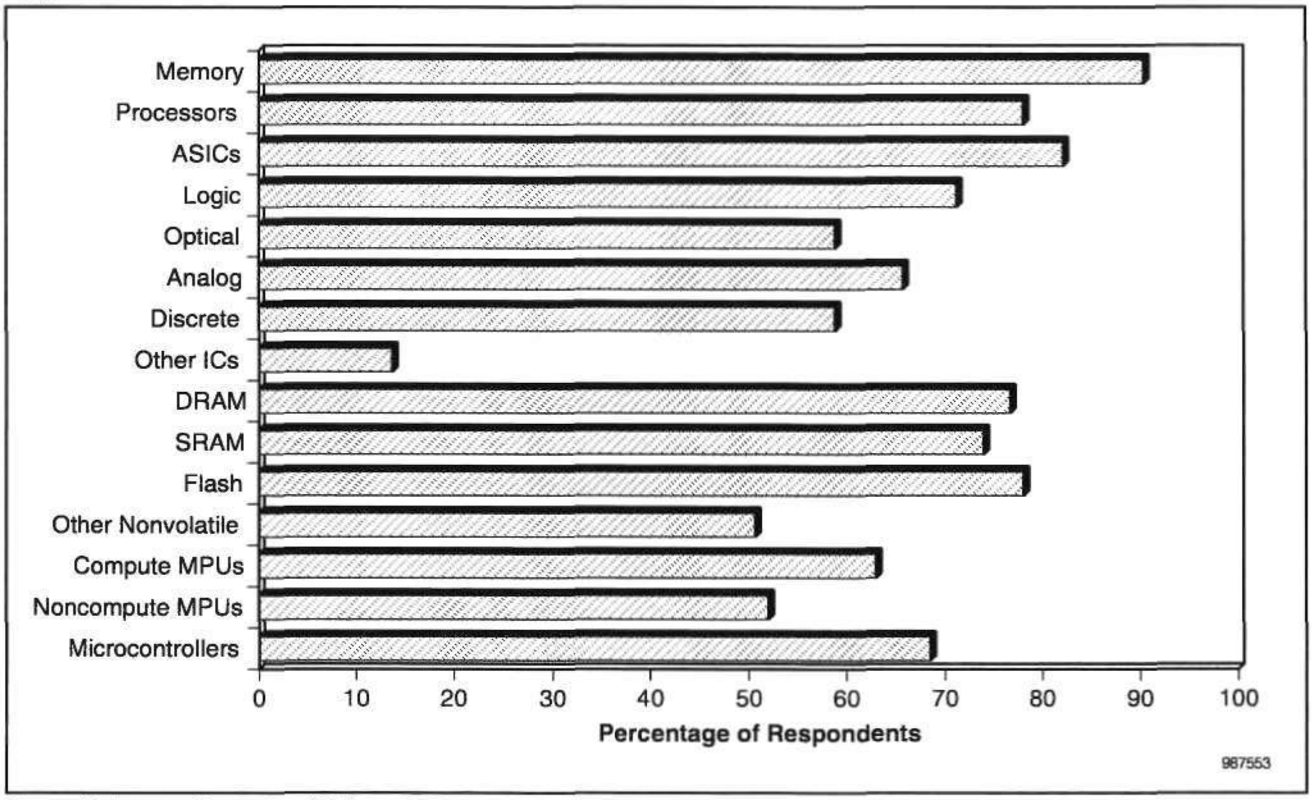
Dataquest next asked the 73 semiconductor buyers to give details on what semiconductor families the devices they buy belong to. The results are shown in Table 3-2 and are also plotted in Figure 3-3.

Table 3-2
Types of Semiconductors Procured (N = 73)

Types of Devices	Frequency	Percent
Memory	66	90.4
Processors	57	78.1
ASICs	60	82.2
Logic	52	71.2
Optical	43	58.9
Analog	48	65.8
Discrete	43	58.9
Other ICs	10	13.7

Note: Percentages do not total 100 as respondents could select more than one option.
Source: Dataquest (November 1998)

Figure 3-3
Types of Semiconductors Procured (N = 73)



Source: Dataquest (November 1998)

Memory was clearly the hot favorite, with more than 90 percent of the group of respondents procuring memory for their customers. This was followed by ASICs (over 80 percent), with processors coming in third at about 78 percent.

With a hit rate of more than 70 percent, the fourth most popular device family was logic, followed by analog devices with 58.9 percent. Optical and discrete devices tied for the sixth spot, at just under 59 percent for each.

What is interesting about these results is that ASICs are ranked so high. It is often assumed that small contract manufacturers are engaged in module population work and therefore source only generic, multisourced devices. This assumption is obviously not correct.

Memory and Processors—Further Granularity

To obtain further granularity, Dataquest asked those respondents who buy memory and processors to specify which device types they source for their customers. The results are plotted in Tables 3-3 and 3-4.

Table 3-3
Memory Device Types Sourced (N = 73)

Device	Frequency	Percent
DRAM	56	76.7
SRAM	54	74.0
Flash	57	78.1
Other Nonvolatile	37	50.7
Memory	66	90.4

Note: Percentages do not total 100 as respondents could select more than one option.
Source: Dataquest (November 1998)

Table 3-3 shows the memory device types bought by the respondents. Looking at how frequently each type of device was purchased, very little separates the top three picks (54 responses for the third-ranked device type, SRAM, versus 57 for flash, the first-ranked one).

Move over, DRAM! Flash is the most popular memory device sourced by the contract manufacturers on behalf of their customers. DRAM was in second place, with only one respondent "hit" separating DRAM from flash. SRAM was third. Other nonvolatiles (comprising EPROM, EEPROM, and mask ROM) came in last, with about 50 percent.

Table 3-4
Processor Device Types Sourced (N = 73)

Processor Devices	Frequency	Percent
Compute MPUs	46	63.0
Noncompute MPUs	38	52.1
Microcontrollers	50	68.5
Processors	57	78.1

Note: Percentages do not total 100 as respondents could select more than one option.
Source: Dataquest (November 1998)

Table 3-4 shows the processor device types sourced by the participants for their customers. Here, microcontrollers are the type of processor most frequently bought by the respondents for their customers. The second and third most frequently purchased processors are compute microprocessors (63 percent) and noncompute microprocessors (52.1 percent).

Summary

Only 5 percent of those surveyed refer to themselves as consignment contract manufacturers. This description is corroborated by the fact that 5 percent of the respondents stated that they do not source products on behalf of their customers. In other words, the overwhelming majority of respondents consider themselves to be capable of providing turnkey contract manufacturer services. They offer an umbrella solution to their customers, from sourcing product to manufacturing.

The array of products they procure for their customers is amazing—everything from plastics to ASICs. Of those turnkey manufacturers, more than 96 percent buy semiconductors. Additionally, the display of different semiconductors indicates that the respondents do more than just manufacture memory modules.

Although most manufacturers (more than 90 percent) buy memory devices, nearly 60 percent buy optical devices, well over two-thirds buy microcontrollers, and over 80 percent buy ASICs. These results indicate that these guys are engaged in specialized board population rather than plain-vanilla machine assembly.

Chapter 4
Inventory Holding Trends

Overview

From Chapter 3, we know that the respondents source a variety of different products that can be loosely classified into two groups: semiconductors and nonsemiconductors. As our interest is in semiconductors, it makes sense to compare and contrast one group with the other.

Although many different matrices can be used to benchmark each product group, Dataquest chose to select inventory holding. Managing inventory holding effectively is extremely important, especially when the companies are small, margins are slim, and the semiconductor market is experiencing rapid price declines. How would these contract manufacturers fare?

Please note that only a subgroup of those who buy products for customers actually provided Dataquest with information. All told, even though 76 of the 80 respondents (95 percent) were qualified to provide data for all products, only 65 respondents actually provided information. Likewise, of the 73 respondents who were qualified to provide data about semiconductors, only 59 actually released information. The main reason for the difference is that often company policy prevented the respondents from releasing information about inventory holding.

Target versus Actual: All Products

Dataquest asked for information about average target inventory holding levels, based on all products respondents bought for their customers. The results are shown in Table 4-1. As already noted, only 65 of the 76 qualified respondents were able to release this specific information to Dataquest. The responses have been split into four ranges for ease of analysis.

Table 4-1
Average Target Inventory Holding for All Products Procured (N = 65)

Target Inventory Holding	Frequency	Percent
1 to 10 Days	14	21.5
11 to 20 Days	15	23.1
21 to 30 Days	20	30.8
31 Days or More	16	24.6

Source: Dataquest (November 1998)

The respondents had clear goals for their inventory holding levels. Of the four ranges, the majority (about 31 percent) had a target range for their inventory holding level of 21 to 30 days. While about 45 percent had a target range of less than 20 days, nearly a quarter of the responses fell into the category of 31 days or more.

What follows is a consideration of actual inventory holding levels for all products in light of what we know about the target inventory holding levels. Table 4-2 shows the average actual inventory levels for all products bought by the contract manufacturers.

Table 4-2
Average Actual Inventory Holding for All Products Procured (N = 65)

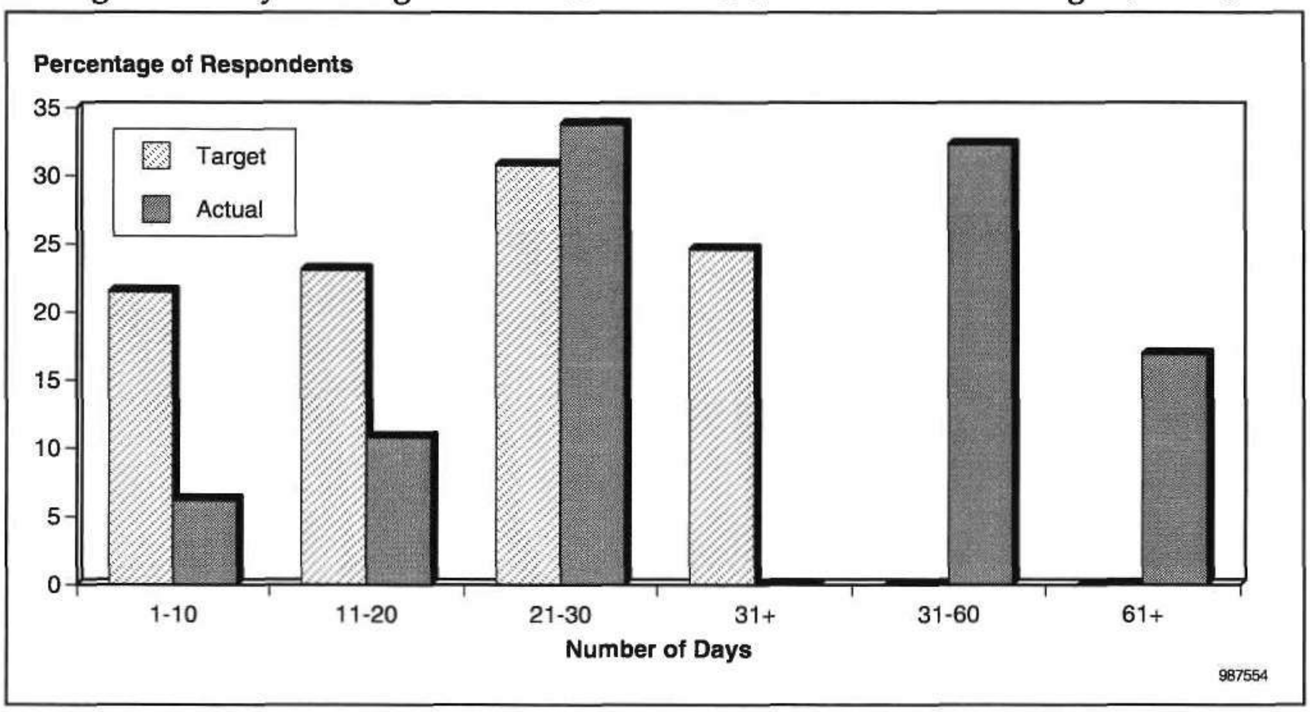
Actual Inventory Holding	Frequency	Percent
1 to 10 Days	4	6.2
11 to 20 Days	7	10.8
21 to 30 Days	22	33.8
31 to 60 Days	21	32.3
61 Days or More	11	16.9

Source: Dataquest (November 1998)

As Table 4-2 shows, these contract manufacturers have some difficulty meeting their targeted inventory holding levels. A full 83 percent of contract manufacturers have overall average inventory holding levels of more than 20 days for products. About 6 percent of contract manufacturers have inventory holding levels of between one and 10 days, and nearly 11 percent have between 11 and 20 days' worth of inventory in-house.

These manufacturers are suffering. One look at Figure 4-1 shows just how far off their target these contract manufacturers are. A mere fraction of them meet their targeted inventory holding levels, and the vast majority haven't even approached their targeted levels. While more than one-fifth have target inventory levels between one and 10 days, only about 6 percent actually achieve this goal. Likewise, just under a quarter of the manufacturers that responded have set themselves a target of between 11 and 20 days, but fewer than 11 percent of them actually meet this target.

Figure 4-1
Average Inventory Holding for All Products Procured: Actual versus Target (N = 65)



Source: Dataquest (November 1998)

Of the manufacturers surveyed, 30.8 percent have 21 to 30 days as a target, but more than 32 percent meet this level in reality. Likewise, in the target section, 31 or more days was the target for about a quarter of all participants. However, nearly 50 percent of participants have actual inventory levels in that area.

The bottom line is that either these manufacturers have unrealistic inventory holding goals, or they just have problems controlling actual in-house holding levels.

Semiconductor Holding Trends

Next, Dataquest asked respondents who buy only semiconductors for inventory holding information. Again, for various company policy reasons, not all contract manufacturers that buy semiconductors were at liberty to provide Dataquest with information.

Table 4-3 shows the target inventory holding levels for semiconductor products bought by the contract manufacturers for their customers. The frequency numbers for the four categories are very similar to one another, with the extremes being 13 and 16.

Table 4-3
Average Target Inventory Holding for Semiconductors Procured (N = 59)

Target Inventory Holding	Frequency	Percent
1 to 10 Days	13	22.0
11 to 20 Days	14	23.8
21 to 30 Days	16	27.1
31 Days or More	16	27.1

Source: Dataquest (November 1998)

Slightly more than half of the semiconductor buyers had target inventory holding levels above 20 days, while slightly less than half reported targets of 20 days or less. The "1 to 10 days" category included the target semiconductor inventory holding levels of 22 percent of those who responded. Just under 24 percent had targets in the next category, between 11 and 20 days.

Those respondents that remain are evenly split between the two remaining categories. Just over 27 percent of respondents had semiconductor inventory holding targets in the range of 21 to 30 days, and the same percentage had targets of 31 days or more.

Once these facts were in, Dataquest asked the respondents in this group to detail their exact actual semiconductor inventory holding levels. This information is given in Table 4-4.

The information shown in Table 4-4 indicates that most of the respondents (32.2 percent) have actual semiconductor inventory holding levels of 31 to 60 days, with the range of 21 to 30 days being the second most common selection (at 28.8 percent). The "11 to 20 days" category includes just under 19 percent of the respondents.

Table 4-4
Average Actual Inventory Holding for Semiconductors Procured (N = 59)

Actual Inventory Holding	Frequency	Percent
1 to 10 days	5	8.5
11 to 20 days	11	18.6
21 to 30 days	17	28.8
31 to 60 days	19	32.2
61 days or more	7	11.9

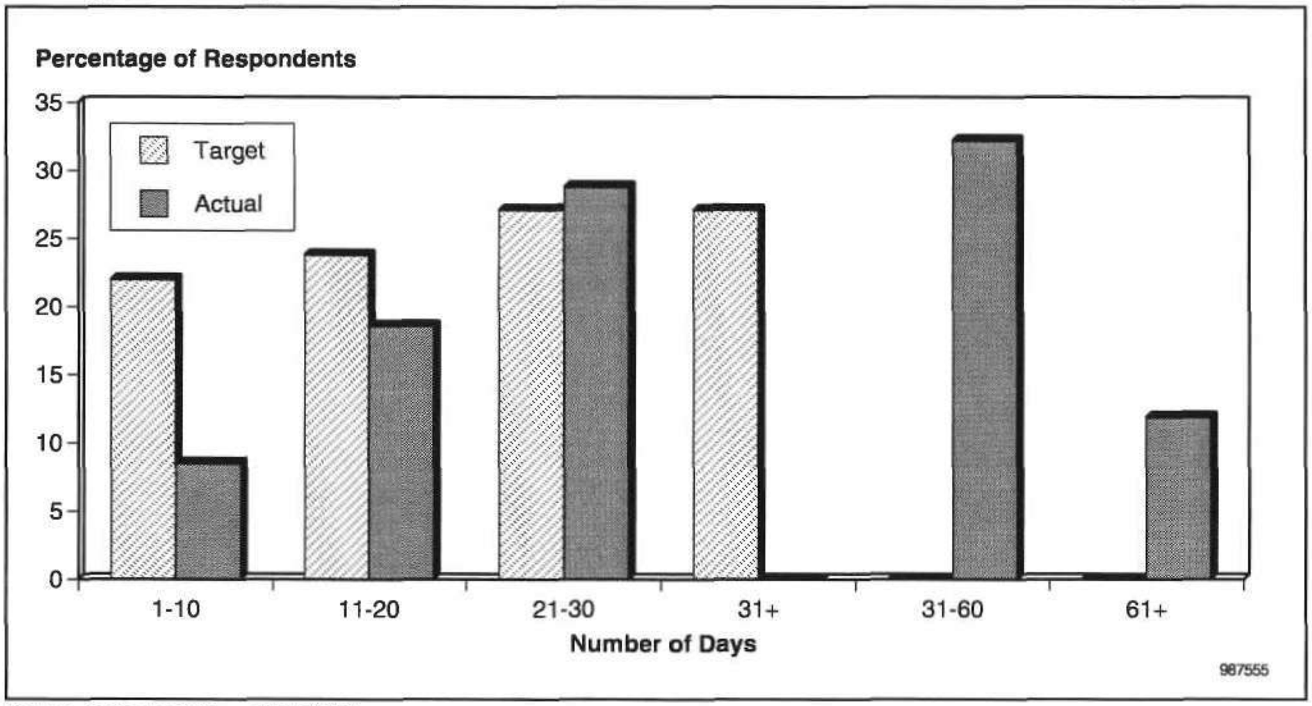
Source: Dataquest (November 1998)

Both the highest and lowest categories for actual inventory holding levels had fewer respondent hits than those in the middle of the range. The "1 to 10 days" category had a respondent hit rate of just 8.5 percent, and the "61 days or more" category covered about 12 percent of the participants' reported actual holding levels.

How do the semiconductor target and actual holding levels compare? This information is found in Figure 4-2. This figure shows the difference between actual and target holding levels among the 59 semiconductor buyers surveyed.

Once again, there is quite a difference between target and actual semiconductor inventory holding levels. Figure 4-2 shows that significant differences occur in both the "1 to 10 days" and the "31+ days" categories.

Figure 4-2
Average Inventory Holding for Semiconductors Procured: Actual versus Target (N = 59)



Source: Dataquest (November 1998)

The target inventory holding level for semiconductors fell into the lowest holding range (1 to 10 days) for over 20 percent of the respondents. However, a mere 8.5 percent of the respondents actually managed to get their semiconductor inventory holding levels within that range.

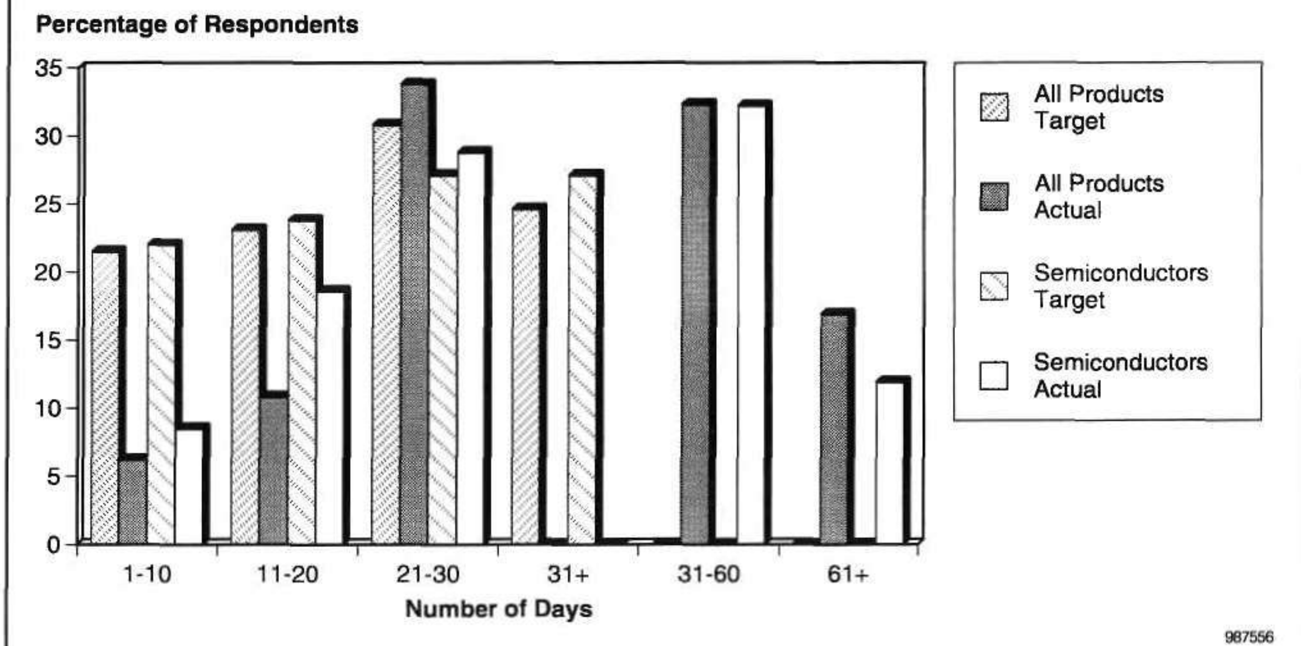
Likewise, 27.1 percent of respondents admitted to having target inventory holding levels for semiconductors of 31 days or more. However, in reality, a full 44.1 percent of all respondents actually have enough semiconductors in-house to meet more than 30 days' worth of requirements.

The disparity for the 11 to 30 days range is far less extreme. Although just under a quarter of the respondents aspired to inventory holding levels of 11 to 20 days, just under 20 percent achieved those levels for semiconductors. For the 21 to 30 days range, 27.1 percent targeted those inventory holding levels, whereas 28.8 percent actually ended up with those levels.

Comparison—All Products versus Semiconductors

The comparison between inventory holding levels for all products and those for semiconductors is an interesting and useful one, and the results are graphed in Figure 4-3. What is clearly illustrated by this graph is that there is a huge difference between target and actual inventory holding levels for both product classifications.

Figure 4-3
Inventory Holding: Target versus Actual for All Products and for Semiconductors



Source: Dataquest (November 1998)

In Figure 4-3, the target inventory holding levels for both product groups show similar patterns. They have nearly identical scores for the "1 to 10 days" and "11 to 20 days" categories. For all products, slightly more respondents placed their targeted inventory holding levels in the "21 to 30 days" category than for semiconductors, while for the "31 days or more" category the reverse was true, with more semiconductor inventory holding level targets falling into that category.

For actual inventory holdings, both groups follow a similar curve—one that is much higher than their targets! The only difference between the curves for actual inventory holdings is that the curve for all products peaks in the "21 to 30 days" category, whereas the curve for semiconductors peaks in the "31 to 60 days" category. Also, both curves have a "61 days or more" category, which does not exist for the target curves.

Summary

The results of this survey indicate good news and bad news. These small contract manufacturers do have target inventory holding levels that they can readily quote when questioned. However, their actual inventory holding levels far exceed their targets. These two statements hold true both for all products and for semiconductors. At least manufacturers are past the denial stage!

A target should be achievable. It is meant to be a goal or milestone to work toward rather than a pie-in-the-sky aspiration. These manufacturers have the two following options:

- Reassess their targets for inventory holding levels to make them more realistic and achievable
- Give their actual inventory holding levels sufficient attention to bring them in line with their target levels

As noted in Chapter 3, 96.1 percent of those who buy products for their customers buy semiconductors. This segment has been subjected to severe price erosion over the past few years. Price erosion means that the devices are literally losing value as they sit in the warehouse. This is not a good situation.

As 95 percent of these small contract manufacturers buy products for their customers, they should hope that the customers do not look too closely at manufacturers' inventory holding levels, as the customers ultimately have to pay for inventory depreciation and obsolescence. However, this disadvantage must be weighed against the flexibility of having enough product present to cover any volume upsurge required.

Maybe these contract manufacturers' customers are large enough not to be concerned about inventory depreciation at smaller contract companies. However, as every other business segment has focused on minimizing inventory holding levels, the smaller contract manufacturers need to consider the advantages of doing likewise. Customers will begin to focus on inventory holding levels soon, and these manufacturers need to act beforehand in order to maintain their client base.

Chapter 5
Package Types and Direct Chip Attachment

Aside from the day-to-day procurement issues associated with contract manufacturing, the technical capabilities of the company are also very important. A key area of consideration is the level of package technology used by the different manufacturers. The technology is a reflection not only of suppliers' technical prowess, but also of their customers' sophistication.

This chapter examines package types used by the respondents both now and in the future. It covers standard and advanced technologies plus direct chip attachment (DCA).

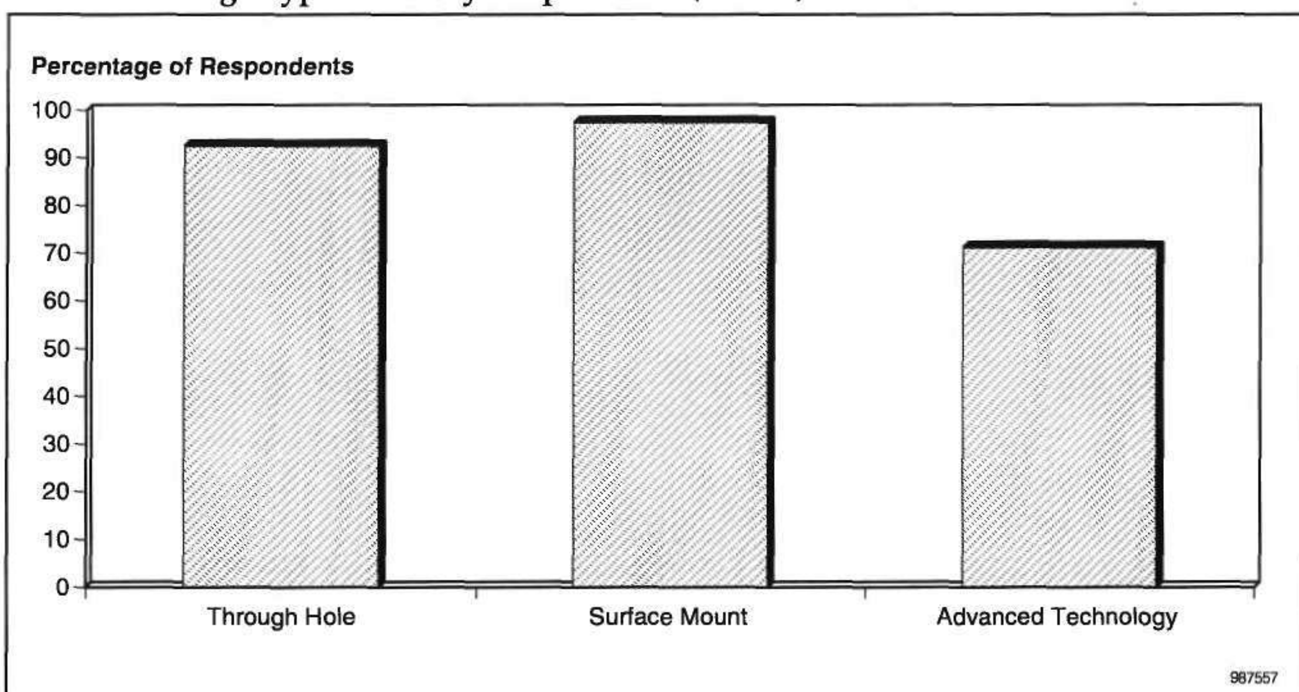
Package Types Used

Dataquest asked all respondents to state which types of chip packages they currently use. The results are plotted in Figure 5-1. Note that these percentages do not add up to 100 because the respondents could select as many answers as were appropriate.

Figure 5-1 indicates that surface-mounted technology is the most commonly used package type among the contract manufacturers surveyed. More than 97 percent of them use this type of packaging, followed closely by through-hole technology (with just under 93 percent of the vote). Although advanced package technologies lag somewhat behind the other two, they still get hit rates in the low 70s—quite impressive considering that the survey covered only smaller companies.

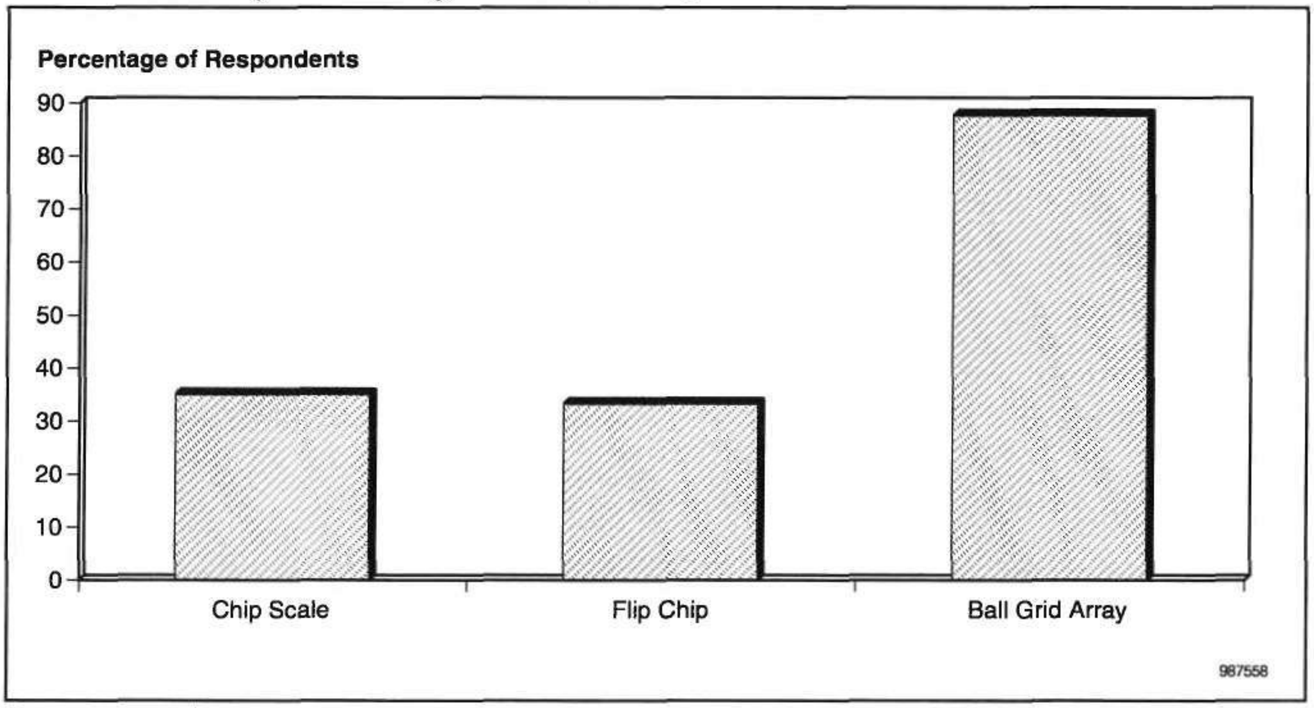
Next, Dataquest asked users of advanced package technology to state which types they used. The responses are plotted in Figure 5-2.

Figure 5-1
Current Package Types Used by Respondents (N = 80)



Source: Dataquest (November 1998)

Figure 5-2
Advanced Package Technologies Used (N = 57)



Source: Dataquest (November 1998)

This column charts shows that the ball grid array (BGA) was the clear favorite, with nearly 90 percent of respondents using it. Trailing considerably behind were chip scale package (CSP), with 35.1 percent, and flip chip, with 33.3 percent.

Direct Chip Attachment (DCA)

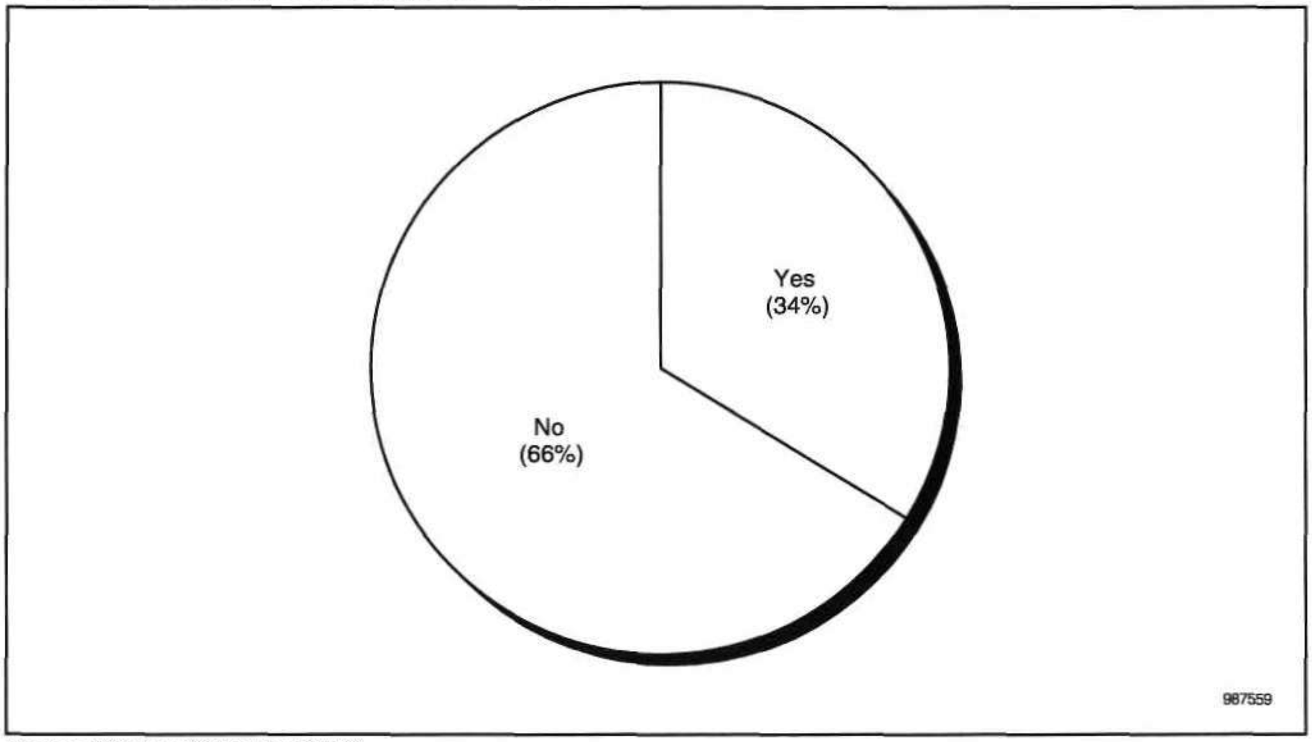
Direct chip attachment (DCA) is a title applied to any chip-to-substrate connections used to eliminate the first level of packaging. DCA eliminates the expense associated with package assembly by affixing the chip directly to the board or substrate.

Dataquest asked all respondents whether or not they used DCA. Figure 5-3 shows that almost a third of the respondents use this technology. Knowing this, Dataquest questioned this subgroup further to determine which types of DCA were used. The results are shown in Figure 5-4.

From Figure 5-4, it is clear that the most popular DCA type used by the contract manufacturers is chip on board (COB), with nearly three-quarters of the total pool of respondents employing it. There was a rather significant gap between it and the other DCA options.

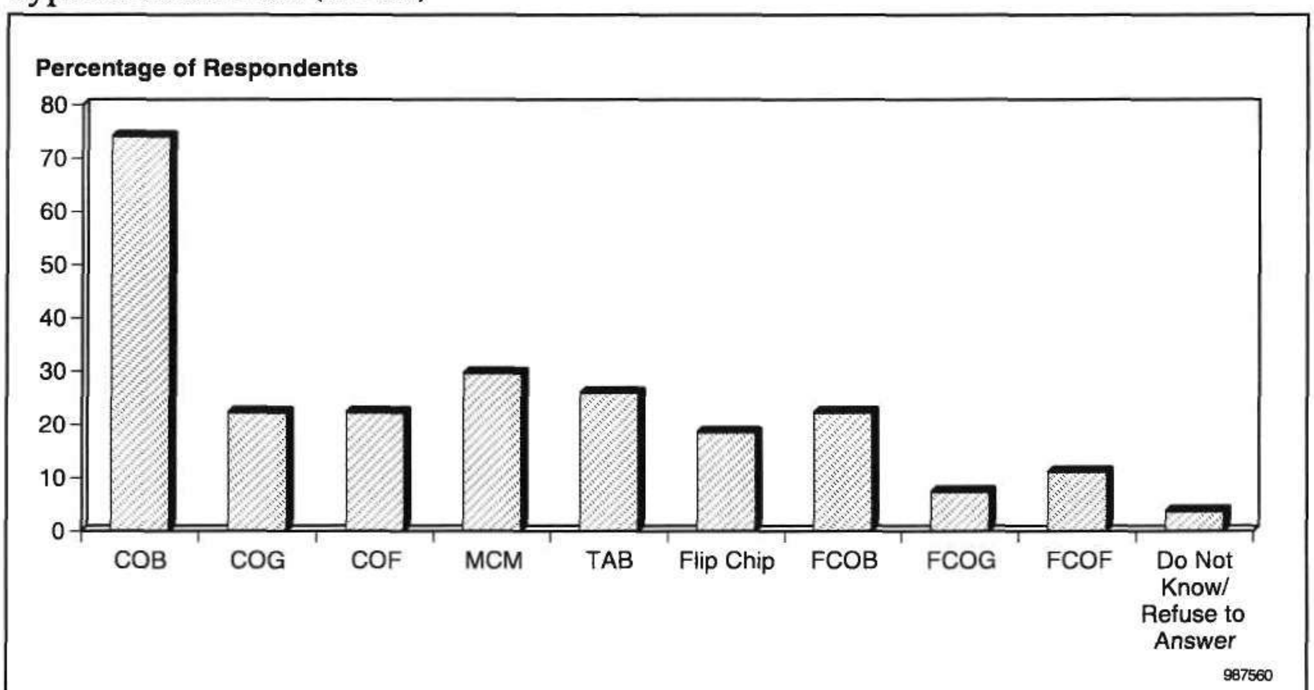
Only one frequency point separates the second, third, and fourth spots. Multichip module (MCM) got nearly 30 percent of the vote (or a frequency of 8) putting it in second place. Tape-automated bonding (TAB) came in third, while fourth place was shared by chip on glass (COG), chip on flex (COF), and flip chip on board (FCOB).

Figure 5-3
Do You Currently Use DCA? (N = 80)



Source: Dataquest (November 1998)

Figure 5-4
Types of DCA Used (N = 27)



Source: Dataquest (November 1998)

In seventh place, but just one frequency vote behind fourth place, was flip chip. The two remaining positions were filled by flip chip on flex (FCOF) and flip chip on glass (FCOG), in eighth and ninth place, respectively.

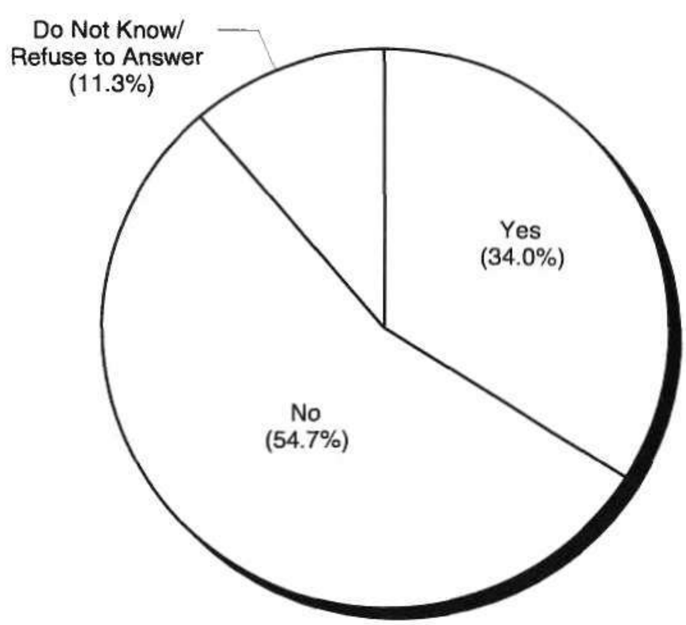
DCA—Future Use?

Dataquest asked the respondents who did not use DCA whether their strategy would change in 1999. The results are shown in Figure 5-5. This pie chart shows that more than half of these respondents do not plan to use DCA in the future. More than a third plan to use it next year. Responses that the respondents did not know or refused to answer totaled just over 11 percent of all responses.

Again, Dataquest asked the group of respondents referred to in Figure 5-5 what types of DCA they planned to use next year. Their responses are shown in Figure 5-6. Again, the overwhelming majority of respondents (more than 60 percent) selected COB.

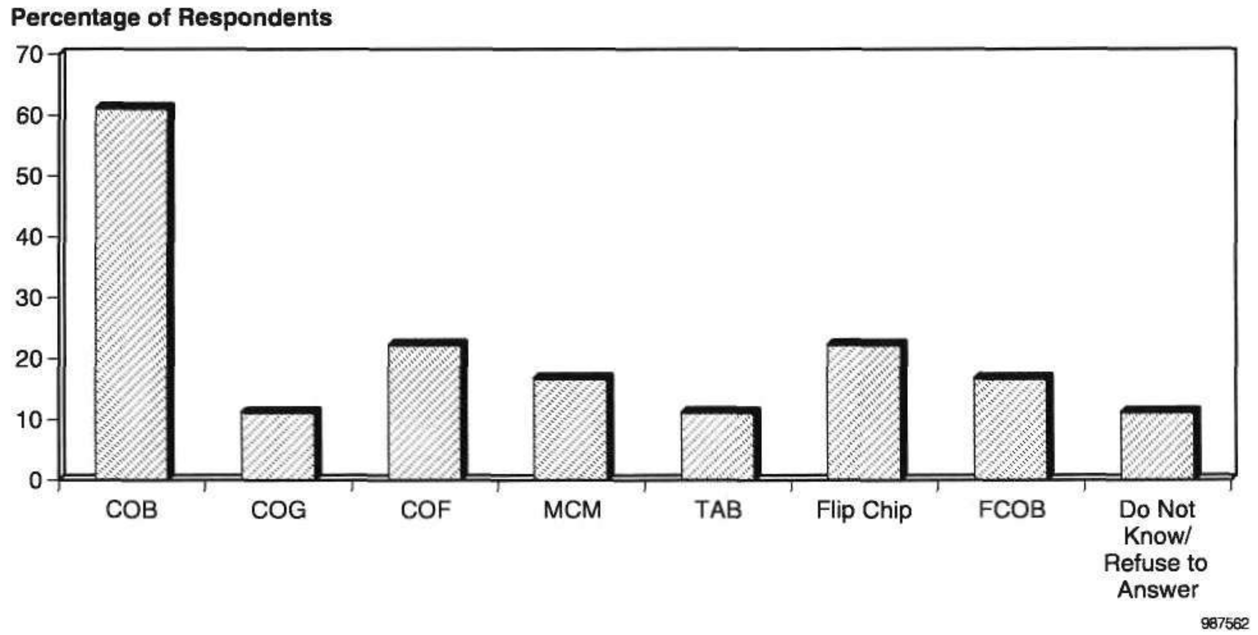
The next most popular types of DCA for future use lagged somewhat behind COB. These were flip chip and COF, with a vote of 22.2 percent each. Tied for fourth place were MCM and FCOB, with a 16.7 percent hit rate for each. Behind these were two other types of DCA (COG and TAB), each having a vote of just over 11 percent.

Figure 5-5
Will You Use DCA in the Future? (N = 53)



Source: Dataquest (November 1998)

Figure 5-6
DCA—Which Types Will Be Used? (N = 18)



Source: Dataquest (November 1998)

Summary

As package types go, surface-mounted technology is the most popular in the world at the moment, based on Dataquest's integrated circuit package forecast. Thus, it is reassuring that this type of package was also the top choice for the small contract manufacturers surveyed. However, the fact that through-hole is nearly as popular indicates that the manufacturers use a lot of cheap commodity devices. When reaching a certain price point becomes key, or the device uses an older technology, the necessity for through-hole remains an inevitable fact of life.

Well over 70 percent of the respondents stated that they use advanced package technology. While BGA is the outright winner, a respectable number of respondents also use CSP and flip chip. All this is very good news and indicates an extremely high degree of technology adoption for such small companies. From Chapter 3, we see that the participants buy a wide range of different types of semiconductors. Processors, ASICs, and analog, for example, are increasingly used in BGA forms. CSP is in production for many flash and other nonvolatile devices.

More than a third of the respondents use DCA, of which COB is by far the most popular. This result is not surprising, given that COB has been around the longest, so that people feel comfortable using or designing it. What is surprising is the popularity of MCM, TAB, COG, COF, and FCOB, as these are often regarded as more advanced forms of DCA. The popularity of these types of DCA indicates a high degree of functionality among the respondents. It also leads to the conclusion that the respondents manufacture for the portable and consumer market applications. It is even more significant given that the respondents are smaller manufacturers and that they are located mainly in the United States (a few are from Europe, but they are fewer than the total number of respondents using these types of DCA).

Chapter 6
PCB: Use, Linewidth, Supply, and Supply Base

Dataquest wanted to study printed circuit board (PCB) usage among the contract manufacturers surveyed. The make-versus-buy debate for PCBs was also relevant for this report. This chapter also examines the current and future usage of different PCB layer types by the group as well as PCB linewidth capabilities.

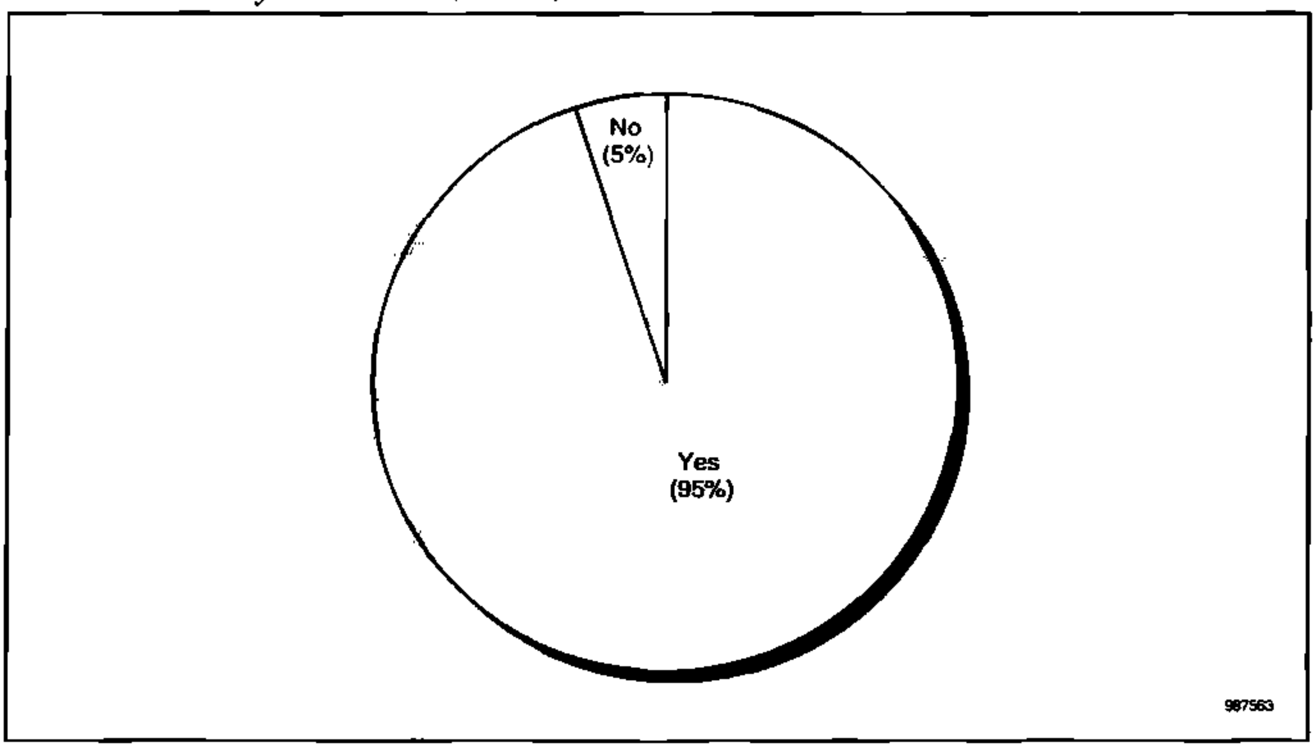
Dataquest also asked the contract manufacturers questions concerning their PCB supplier selection and their supply base size, both current and projected. We wanted to see whether they used different suppliers for different PCB layers and whether their supply base size varied.

PCB Usage

Dataquest asked all 80 respondents whether or not they used PCBs. As illustrated in Figure 6-1, 95 percent do use them.

Dataquest asked the four respondents who do not currently use PCBs if they planned to use them next year. Only one of these respondents planned to begin using PCBs in the future.

Figure 6-1
Do You Currently Use PCBs? (N = 80)



Source: Dataquest (November 1998)

PCBs: Make or Buy

All contract manufacturers were asked whether they manufactured or bought PCBs. The responses are shown in Table 6-1. Only 2.5 percent of respondents make PCBs themselves, with the overwhelming majority using the services of an external manufacturer.

Table 6-1
PCBs—Do You Make Them or Buy Them? (N = 80)

Response	Frequency	Percent
Manufacture In-House	2	2.5
Manufactured by Sister Company	1	1.3
Manufactured by External Company	66	82.5
Other	6	7.5
Do Not Know/Refuse to Answer	5	6.3

Source: Dataquest (November 1998)

Of the external manufacturing means chosen by the respondents, an external supplier was the clear leader, selected by well over 80 percent of those surveyed. Only one respondent sourced product through a sister company.

The 7.5 percent (six individuals) who selected the "others" category were asked to specify how they sourced PCBs. Their responses are plotted in Table 6-2, and it is clear that these respondents use a combination of sourcing methods. A third of this group obtain their PCBs from both internal and external sources, with another third using both sister and external companies to get product. One respondent claimed to use a combination of all three sourcing methods (internal, external, and sister companies), and the last respondent obtained its PCBs from its customers.

Table 6-2
Others—Further Explanation (N = 6)

Response	Frequency
In-House and External	2
In-House, External, and Sister Company	1
Sister Company and External	2
Supplied by Customers	1

Source: Dataquest (November 1998)

PCB Layers Bought: Now and in the Future

Tables 6-3 and 6-4 show PCB layer purchase plans.

PCB Linewidths

Moving on from actual PCB layers used by the respondents, Dataquest wanted to see what the linewidth capability was for the contract manufacturers surveyed. (Please note that, as the respondents could pick as many linewidth ranges as were relevant, the percentages do not add up to 100.) The results are plotted in Table 6-5.

Table 6-3
Current PCB Layers Bought (N = 76)

Layers	Frequency	Percent
2-Layer	63	82.9
4-Layer	64	84.2
6-Layer	58	76.3
8-Layer	49	64.5
10-Layer	41	53.9
12-Layer	32	42.1
14-Layer	24	31.6
16-Layer	23	30.3
Others	15	19.7
Do Not Know/Refuse to Answer	0	0

Source: Dataquest (November 1998)

Table 6-4
PCB Layers to Be Bought in the Future (N = 76)

Layers	Frequency	Percent
2-Layer	60	78.9
4-Layer	62	81.6
6-Layer	57	75.0
8-Layer	48	63.2
10-Layer	39	51.3
12-Layer	30	39.5
14-Layer	23	30.3
16-Layer	22	28.9
Others	9	11.8
Do Not Know/Refuse to Answer	22	28.9

Source: Dataquest (November 1998)

Table 6-5
PCB Linewidth Capability (N = 80)

Response	Frequency	Percent
3mm and Below	35	43.8
4 to 6mm	39	48.8
7 to 9mm	30	37.5
10 to 12mm	21	26.3
13 to 18mm	14	17.5
18mm and Over	14	17.5

Source: Dataquest (November 1998)

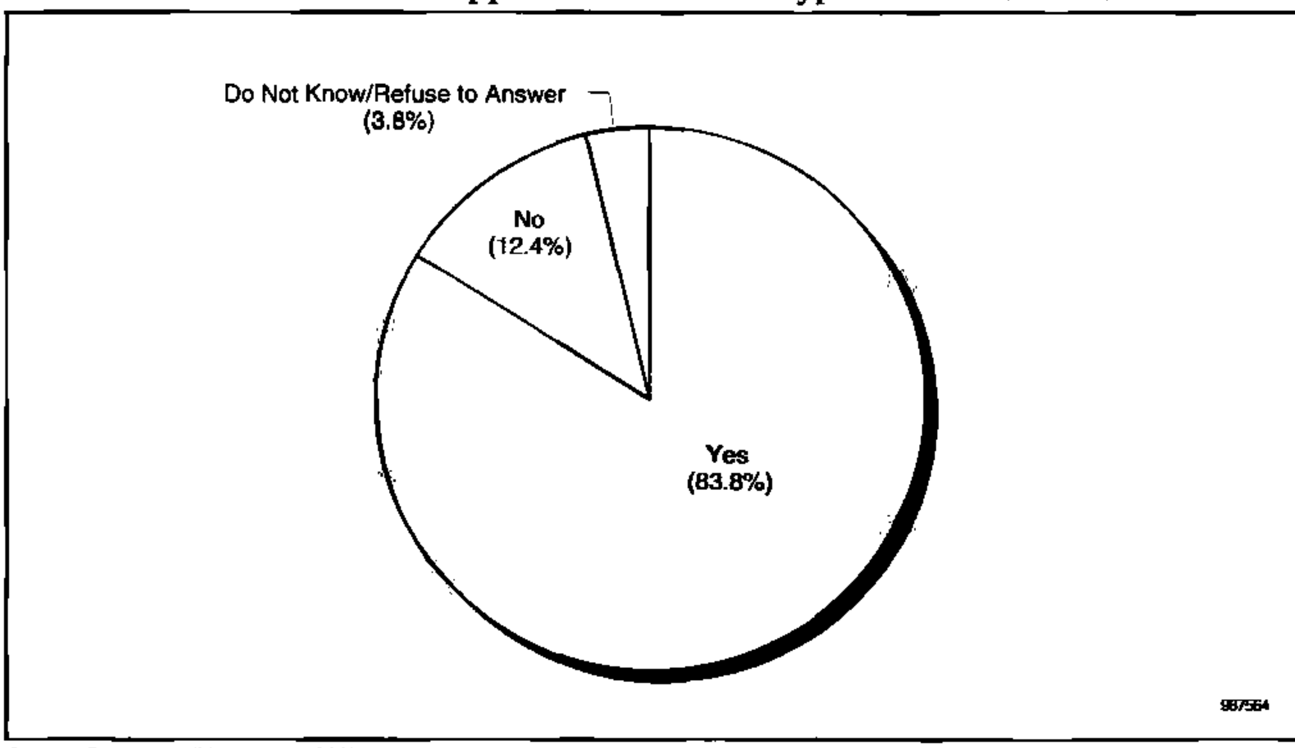
Table 6-5 shows that the smaller the linewidth, the higher the percentage of respondents with this manufacturing ability. It shows that the two most popular linewidth ranges were the smallest—the 3mm and below and the 4 to 6mm ranges. Nearly 44 percent of the respondents had PCB linewidth capabilities for each of these ranges.

In third place based on the respondent hit rate was the 7 to 9mm range, with 37.5 percent of respondents claiming this capability. In fourth position, with more than a quarter of respondents with this ability, was the 10 to 12mm range. The 13 to 18mm and 18mm and over ranges shared the fifth position, each capturing 17.5 percent of the respondents' competence.

Supply Base Selection

Dataquest asked all 80 survey participants whether they had different suppliers for PCBs with different numbers of layers. A resounding 82.5 percent confirmed that they do, with 10 individuals denying that they used different suppliers. These responses are plotted in Figure 6-2. As is to be expected, 5 percent of the respondents chose the "Do Not Know/Refuse to Answer" option, corresponding to the 5 percent who claimed not to use PCBs.

Figure 6-2
Do You Have Different PCB Suppliers for Different Types of PCB? (N = 80)



Source: Dataquest (November 1998)

Supply Base Size

Given the trend toward supply base rationalization, we sought to discover the current PCB supply base size and how it would change in the near future (in 1999). Figure 6-3 and Table 6-6 plot the results of these questions.

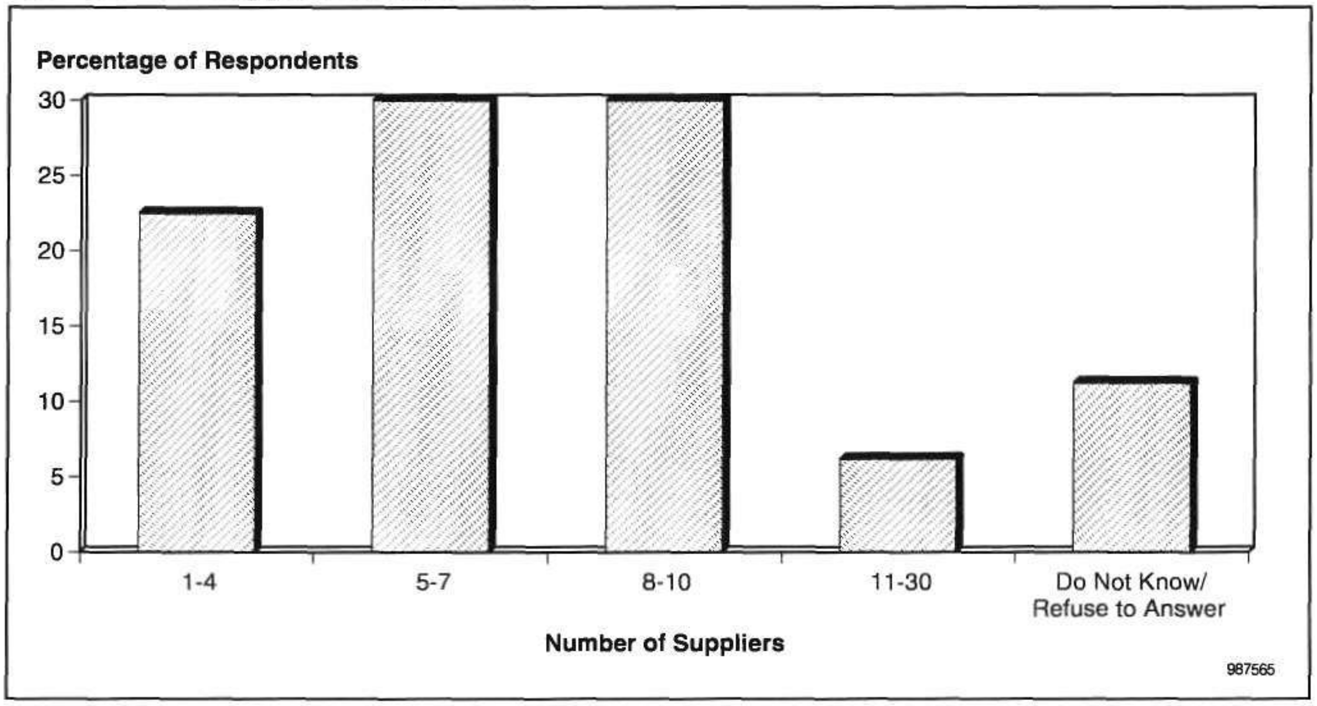
It is clear from Figure 6-3 that the most popular PCB supply base sizes are in two ranges: 5 to 7 suppliers and 8 to 10 suppliers. These two ranges each got 30 percent. The second most popular size was the smallest of the ranges offered, 1 to 4 suppliers, while the 11 to 30 range got just over 6 percent of the vote. Those who selected "Do Not Know/Refuse to Answer" were 11.3 percent of the respondents.

But what will happen in the future? Table 6-6 shows that nearly 60 percent of our respondents plan to maintain their current PCB supply base size next year. Twenty percent hope to decrease their supply base size for PCBs in 1999, and 13.7 percent are planning to increase it.

Summary

This chapter is all-encompassing, covering a variety of different elements of the relationship between contract manufacturers and PCBs. First, it was established that 76 out of 80 contract manufacturers surveyed currently use PCBs, with the number expected to rise to 77 out of 80 next year.

Figure 6-3
Current PCB Supplier Size (N = 80)



Source: Dataquest (November 1998)

Table 6-6
How Will Your PCB Supply Base Size Change in 1999? (N = 80)

Response	Frequency	Percent
Increase	11	13.7
Decrease	16	20.0
Remain Flat	47	58.8
Do Not Know/Refuse to Answer	6	7.5

Source: Dataquest (November 1998)

Of these manufacturers, the vast majority source products externally. This finding is to be expected considering that these are small contract manufacturers, which generally speaking would not have the volume of business to justify in-house manufacture. The make-versus-buy analysis has probably been done, and the conclusion was, "Buy!"

Most contract manufacturers participating in the survey bought a variety of different PCBs with different numbers of layers. The PCB layer range went from two to 16, and nearly a fifth of those surveyed currently buy 16-layer boards. This finding would indicate that despite these companies' relatively small revenue and number of employees, they are capable of quite a degree of complexity.

Likewise, nearly 44 percent of the respondents have linewidth capabilities of 3mm or less. This is the cutoff point between hand and machine assembly, and the ability to achieve these PCB linewidths indicates that these manufacturers possess quite a degree of automation capability. Clearly, small does not equal old-fashioned when it comes to technology adoption among contract manufacturers.

Supply base analysis reveals that nearly 80 percent of the respondents expected their supply base to remain flat or decrease over time. Currently, 82.5 percent have fewer than 10 PCB suppliers. As 83.8 percent indicate that they have different suppliers for different PCB layers, and the majority buy many different PCB layers, it is probably inevitable that they have more than two or three PCB suppliers.

No doubt the goal of these manufacturers is to have multiple supply sources for each type of PCB bought. Thus, 10 or fewer is a good goal. However, the manufacturers should be looking to get more of a PCB mix from fewer suppliers if they want to maximize their volume leverage. This is the only way these smaller companies can hope to maintain costs similar to those of the bigger contract manufacturers. Good news, however: Consolidation should occur next year, improving the possibility of reducing the PCB supply base.

Chapter 7

Trends in Exotic Materials, Pricing, and Availability

This chapter covers different topics, namely PCB pricing, availability, and lead times, plus exotic materials. It examines current and future PCB pricing trends (upward, downward, and flat) and also asks the respondents a number of status questions.

A procurement component such as PCB lead times will vary from supplier to supplier. As long as it is mutually agreed on by supplier and buyer, even the longest of lead times can be made workable. Therefore, to avoid becoming preoccupied with various different lead times, Dataquest asked the participants a trend question on lead times: Do they see lead times as increasing, decreasing, or remaining flat?

Looking at PCB availability, Dataquest asked the contract manufacturers to state how they viewed current and near-term availability and whether this was increasing, decreasing, or remaining flat.

The area of exotic material was also covered. Dataquest asked whether participants were charged a price adder for use of exotic materials and, if yes, what percentage. By "exotic," Dataquest means any PCB material type other than standard fiberglass or flex.

PCB Pricing Trends

Dataquest asked the contract manufacturers what their perception of PCB pricing was, both for this year and for next year. Of the 80 respondents, only 77 were prepared to comment when questioned on this subject. The results for 1998 and 1999 PCB pricing trends are plotted in Tables 7-1 and 7-2.

Table 7-1
PCB Price Trends for 1998 (N = 77)

Responses	Frequency	Percent
Price Increasing	12	15.5
Price Decreasing	27	35.1
Price Flat	38	49.4
Do Not Know/Refuse to Answer	0	0

Source: Dataquest (November 1998)

Table 7-2
PCB Price Trends for 1999 (N = 77)

Responses	Frequency	Percent
Price Increasing	15	19.5
Price Decreasing	30	39.0
Price Flat	31	40.3
Do Not Know/Refuse to Answer	1	1.2

Source: Dataquest (November 1998)

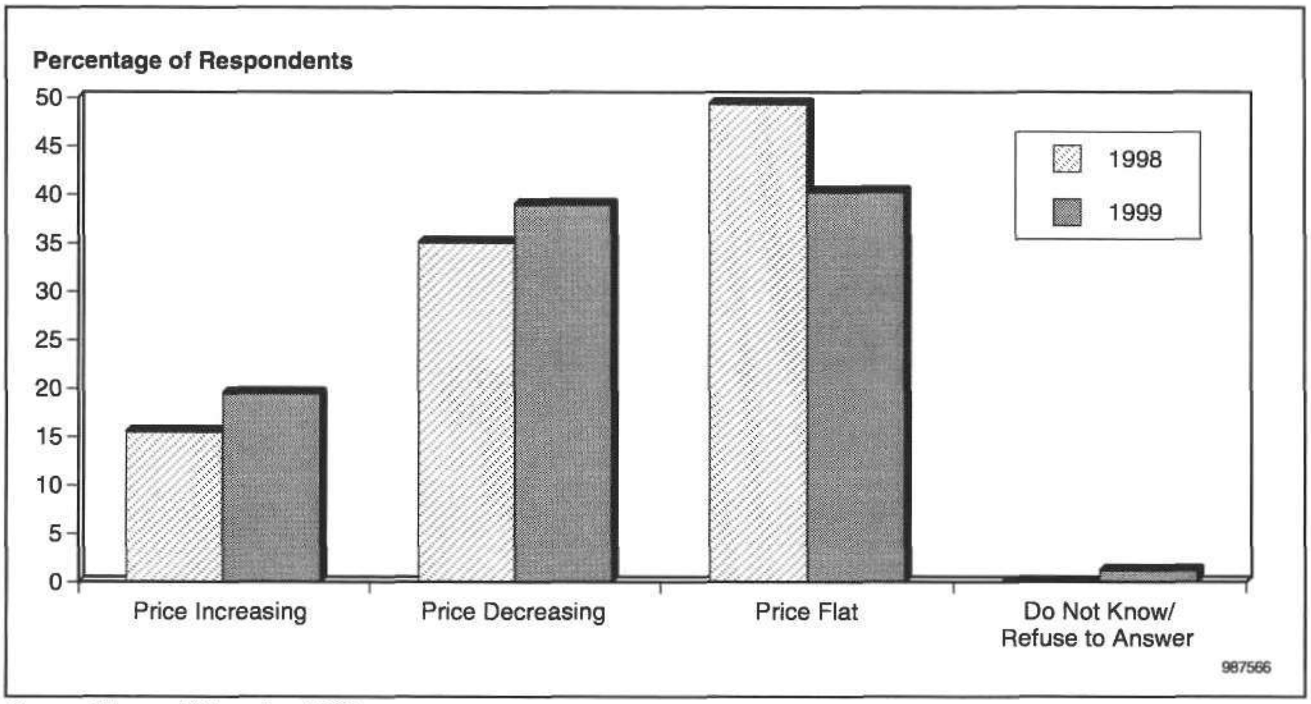
From Table 7-1, it is clear that the majority of respondents hope to either maintain or decrease their PCB pricing this year. Nearly 50 percent expected their prices to remain flat, with well over 33 percent expecting to save money through declining PCB prices. Only 15.5 percent of all respondents anticipated price increases for PCBs.

For 1999, the distribution of respondents' opinions about the direction of PCB prices—up, down, and not moving—was fairly similar. However, Table 7-2 shows that for 1999, there was one respondent who either did not know or refused to comment. Again, the majority were prepared for prices to remain flat or decrease. Nearly four out of 10 were banking on prices to continue downward, with about the same number expecting to keep their current PCB price points into next year. Just under 20 percent expected prices to rise from their current levels in the next year.

If we compare PCB price trends from 1998 and 1999 (as in Figure 7-1), we can see that the distribution of responses among the four options varies a little over the time frames. For example, more respondents expected prices to increase in the future (1999) than in the here and now—19.5 percent for 1999 versus 15.5 percent for 1998.

On the other hand, more respondents also expected to see lower PCB prices in 1999 than they saw this year. Exactly 39 percent of respondents forecast decreasing prices for PCBs next year, with about 35 percent confident of declining prices in 1998.

Figure 7-1
PCB Price Trends: 1998 versus 1999



Source: Dataquest (November 1998)

Interestingly enough, the number of respondents who anticipate flat PCB prices actually decreased from 1998 to 1999. This year, just under half of the contract manufacturers surveyed expected flat prices, whereas about four in 10 are preparing for stable prices in 1999.

Exotic Materials

The next area that Dataquest wanted to investigate was exotic materials. Dataquest asked the contract manufacturers whether they were charged extra for using exotic materials. From Table 7-3 we see that 55.8 percent say that they paid extra for exotic materials.

Exotic materials are often referred to as advanced materials and are selected based on a number of key drivers, based on electrical and mechanical characteristics. Common electrical characteristics include dielectric constant, signal loss, and impedance requirements. Some common mechanical characteristics include dimension stability and temperature limitations.

Types of exotic materials used for PCBs include polyimide, GETek, FR-4, BT, CE, Tetra II, Thermount, and different PTFE options.

Table 7-3
Extra Charge for Exotic Materials (N = 77)

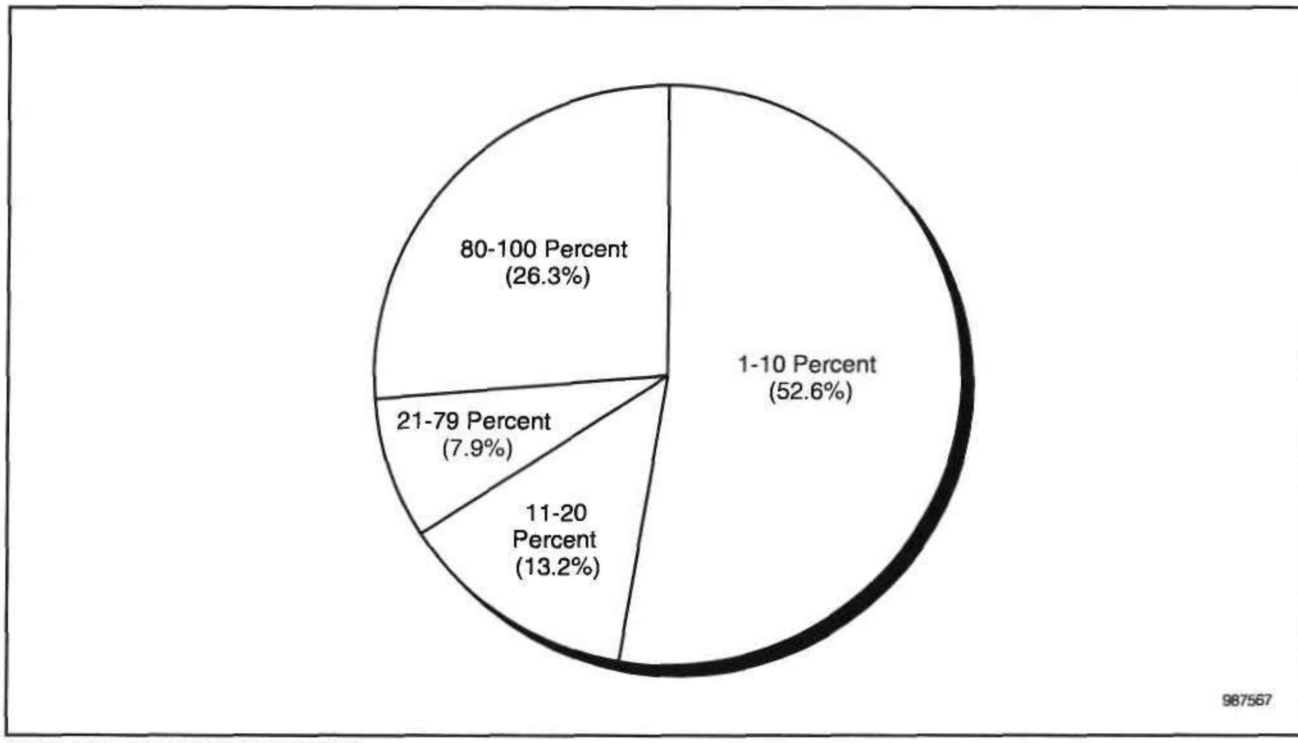
Response	Frequency	Percent
Yes	43	55.8
No	34	44.2

Source: Dataquest (November 1998)

With this in mind, Dataquest asked what the typical extra charges were for exotic PCB materials. Although 43 respondents were charged extra, only 38 were able to answer this question. Each of these respondents gave an exact percentage adder that they were charged for exotic materials. However, for ease of analysis, Dataquest organized the answers into five ranges. These ranges and the responses are graphed in Figure 7-2.

Of the five ranges, the two extremes proved to be the most popular. The range with the most hits was the 1 to 10 percent range, with more than half of the respondents' adders falling into this category. The second most popular range was between 80 and 100 percent, with a hit rate of more than 25 percent of respondents. The remaining responses fell into the 11 to 20 percent range (13.2 percent of all respondents) and the 21 to 79 percent range (7.9 percent of all respondents).

Figure 7-2
Percentage Adders for Exotic PCB Materials (N = 38)



Source: Dataquest (November 1998)

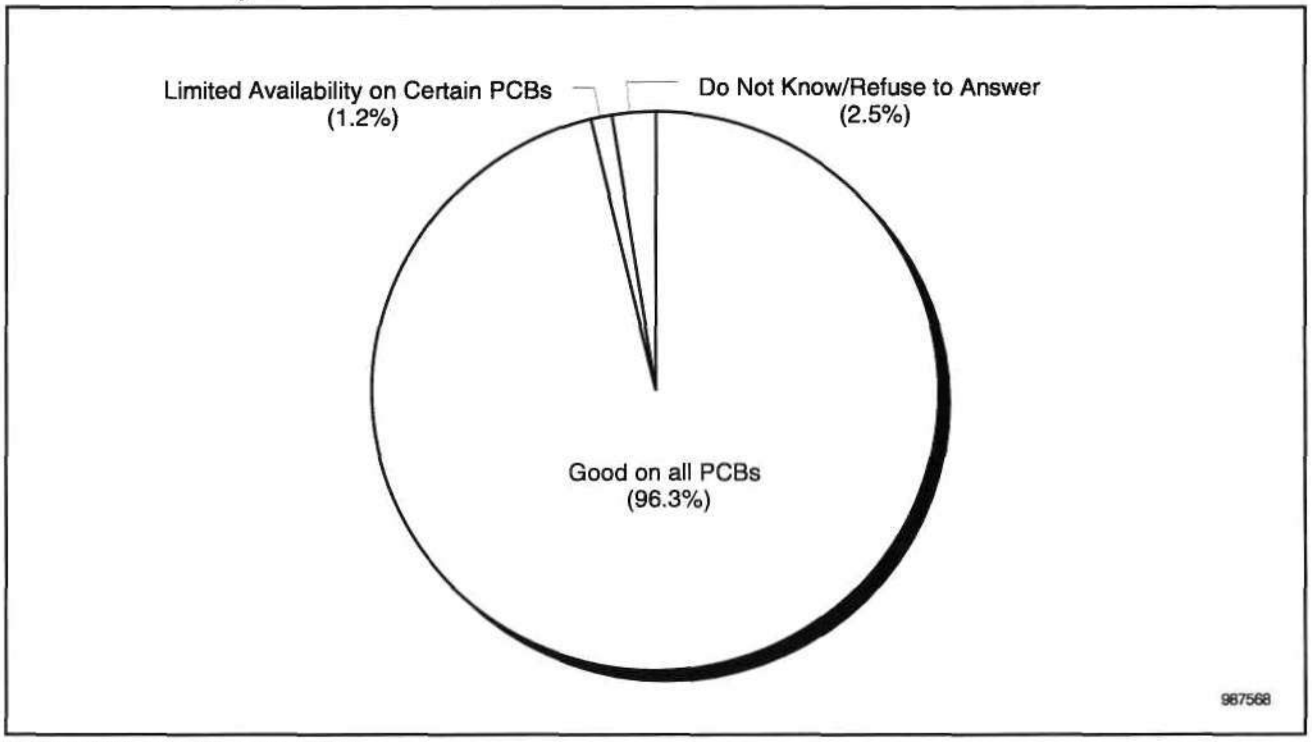
PCB Availability

Earlier in this chapter, we looked at the price trends for PCBs among the small contract manufacturers surveyed. Now, we will examine the PCB availability for this year and next year. In addition to the "Do Not Know/ Refuse to Answer" option, the respondents were given the following six options for PCB availability:

- Good availability on all PCBs
- Good availability on certain PCBs (state layers)
- Limited availability on all PCBs
- Limited availability on certain PCBs (state layers)
- Tight availability on all PCBs
- Tight availability on certain PCBs (state layers)

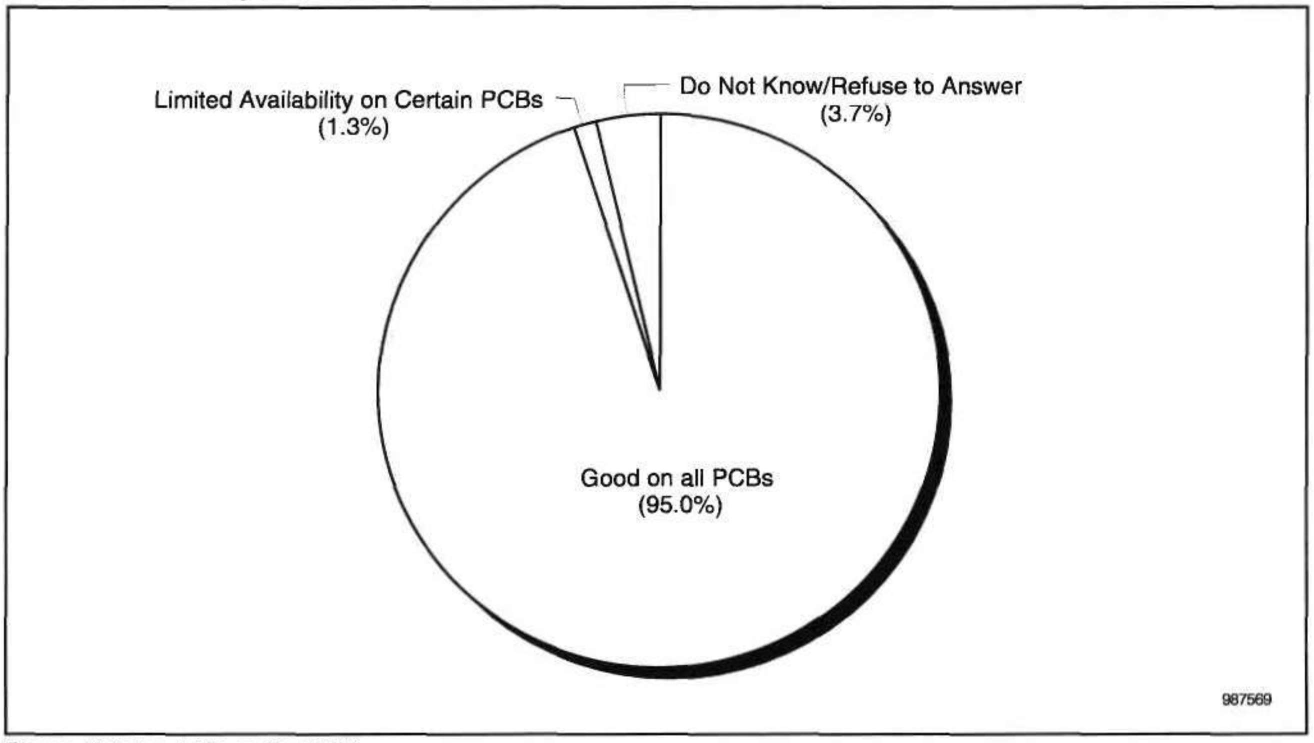
The results for 1998 and 1999 are plotted in Figures 7-3 and 7-4, respectively. Interestingly enough, despite having six different availability options, the respondents chose only two for both years. For current (1998) availability, a resounding 96.3 percent stated that availability on all PCBs was good, with only one respondent indicating limited availability and two respondents stating that they did not know or refused to answer.

Figure 7-3
PCB Availability for 1998 (N = 80)



Source: Dataquest (November 1998)

Figure 7-4
PCB Availability for 1999 (N = 80)



Source: Dataquest (November 1998)

When asked to comment on future availability, the replies were very similar. Figure 7-4 shows that an overwhelming 95 percent expected good availability for all PCBs for the future. Again, only one lone participant anticipated limited availability on certain PCBs. Three respondents picked the "Do Not Know/Refuse to Answer" option.

PCB Availability Status

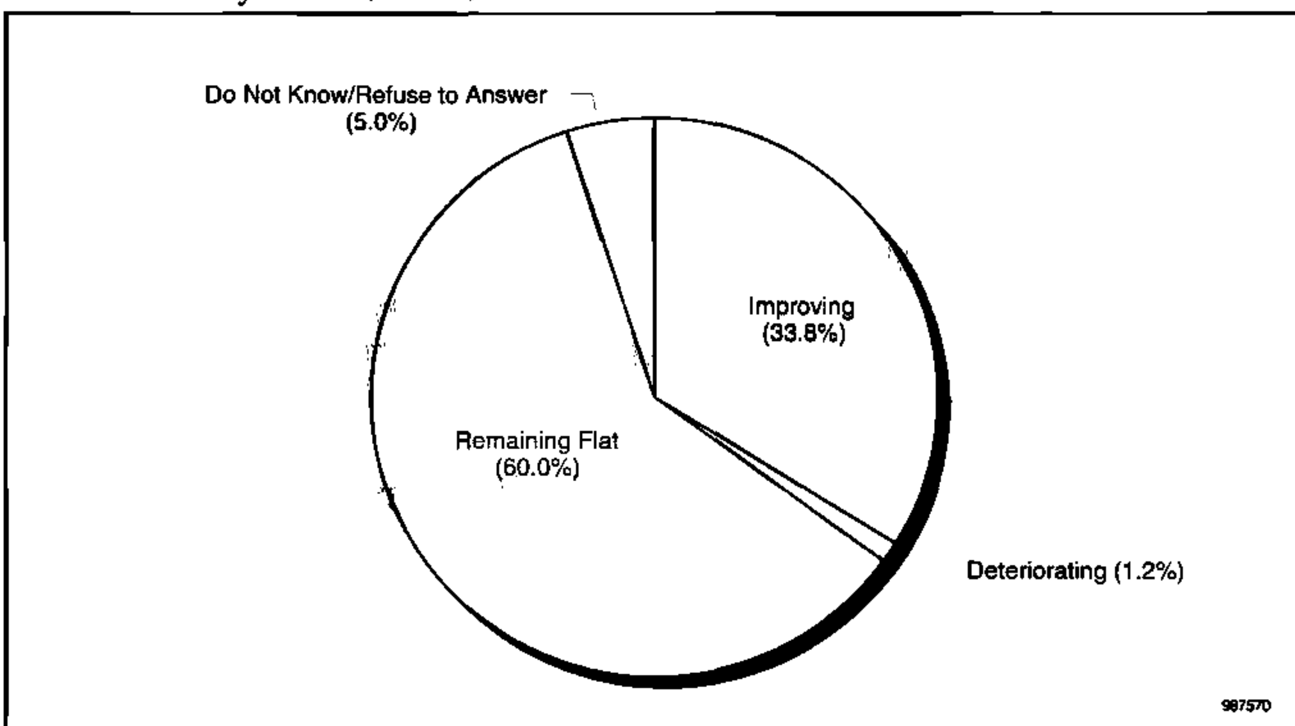
We saw from Figures 7-3 and 7-4 that these contract manufacturers are fairly comfortable with current and future PCB availability. However, as a way of checking their gut feelings on availability, Dataquest asked all respondents to comment on availability status. In other words, how do they view things as related to the present and near past?

Figure 7-5 plots the results of the PCB availability question. Six out of 10 respondents believe that availability remains the same, with just over 33 percent believing that it is improving. Only one respondent believes things are deteriorating, with 5 percent abstaining.

PCB Lead Times

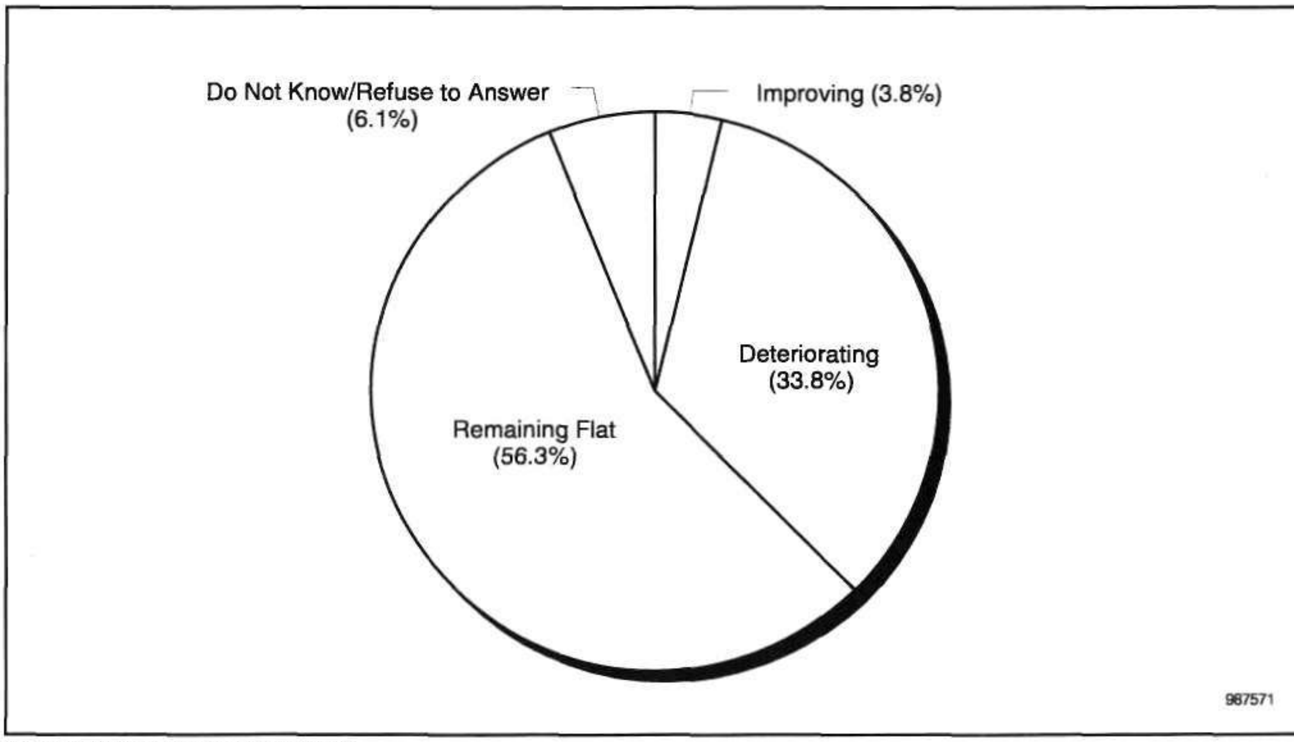
Once again, Dataquest asked a status question, this time asking all respondents to look at PCB lead times. Figure 7-6 shows that well over 50 percent see lead times remaining flat, with only 3.8 percent expecting them to improve (that is, decrease). A third pessimistically anticipate that PCB lead times will deteriorate (that is, increase). Five respondents chose the "Do Not Know/Refuse to Answer" option.

Figure 7-5
PCB Availability Status (N = 80)



Source: Dataquest (November 1998)

Figure 7-6
PCB Lead Time Status



Source: Dataquest (November 1998)

Summary

The majority of those surveyed were optimistic about PCB pricing trends. About 85 percent currently see PCB pricing remaining flat or decreasing, with a further 79 percent expecting the same pattern to continue into next year. As is to be expected, given the confident pricing trend forecast, the overwhelming majority also considered availability to be good on all types of PCBs, now and into 1999. Only one lone voice among all surveyed thought otherwise, begging the question, "On which planet do you source PCBs?"

However, a slight contradiction appears, with contract manufacturers bullish about good pricing and availability but anticipating that lead times will remain flat or increase. Although lead time increases do not inevitably mean product shortages, an increase does add an extra dimension to the sourcing channel, necessitating good demand forecasting.

Nearly 56 percent of those surveyed pay a premium for use of exotic PCB materials, which is to be expected. Use of these materials produces added PCB manufacturing challenges in the areas of lamination, drilling, and metallization. End applications are varied and include space, radar, and so on.

This result correlates with the high number of respondents who see PCB prices as either increasing or remaining flat. Those who use exotic materials can expect to continue to experience above-average pricing from a specific PCB supply base.

Chapter 8
Summary and Conclusion

Dataquest's goal was to examine the performance of a group of 80 small contract manufacturers on a number of key technical and commercial issues. We surveyed them in terms of such key commercial issues as supply base, products bought, lead times, inventory holding, and pricing. Technical issues covered include package types employed, DCA, and PCBs.

The clear message is that being a small manufacturer does not equate to being a low-tech dinosaur. In all areas of technical concern, our sample demonstrated a high adoption rate.

It is to be expected that the vast majority of participants can offer turnkey manufacturing to their actual and potential customers. To remain in business, contract manufacturers need to meet their customers' requirements. They need to be flexible, efficient, and professional, and they must be able to offer the customer as much or as little as is required.

Of the turnkey contract manufacturers that source products, a full 96 percent buy semiconductors. The semiconductors procured range from DRAM through to ASICs and MCUs. These people are not just engaged in low-spec module population or box assembly.

As was to be expected based on the cornucopia of semiconductors procured, participants indicated a very high adoption of advanced package types (well over 70 percent). Respondents buy more than just BGA forms (for example, processors and ASICs) of advanced technology, as CSP (for flash) as well as flip chip also scored high.

Adoption of DCA demonstrates a high degree of functionality among the respondents. As a follow-on, it can be assumed that many manufacture on behalf of customers engaged in the portable and consumer end-application markets. This is significant for two reasons.

The first is that geographically, most respondents were located in the United States, which is hardly a hotbed of consumer and portable manufacture. Thus, the use of DCA among our participants shows that they are specialized, focused contracting companies. Secondly, as our respondents are small in size, the use of DCA demonstrates a high technology investment on their part. It also indicates that their end customers are not too hung up on company size alone.

Looking at PCBs, once again the small contract manufacturers continue their technology adoption trend. They buy products up to 16 layers, can work with linewidths as low as 3mm, and also use exotic materials.

These results lead to the conclusion that these manufacturers have a high degree of both manufacturing process automation and end market focus. These results also back up the DCA data, as DCA cannot be successfully achieved in a manual setting! These results also show that these manufacturers have customers with very specialized end applications, such as military and space.

Also, from a commercial standpoint, these manufacturers predominantly outsource the manufacturing of PCBs—good news, as it shows that they do not fall into the trap of trying to do everything. The majority have clear pricing and availability expectations and can readily forecast future trends when asked.

The clear Achilles heel for the group is the area of inventory holding. While all have clear targets, most do not even come close to reaching them. Basically, the manufacturers are sitting on rapidly depreciating stock, which is tying up their capital.

Although some may argue that this is all ultimately owned by their customers, the contract manufacturers still need to take a greater ownership role in this process either through better forecasting and in-feed scheduling or by some other mutually agreed-on method.

Given the degree of consolidation that continues to take place in this field, small contract manufacturers need to stay a step ahead of the game to remain in business. They cannot offer multiple manufacturing locations on many different continents. They cannot piggyback on purchase orders for millions of devices. However, they can offer customers the advantages of working with a small company. As long as these manufacturers continue to remain technologically focused and work to improve some commercial issues (most notably actual inventory holding levels), they will continue to enjoy a prosperous, but competitive, marketplace and fill an essential market niche.

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest/Gartner Group
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: +1-408-468-8000
Facsimile: +1-408-954-1780

East Coast Research Center
Gartner Group Lowell
900 Chelmsford Street
Tower Two, Floor Nine
Lowell, Massachusetts 01851
United States
Phone: +1-978-323-6914
Facsimile: +1-978-323-6933

EUROPE

European Headquarters
Gartner Group Ltd.
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44-1784-431-611
Facsimile: +44-1784-488-980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33-1-41-35-13-00
Facsimile: +33-1-41-35-13-13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49-89-42-70-4-0
Facsimile: +49-89-42-70-4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153-0042
Japan
Phone: +81-3-3481-3670
Facsimile: +81-3-3481-3644

ASIA/PACIFIC

Asia Headquarters
Gartner Group Hong Kong
Suite 5904-7, Central Plaza
18 Harbour Road
Wanchai
Hong Kong
Phone: +852-2824-6168
Facsimile: +852-2824-6138

Pacific Headquarters
Gartner Group Pacific
80 Alfred Street - 6th Floor
Milsons Point, NSW 2061
Australia
Phone: +61-2-9941-4860
Facsimile: +61-2-9941-4868

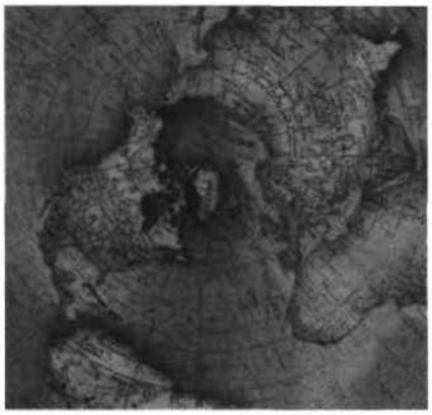
Korea
Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: +82-2-551-1331
Facsimile: +82-2-551-1330

Taiwan
Gartner Group Taiwan Ltd.
11F-2, 188, Section 5
Nan King East Road
Taipei 105
Taiwan R.O.C.
Phone: +886-2-2756-0389
Facsimile: +886-2-2756-2663/4122

Thailand
Gartner Group Thailand Ltd.
29 Vanissa Building, 12F
Soi Chidlom, Ploenchit Road
Pathumwan, Bangkok 10330
Thailand
Phone: +662-655-0577
Facsimile: +662-655-0576

Singapore
Gartner Group Advisory (S) Pte Ltd.
6 Temasek Boulevard #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: +65-333-6773
Facsimile: +65-333-6787

Dataquest
A Gartner Group Company



Dataquest

1998 Semiconductor User Wants and Needs: Save Me the Money

User Wants and Needs

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-UW-9801
Publication Date: September 7, 1998
Filing: Reports

1998 Semiconductor User Wants and Needs: Save Me the Money

User Wants and Needs

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-UW-9801
Publication Date: September 7, 1998
Filing: Reports

Table of Contents

Table of Contents (Continued)

List of Figures

List of Figures (Continued)

List of Tables

Chapter 1
Executive Summary

Four Semiconductor Applications Categories

For the purposes of estimating semiconductor consumption, Dataquest has segmented electronics equipment production into four broad groups. These four groups are data processing, communications, industrial, and others. These groups in turn are broken into narrower electronic product categories, as follows:

- Data processing
  - Computers
  - Data storage
  - Input/output devices
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecom
  - Public telecom
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications
- Industrial
  - Industrial control
  - Robotics
  - Medical
- Others
  - Consumer
  - Military/civil aerospace
  - Transportation

According to Dataquest's spring 1998 semiconductor application forecast, data processing accounts for 51 percent of 1997 semiconductor consumption (based on revenue), communications for 21 percent, industrial for 13 percent, and others for 15 percent.

For the purposes of this report, Dataquest selected the demographics of the companies participating so that 49 percent of respondents represented the data processing segment, 25 percent communications, 15 percent industrial, and the remainder others.

Survey Objective

Dataquest wanted to examine the buyer/supplier relationship from the procurement/user standpoint. Users of semiconductors, primarily buyers, were surveyed on various aspects of their supplier relationship.

The objective of the survey was to complete 100 surveys with the respondents' demographics: 50 percent data processing companies, 25 percent communications companies, and 15 percent industrial, and 10 percent military, transportation, and consumer companies.

Project Analysts: Evelyn Cronin and Mark Giudici

Chapter 2
Introduction

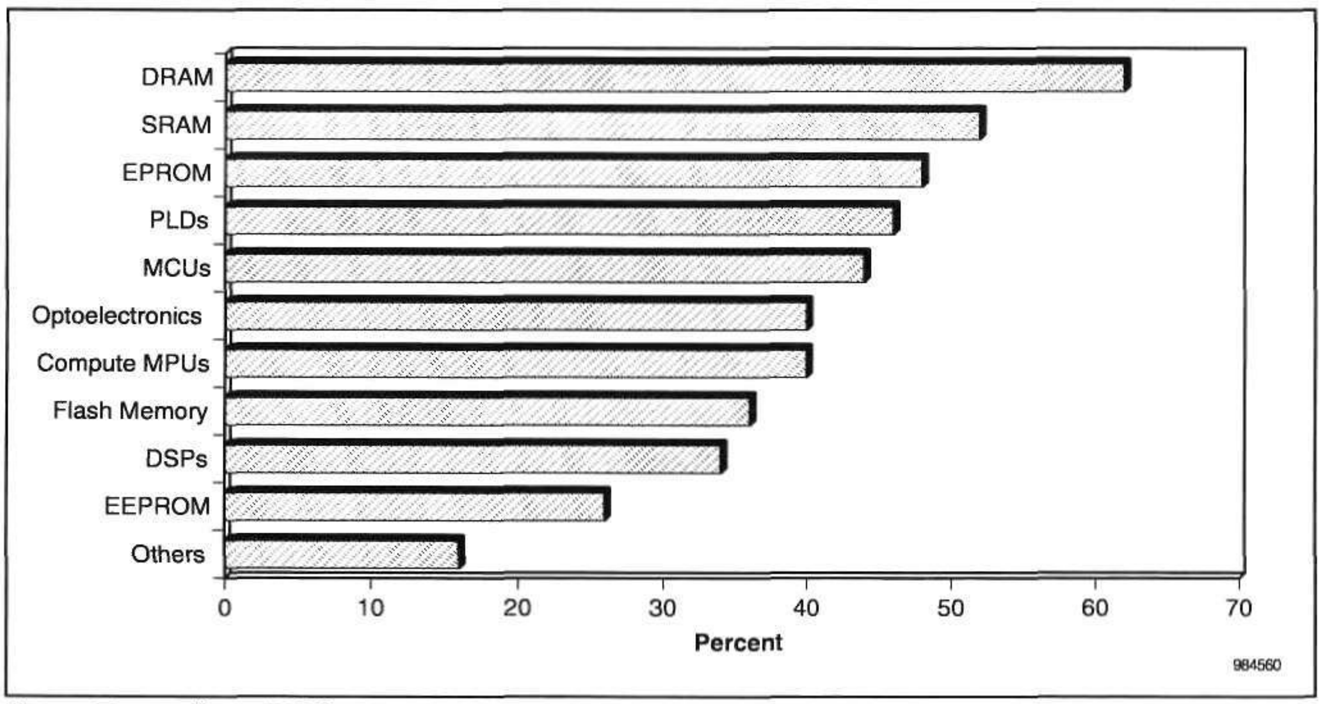
Management Summary

Dataquest completed a survey of 103 semiconductor users that explored the relationship between users (buyers) and vendors to find out what is critical to semiconductor procurement in the current oversupplied market. Those responding account for 4 percent of the total semiconductor spending forecast for North America in 1998, based on Dataquest's total North American semiconductor market revenue. The results were very interesting.

For example, it was confirmed that the device family that buyers surveyed sourced most in the spot market was DRAM. A solid 62 percent of all buyers who use the spot market source DRAM devices this way. Figure 2-1 plots these results.

The next group consisted of two memory devices, static RAM (SRAM) and erasable programmable ROM (EPROM). A respective 52 and 48 percent of buyers who use the spot market buy these devices there. Programmable logic devices (PLDs), microcontrollers (MCUs), and optoelectronics and compute microprocessors (MPUs) are next ranked, with 46 percent, 44 percent, and 40 percent (tie), respectively, of spot buyers sourcing these parts through this channel.

Figure 2-1
Percentage of Buyers Surveyed Using the Spot Market for the Listed Semiconductor Device Families (N = 88)

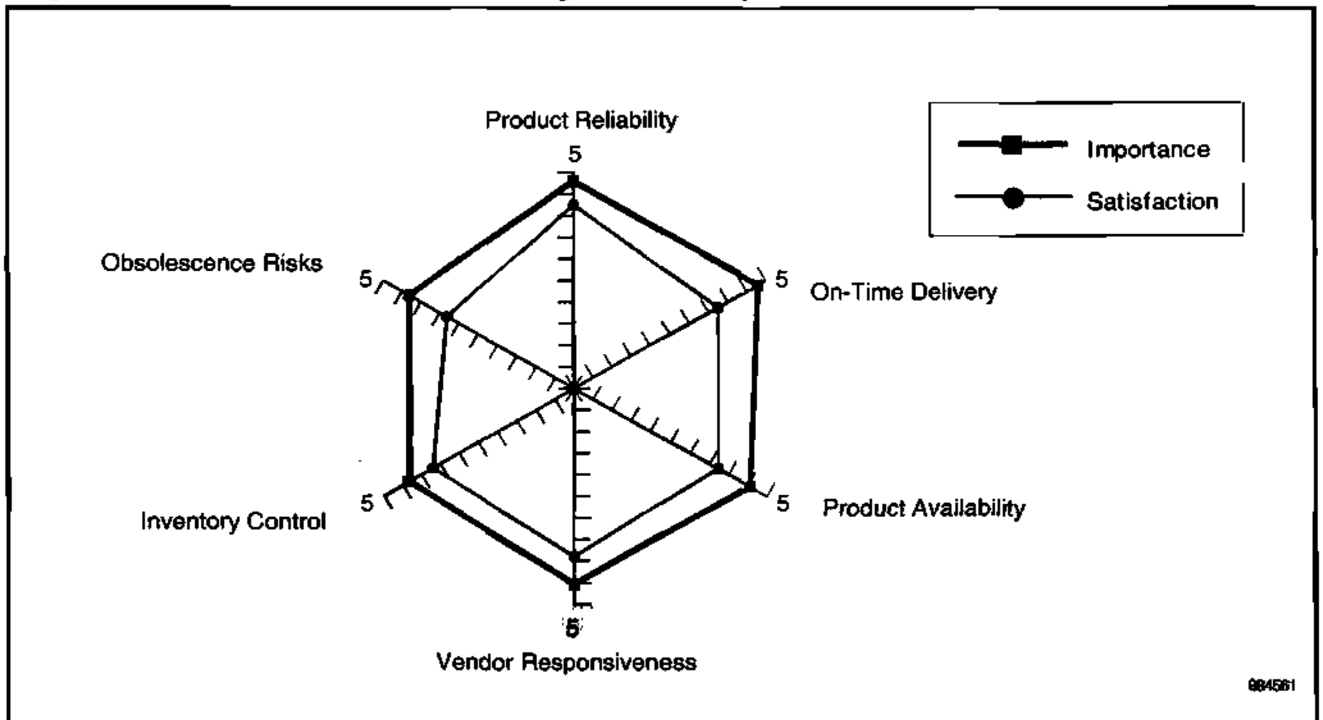


Source: Dataquest (August 1998)

Close behind were flash memory, digital signal processors (DSPs), and EEPROM, which buyers surveyed bought on the spot market 36, 34, and 26 percent of the time, respectively. The "others" category is a mixed bag made up of buyers who refused to state which devices they bought, those buying discretes, and those who bought a wide variety but would not specify.

Another topic in the report concerns the differences in importance and satisfaction ratings for key purchasing criteria (see Figure 2-2). This is a critical area of study, highlighting ways semiconductor suppliers can quickly improve market presence by improving in the areas noted. In the current market, where supplies are abundant and prices are low, the key issues relating to overall lower cost (where suppliers can directly help) are now under scrutiny. As a result, product reliability, on-time delivery, product availability, and vendor responsiveness rank as the top four issues of high importance on which the buyers surveyed experienced the largest gap between importance and satisfaction. The buyers have spoken: They want increased support in these areas. Suppliers that can perform in these four areas will have a leg up on their competition.

Figure 2-2
Importance versus Satisfaction Ratings for the Top Six Issues (N = 103)



Source: Dataquest (August 1998)

Report Contents

The report consists of 11 chapters. Chapter 1 is the executive summary; Chapter 2 is an introduction and management summary. Chapter 3 covers the demographics of the survey participants. Chapter 4 looks at the users' areas of semiconductor spending and their relation to total market size as well as to inventory holding and total cost of ownership.

Chapter 5 covers procurement sourcing channels, specifically the distribution and spot market channels. It looks at advantages and disadvantages of the channels and sourcing strategies. Chapter 6 deals with the supply chain and vendor trends. The chapter also covers strategic versus nonstrategic suppliers. Chapter 7 looks at vendor measurement, its frequency, and its perception by nonprocurement management.

Chapter 8 explores ratings of importance versus satisfaction for delivery, quality, responsiveness, technical support, flexibility, total cost of ownership, and price. Chapter 9 looks at information sharing between buyers and suppliers and also covers the issues of trust and goal-sharing in the relationship. Chapter 10 deals with buyer and vendor joint approval of semiconductors. The report finishes with conclusions and comparisons in Chapter 11.

Chapter 3
Survey Participant Demographics

Statement of Research Methodology

Dataquest's 1998 semiconductor procurement study contains the results of a telephone survey conducted by Dataquest's Research Operations group. The survey questionnaire was developed by analysts from Dataquest's Semiconductor Supply and Pricing Worldwide (SSPS) program. The questionnaire comprises 45 questions. Many of the questions allowed or required more than one response. There are 137 data points in the database. Trained interviewers conducted the 20-minute survey using a computer-aided telephone interviewing (CATI) system. About 15 percent of each interviewer's work was monitored for validation. Research Operations analysts tabulated the survey results using SPSS, a statistical analysis software package.

Dataquest conducted the study during June 1998. The sample list was obtained from a ZD Market Intelligence database. Dataquest obtained a total of 5,953 randomly selected names of people with the title of president/general manager, senior financial executive, PC manager, or purchase manager in the industry areas of computer and equipment, household appliances, communications, transportation, military and aerospace, medical, optical instrument, environment, and process control.

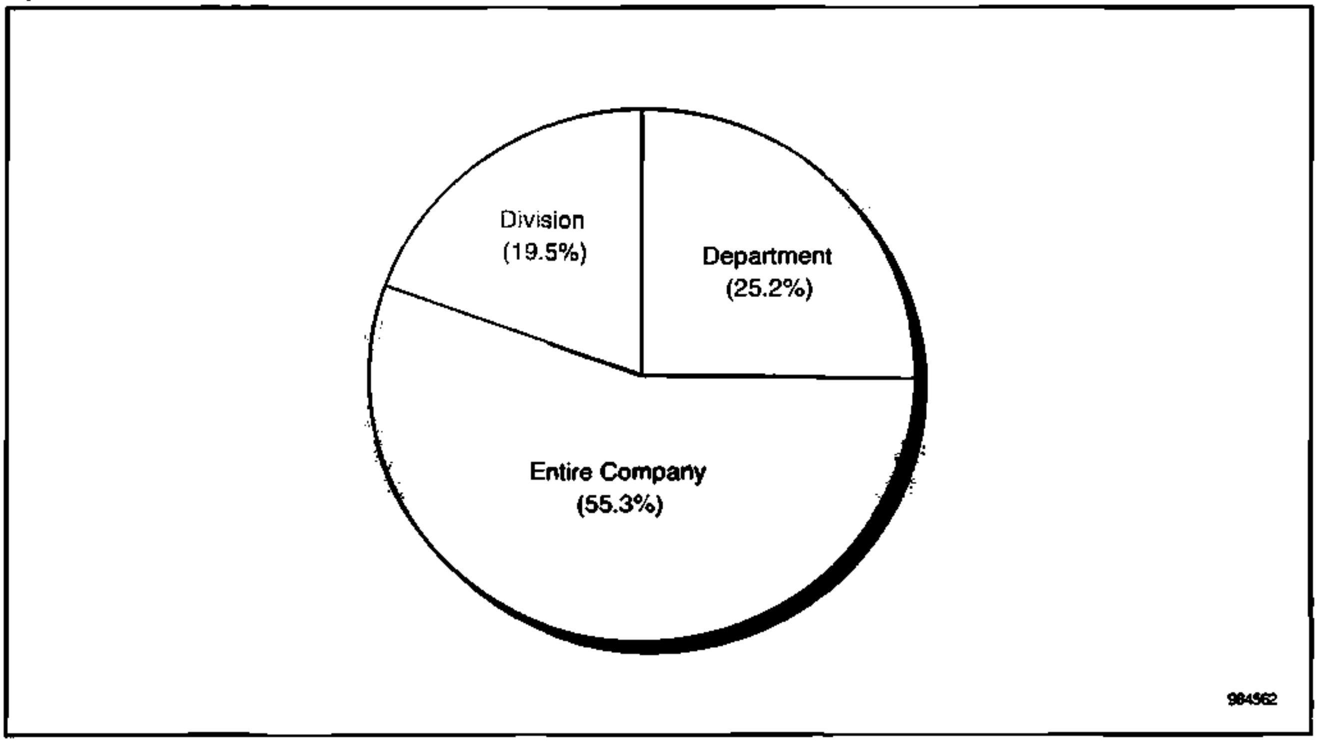
Dataquest placed a total of 3,103 calls. The sample disposition is as follows:

- 103 calls resulted in completed interviews.
- 267 were bad numbers.
- 2,220 of those called could not be contacted, were left a message, or otherwise did not produce an interview.
- 117 of those called refused to be interviewed.
- 396 did not qualify to participate in the study.

Respondents' Function Groups

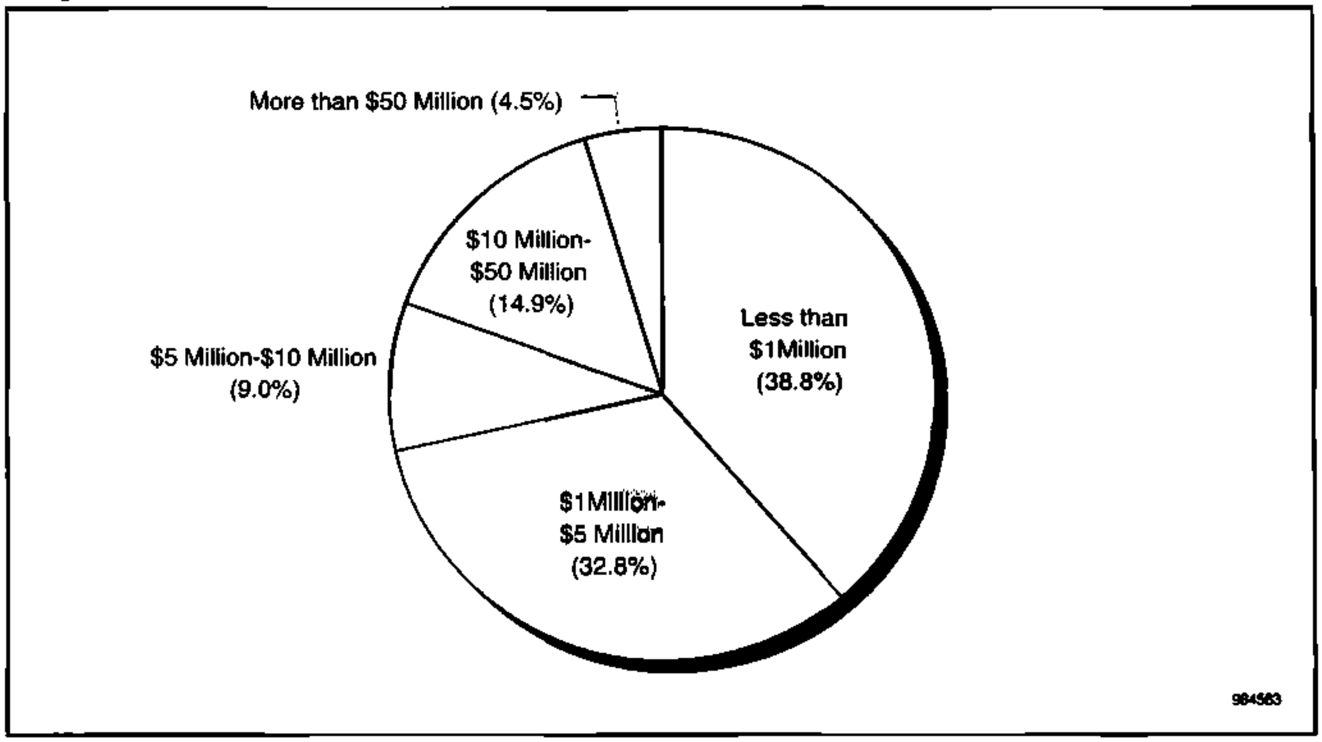
The functional groups of those responding to the survey ranged from the entire company to division and department levels. As shown in Figure 3-1, more than one-half (55.3 percent) of the sample purchased for their entire companies, close to a fifth (19.5 percent) represented divisions, and a quarter (25.2 percent) represented their departments. The high percentage of full company-level respondents accounts for the size of the purchases made. Figure 3-2 shows that close to two-thirds of the respondents (61.2 percent) bought more than $1 million in semiconductors in 1997, with 38.8 percent buying less than $1 million. The total of semiconductors purchased in 1997 by this sample was $1.92 billion (4.11 percent of all 1997 semiconductors consumed in the Americas).

Figure 3-1
Type of Functional Group (N = 103)



Source: Dataquest (August 1998)

Figure 3-2
Respondents' Semiconductor Purchases (N = 103)

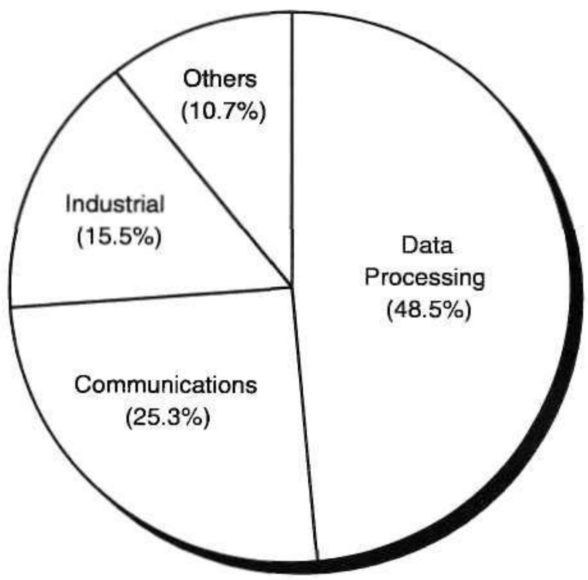


Source: Dataquest (August 1998)

Respondents' Demographics

The makeup of the survey response closely reflects the North American electronics industry that was polled. As shown in Figure 3-3, respondents from the data processing industry (any nonsoftware company manufacturing or selling computers or equipment used with computers) made up 48.5 percent of the sample. Just over one-quarter of the response came from communications companies, 15.5 percent was from the industrial market, and the remaining 10.7 percent of the sample was made up of consumer and military/civil aerospace companies. Based on the spring 1998 forecast for 1997 semiconductor revenue by application, 51.3 percent of the overall North American electronics industry is data processing companies, 21.2 percent is communications companies, and 12.8 percent is industrial, with the remaining consumer, transportation, and military/civil aerospace applications making up 14.7 percent of the market.

Figure 3-3
Respondents' Application Markets (N = 103)



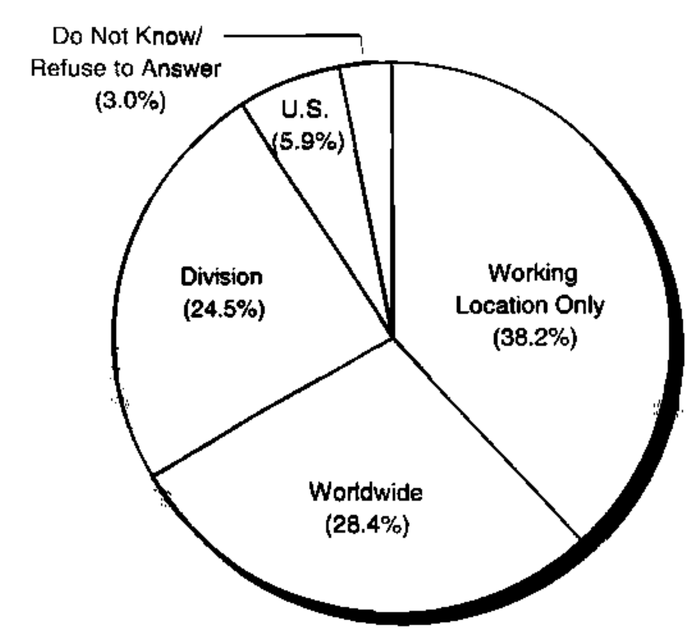
Source: Dataquest (August 1998)

Respondents' Market Size

The level of purchasing control also ranged from high to low. The spectrum spanned from handling worldwide operations to handling only the location at which the respondent worked. As shown in Figure 3-4, more than one-quarter (28.4 percent) of the respondents were responsible for worldwide semiconductor procurement, 5.9 percent were responsible for U.S. purchases, 24.5 percent handled divisional semiconductor procurement, and more than a third (38.2 percent) were responsible for their work location only. This response sample represents a good mix of tactical and strategic procurement requirements.

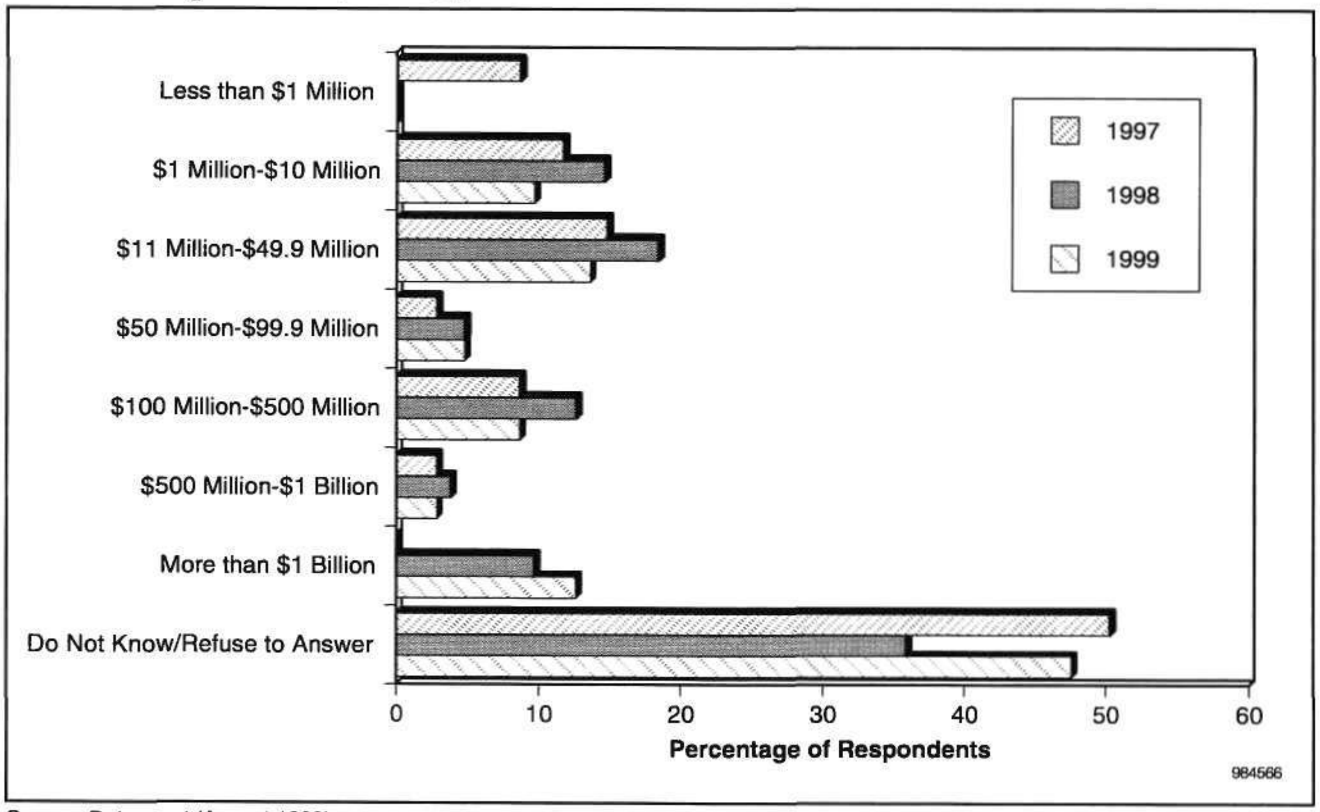
There was a large spread in the size of the companies for which the respondents worked. The largest group in 1997 (26.2 percent) came from companies ranging from $10 million to $49 million in sales; there was a tie for the next-largest group of respondents (8.7 percent each); these two groups had sales of less than $1 million and sales of $100 to $499 million, respectively. The full detail of 1997, 1998, and 1999 sales estimates is shown in Figure 3-5. Although the companies that expect to grow larger than $1 billion are increasing, all of the other companies expect sales to grow in 1998 compared with 1997 and then to decline. This result partly reflects the increased number of respondents who did not know what to expect or refused to comment on 1999, which highlights the current uncertain market conditions.

Figure 3-4
Level of Purchasing Responsibility (N = 103)



Source: Dataquest (August 1998)

Figure 3-5
Sales of Respondents (N = 103)



Source: Dataquest (August 1998)

Chapter 4
Where Does It All Go? Spending and Total Cost of Ownership

The role of the buyer is complex and sometimes all-encompassing. Given the number of different hats a buyer must wear, it is often all too easy to overlook the basics of the purchasing function. This chapter aims to cover the brass tacks of purchasing: semiconductor spending, inventory holding, and total cost of ownership (TCO).

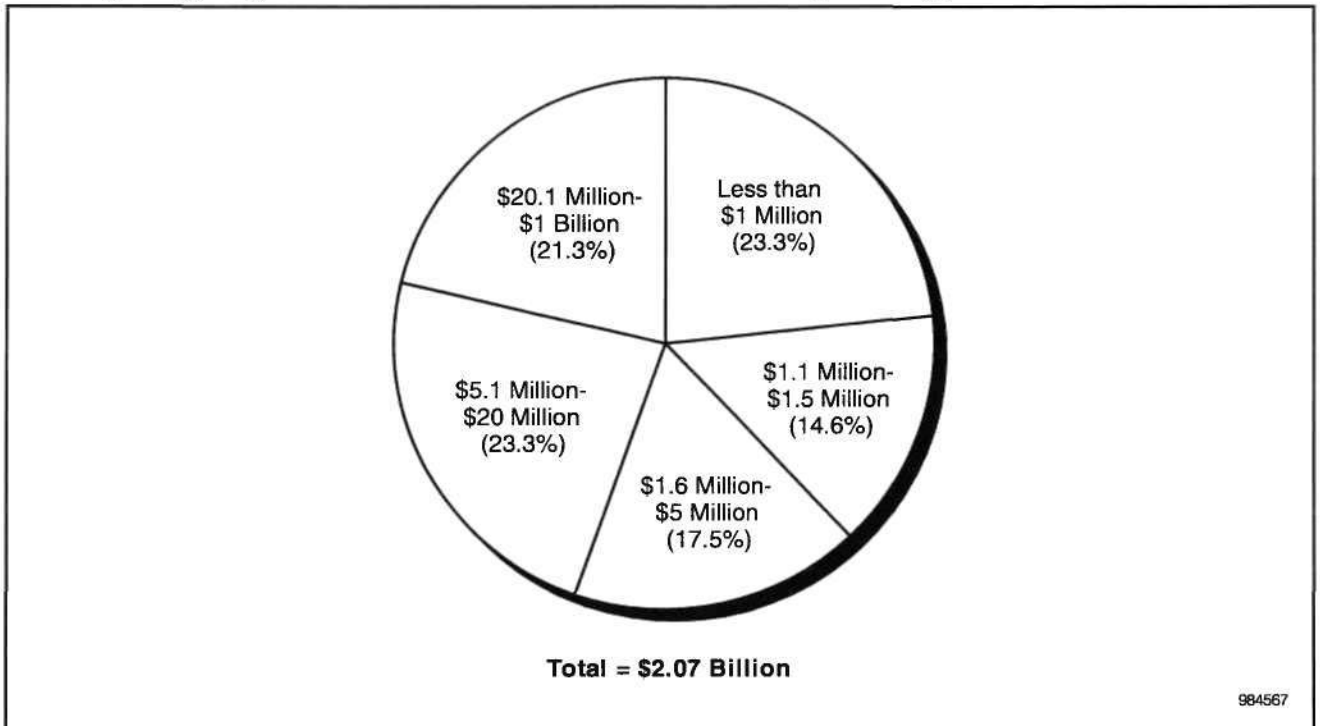
Semiconductor Spending

Dataquest asked all participants to indicate what their total semiconductor spending was forecast to be for 1998. The buyers were given the option of either stating what they estimated their spending to be or indicating the range that "best fit" their company's spending predictions.

For ease of viewing, the respondents' semiconductor spending results have been graphed by range size. Figure 4-1 indicates that there were five principal range sizes for the surveyed group of buyers. This spread indicates a good representation of a variety of sizes of companies within the North American region.

The five group ranges are below $1 million, $1 million to $1.5 million, $1.6 million to $5 million, $5.1 to $20 million, and finally $20.1 million to $1 billion.

Figure 4-1
Participating Buyers' Estimated Total Semiconductor Spending, 1998



Source: Dataquest (August 1998)

The forecast total semiconductor spending for the buyers surveyed for 1998 was $2.07 billion, representing 3.9 percent of the overall Americas market. This spending level reflects the higher number of small and medium-size companies as well as reflecting the impact of average price declines of 40 percent and more since last year, which have kept spending levels relatively low while increasing unit purchases.

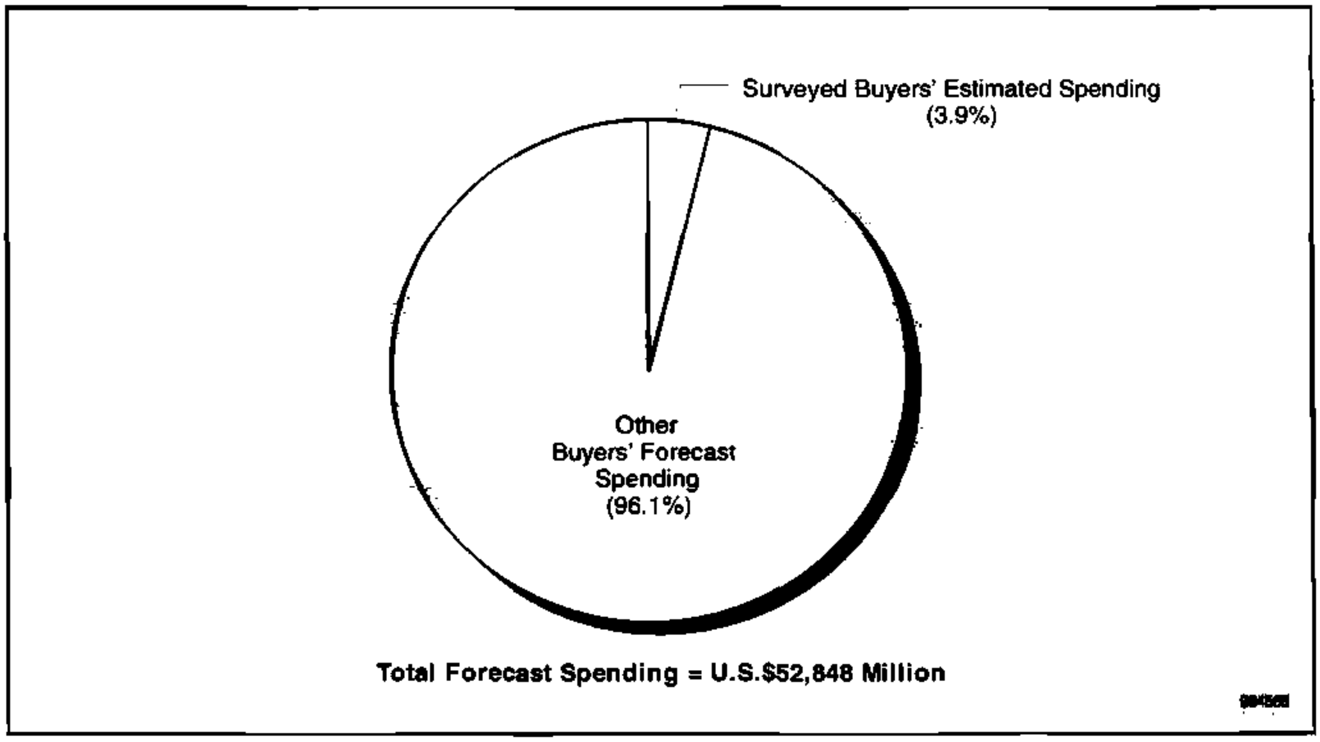
Survey Participants versus Total North American Market

Dataquest now wanted to see how the surveyed group compared to the overall North American semiconductor consumption market for the same time frame (1998).

Using information obtained from Dataquest's semiconductor applications market forecast, it is possible to compare the participants' semiconductor consumption with the total semiconductor consumption in the relevant market.

From Figure 4-2, it can be seen that the participants account for 3.9 percent of the total North American market.

Figure 4-2
Participants' Semiconductor Spending versus Total North American Consumption, 1998 Forecast



Source: Dataquest (July 1998)

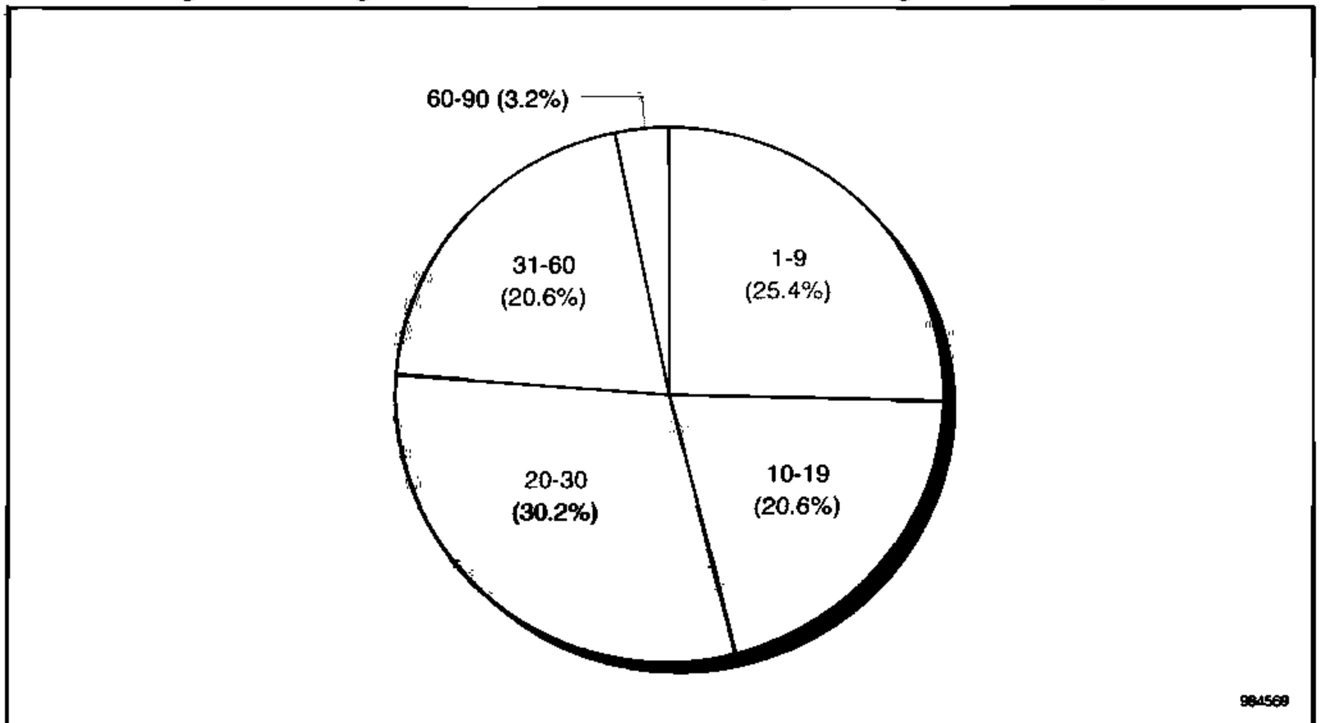
Targeted Inventory Holding

Dataquest next questioned the participants on semiconductor inventory holding levels. Buyers usually have a targeted inventory holding level that they aim to meet or beat. The reason is that capital tied up in needless inventory is capital wasted. Additionally, given current market conditions, with many semiconductor device families experiencing rapid price reductions, it makes sense to hold only the absolute minimum amount of inventory in-house.

Dataquest first asked buyers what their average inventory holding level (in days) was for semiconductors. Of the 103 participants, 63 responded, while 40 either refused to answer or did not know. Figure 4-3 shows the ranges of targeted semiconductor holding in days for those who responded.

From Figure 4-3, it is clear that most participants have very aggressive inventory holding targets. More than a quarter have inventory holding targets of less than 10 days, with just over 20 percent having their target in the range of 10 to 19 days and another 20 percent targeting 31 to 60 days. About 30 percent have a goal of inventory holding for 20 to 30 days. The balance have targets over 60 days.

Figure 4-3
Current Targeted Average Semiconductor Inventory Holding Level, in Days (N = 63)



Source: Dataquest (August 1998)

Semiconductor Inventory Holding: Actual versus Target

The next question concerned actual semiconductor inventory holding levels as compared to the buyers' respective target levels. A total of 83 participants responded to this question. Table 4-1 shows the responses received.

Table 4-1
Current versus Target: Semiconductor Inventory Levels (N = 83)

	Number of Responses	Percent (N = 83)
Actual Is Same as Target	29	35
Actual Is Higher than Target	43	52
Actual Is Lower than Target	11	13
Do Not Know/Refuse to Answer	20	-
Total	**103**	**100**

Source: Dataquest (July 1998)

About half the buyers surveyed reported actual inventory holding higher than their target. This result means either that their original targets are unrealistically high and should be revisited or that they need to work more aggressively with the appropriate suppliers to ensure that the excessive inventory holding situation is rectified.

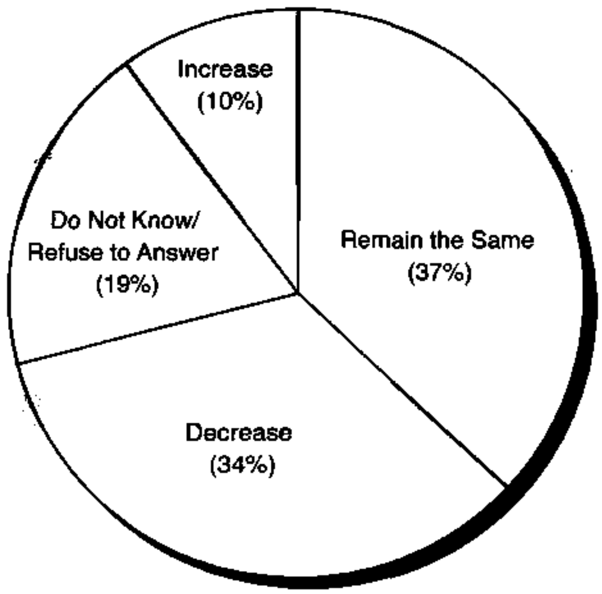
However, about the same percentage reported that their actual inventory holding level is at or below target; 35 percent stated that their actual semiconductor inventory holding is at the target, and 13 percent stated that their actual level was lower that their original target). Although this group should give themselves a well-deserved pat on the back, it is worth remembering that more work can still be done to further refine the inventory holding process and thus shave valuable time off the cost associated with storing the inventory in-house.

Future Semiconductor Inventory Holding Targets

Finally, in terms of inventory holding trends, Dataquest questioned the buyers in terms of their future inventory holding targets. The results of this exercise are shown in Figure 4-4.

A whopping 34 percent indicated that they expected their targeted semiconductor inventory holding levels to decrease in 1999. Likewise, just shy of 40 percent indicated that they expected their target for 1998 to hold true for 1999 as well. Only 10 percent indicated that an increase to their current semiconductor target inventory holding levels was likely. Buyers who responded that they did not know or refused to answer accounted for 19 percent.

Figure 4-4
Change to Targeted Inventory Holding Levels, 1999 (N = 103)



Source: Dataquest (August 1998)

Inventory Holding Trends: Comparison between 1997 and 1998

When Dataquest conducted its 1997 North American procurement user wants and needs survey (see the Dataquest report titled *1997 Semiconductor User Wants and Needs: They Want More!* [SSPS-WW-UW-9701], dated December 8, 1997), questions were asked about actual inventory holding, targets, and trends. Given that the size of the respondent base is almost exactly the same, we can compare some of the differences in replies between the two groups; see Table 4-2.

Table 4-2
Actual versus Targeted Inventory Holding, 1997 and 1998

	1997 Number of Respondents	1998 Number of Respondents
Same as Target	45	29
Higher than Target	41	43
Lower than Target	8	11
Do Not Know/Refuse to Answer	10	20
Total	**104**	**103**

Source: Dataquest (August 1998)

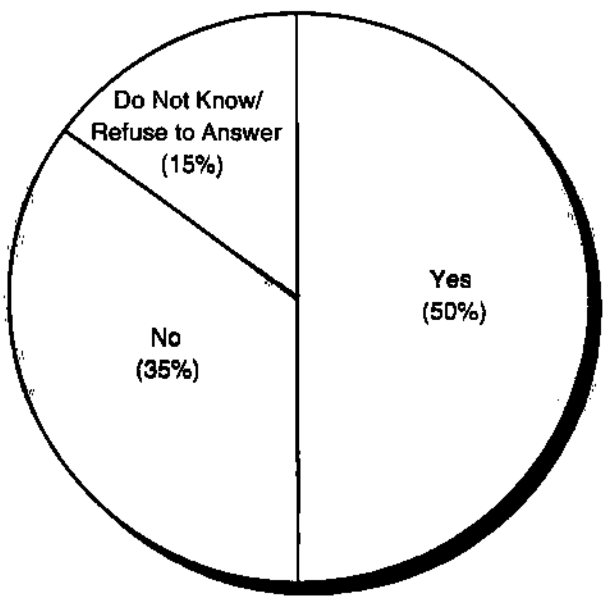
The main difference between the results obtained in 1997 and 1998 boils down to the increase in the "do not know/refuse to answer" category. Both years had similar numbers for the "higher than target" and "lower than target" categories. However, because of the 20 respondents in the undecided category, 1998 shows a lot fewer respondents whose actual inventory level is the same as target.

Total Cost of Ownership

For the past few years, TCO has been a hot topic in the purchasing community. It is widely reported on in the press, and many conferences have been held on the subject. However, Dataquest wanted to know whether all this smoke is coming from a real fire of TCO interest or instead from another, more dubious source.

From Figure 4-5, it is clear that the press heat associated with TCO has not translated into a flurry of interest among buyers and on through their reporting structure. Although half reported that they currently measure TCO, the other half either don't measure it or did not know/refused to answer. Apparently, the jury has not yet finished its deliberations. But at least we know that half the jurors have been converted over to TCO, while the rest remain on the fence.

Figure 4-5
Measurement of TCO (N = 103)



Source: Dataquest (August 1998)

Chapter 5

How Buyers Buy: Indirect Procurement Sourcing Channels

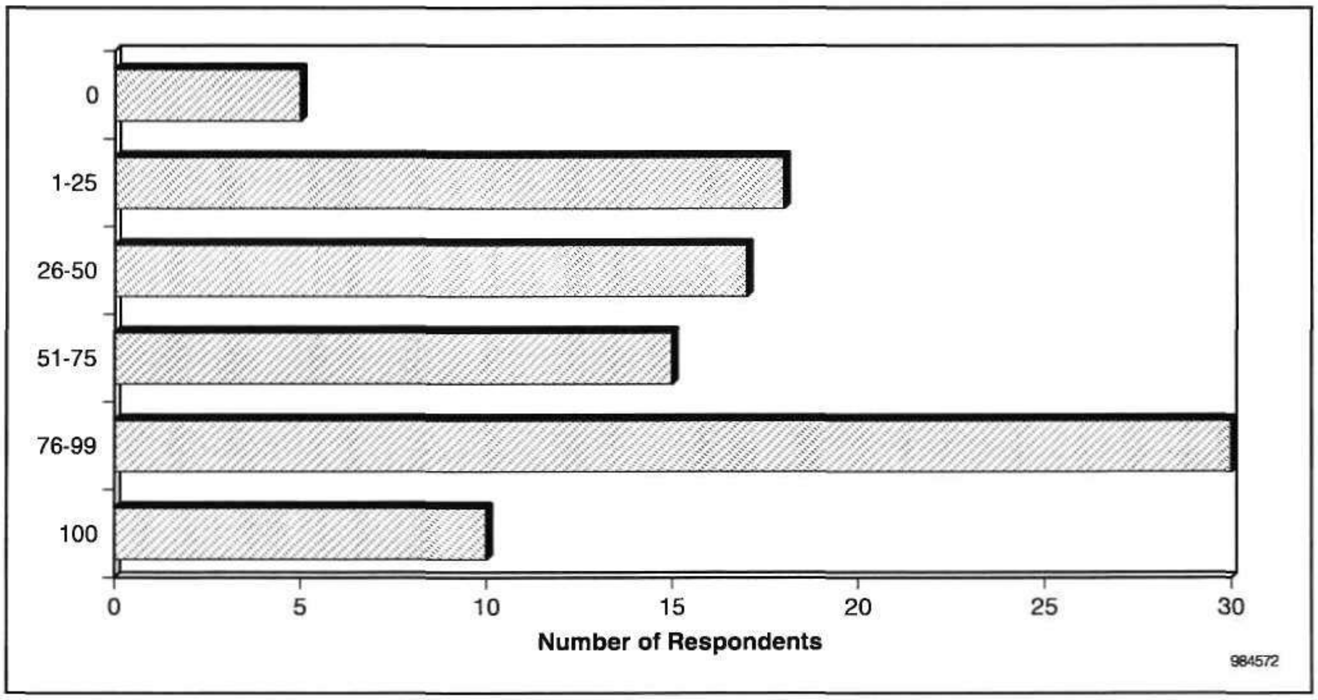
Generally speaking, buyers have two main choices when sourcing products. They can deal with the manufacturer of the semiconductor either directly or indirectly through an authorized or unauthorized agent. This chapter examines the trends in the indirect sourcing channel. Dataquest has split the indirect channel into two distinct groups: the distribution market and the spot or gray market.

Dataquest looked first at the distribution channel, to determine how many of the buyers surveyed use this channel, and second at the spot market.

The Role of Distribution

To establish the role of distribution among the buyers surveyed, Dataquest asked the participants to state what percentage of their semiconductor spending was sourced through the distribution channel. Figure 5-1 shows the results (eight of the 103 respondents did not know or refused to answer).

Figure 5-1
Percentage of Semiconductor Spending Sourced through the Distribution Channel (N = 95)



Source: Dataquest (August 1998)

Figure 5-1 shows that 42 percent of buyers surveyed sourced less than half of their semiconductors from the distribution channel. It also shows that 58 percent of buyers surveyed obtained more than half of their semiconductors from this channel.

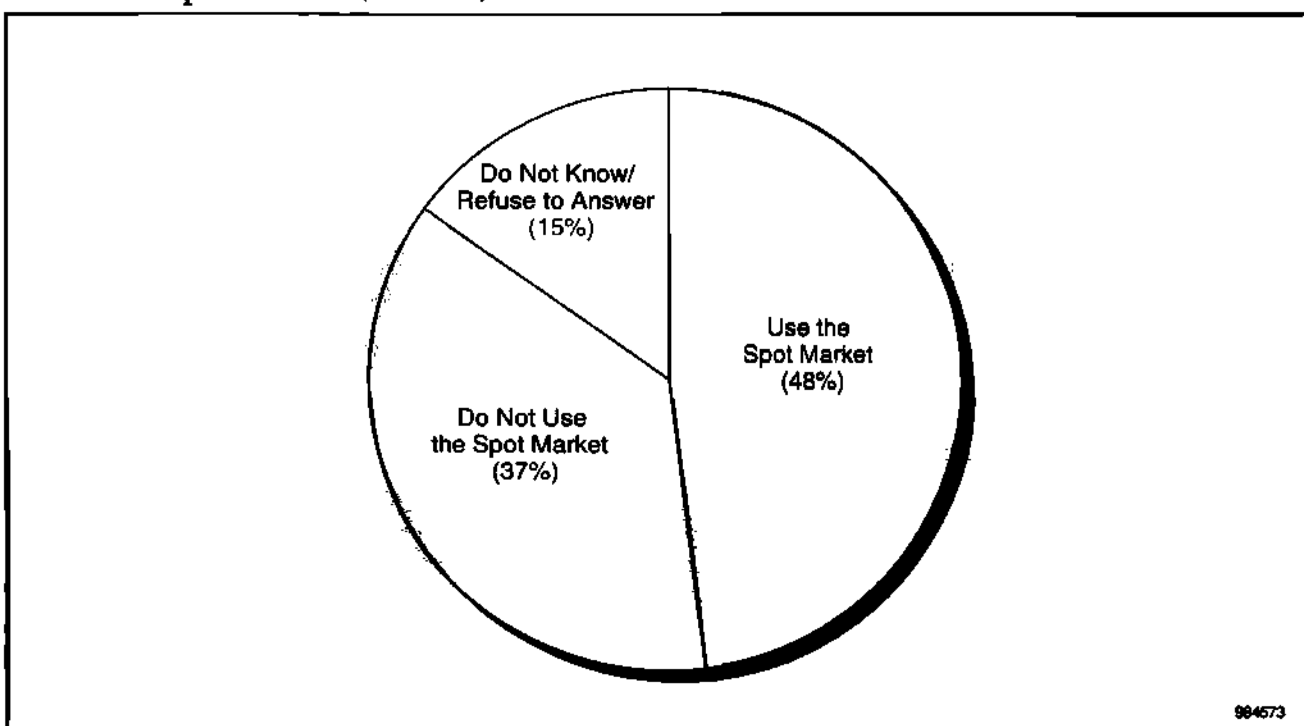
At either extreme of the curve are those buyers who either always use the distribution channel or never use the distribution channel for their semiconductor procurement needs. Those who never use the distribution channel numbered five (or 5.3 percent), while those who always use the distribution channel were 10.5 percent of the buyers surveyed.

Spot Market

The general oversupply of semiconductors and the resultant price slides of many large device families have intensified the discussions and interest in the spot market (also known as the gray or broker market). Dataquest's 1997 survey of semiconductor user wants and needs included the category of the spot market for the first time.

For the 1998 survey, Dataquest again wanted to determine whether the buyers surveyed use the spot market. Figure 5-2 shows the results for the group of buyers surveyed by Dataquest. Just under half of the buyers made use of the spot market, while the rest either did not use it or refused to answer.

Figure 5-2
Use of the Spot Market (N = 103)



Source: Dataquest (August 1998)

Strategy toward the Spot Market

It is all well and good to know whether the buyers use the spot market or not. However, Dataquest also wanted to know buyers' attitudes toward the spot market. In other words, what was buyers' strategy about using the spot market?

Table 5-1 sets out buyers' responses. Not surprisingly, the largest percentage of buyers are those who claim to use the spot market only when all other sources are unavailable, as a last resort. Less than a fifth use the spot market to procure a given percentage of their total requirements if the spot market is cheaper than their other sources. A minute group, 2 percent, use the spot market to source all requirements.

Table 5-1
Strategy toward the Spot Market (N = 50)

	Number of Respondents	Percentage
Use it only when I have to	35	70
If it is cheaper, buy a percent of the total requirement there	9	18
Buy all products in the spot market	2	4
Refuse to comment	4	8
Total	**50**	**100**

Source: Dataquest (August 1998)

Comparison of Spot Market Uses, 1997 to 1998

Table 5-2 compares the uses of the spot market from 1997 to 1998. In both 1997 and 1998, there has been a great deal of volatility in the whole semiconductor arena generally and the spot market specifically.

It is clear from Table 5-2 that although the majority of buyers surveyed in both years use the spot market as a last-stop shop, there has been a move toward a greater acceptance of the spot market by North American buyers.

Table 5-2
Comparison of Spot Market Uses, 1997 to 1998

	1997 Percentage of Respondents	1998 Percentage of Respondents
Use it only when I have to	90	70
If it is cheaper, buy a percentage of the total requirement there	5	18
Buy all products in the spot market	5	4
Refuse to comment	0	8
Total	**100**	**100**

Source: Dataquest (August 1998)

Whereas only 5 percent of the buyers surveyed bought a specific percentage of their total requirements in the spot market in 1997, this number rose to 18 percent in 1998—quite a jump! The percentage of buyers who use only the spot market as a sourcing channel has remained pretty much flat.

Semiconductor Device Families Procured from the Spot Market

The spot market sells a variety of different semiconductor devices. However, the majority of press space seems to cover only the DRAM dynamics within the spot market and largely overlooks the other semiconductor device families.

With this tendency in mind, Dataquest wanted to see what device families the surveyed buyers procured from the spot market. Dataquest asked the buyers to select which of a list of device families they bought from the spot market. The results are set out in Table 5-3.

Please note that buyers were asked to select as many device families as were applicable, so the percentages in Table 5-3 are independent of one another. Each row shows the percentage of the 50 respondents who buy or have bought that device family from the spot market.

The most popular device procured in the spot market for this group of buyers was DRAM, with 62 percent of the buyers sourcing this product in the spot market. This device was followed by SRAM (52 percent), EPROM (48 percent), PLDs (46 percent), MCUs (44 percent), and optoelectronics and MPUs (40 percent each). Flash memory ranked eighth (at 36 percent); DSPs (34 percent), EEPROM (26 percent), and others (16 percent) followed.

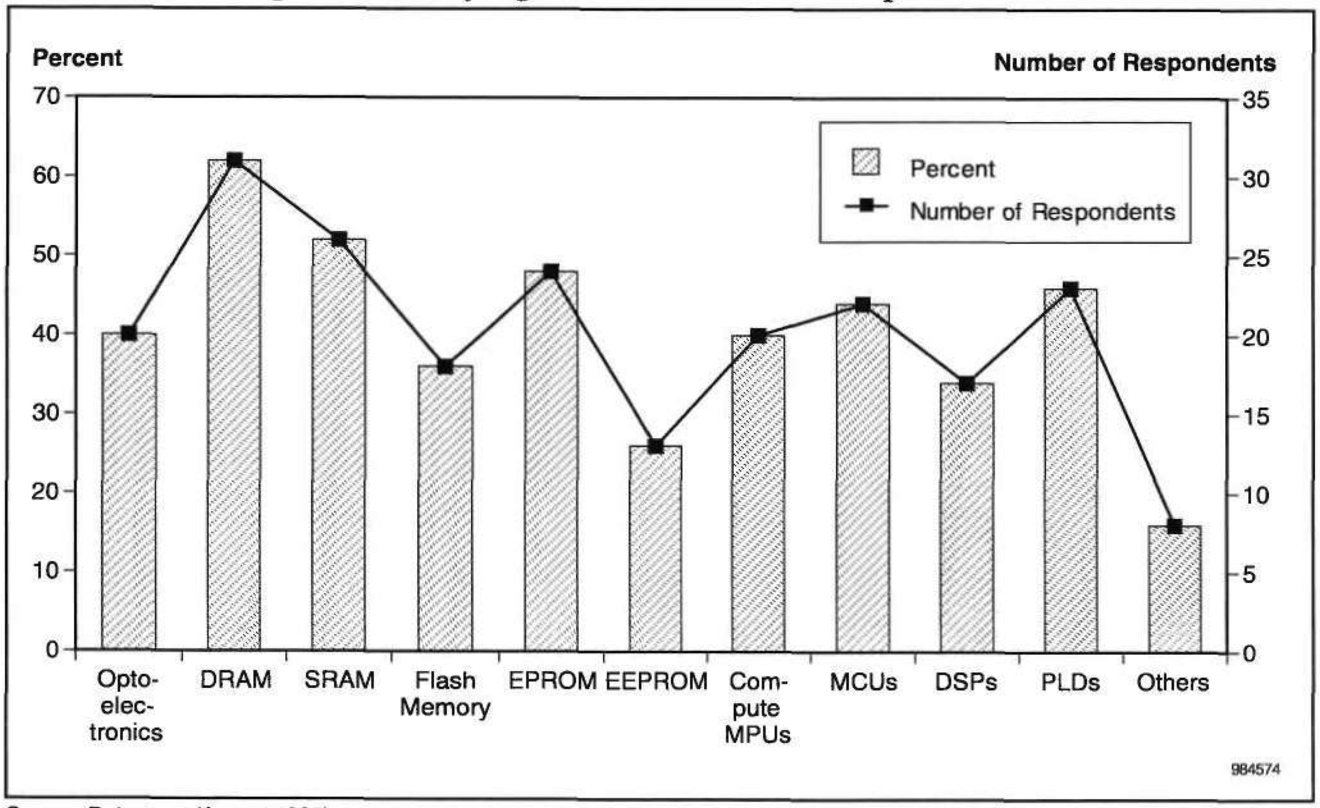
Figure 5-3 also shows the percentage of buyers procuring each of these device families from the spot market.

Table 5-3
Percentage of Respondents Buying Each Device Family from the Spot Market (N = 103)

	Number of Respondents	Percent
Optoelectronics	20	40
DRAM	31	62
SRAM	26	52
Flash Memory	18	36
EPROM	24	48
EEPROM	13	26
Compute MPUs	20	40
MCUs	22	44
DSPs	17	34
PLDs	23	46
Others	8	16

Source: Dataquest (August 1998)

Figure 5-3
Percentage of Respondents Buying Each Device from the Spot Market (N = 50)



Source: Dataquest (August 1998)

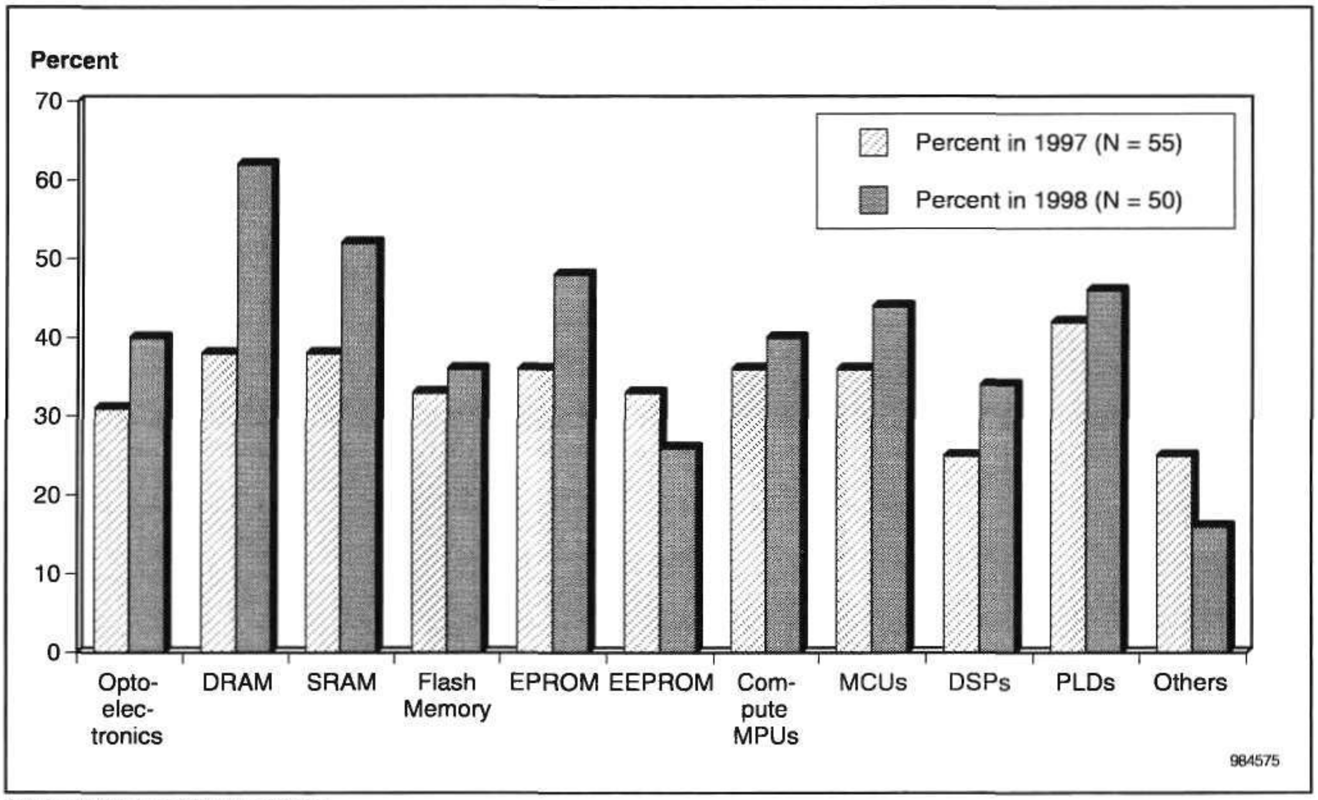
Comparison of Semiconductor Device Families Procured from the Spot Market, 1997 to 1998

As mentioned earlier, in Dataquest's 1997 report on semiconductor user wants and needs, buyers were also asked to state which device families they procured from the spot market. As an interesting comparison between both surveys, Figure 5-4 plots the percentage of buyers from each survey who were procuring the listed device families from the spot market.

Although PLDs were the most widely procured device family in 1997, the situation has changed in 1998. In 1998 DRAM has been the semiconductor family most widely sourced from the spot market.

Another interesting observation is that in 1998 the buyers surveyed procured many more different device families from the spot market than buyers did in 1997. This difference explains why the percentages purchased are higher in 1998 than in 1997.

Figure 5-4
Semiconductor Device Families Bought from the Spot Market, 1997 to 1998



Source: Dataquest (August 1998)

Chapter 6
Whom Buyers Deal with: Supply Base Analysis

Supply base size is something of great importance for buyers the world over. The secret to success for most buyers is striking a balance between maximizing the commercial benefits to their company while minimizing the number of suppliers used. That said, it is often difficult to keep the number of suppliers employed down to a minimum because of the variety of different device requirements and sourcing constraints associated with new or proprietary technology.

Additionally, when semiconductor devices are in oversupply, price normally drops in larger increments than usual, as suppliers try to outprice one another in the jostle for buyers' business. Likewise, buyers usually place less weight on supply base reduction when actual buy prices from suppliers vary greatly.

This chapter analyzes the supply base trends and strategic supplier trends for the participants surveyed in 1998. Where appropriate, comparisons are also made with the Dataquest's 1997 semiconductor user wants and needs survey.

Current Supply Base

Dataquest asked all survey participants how many vendors they currently use. Figure 6-1 plots the results obtained. From Figure 6-1 it is clear that well over 71 percent of the buyers who participated dealt with fewer than 40 vendors, while 29 percent dealt with 41 to 200 different vendors.

In fact, just shy of 30 percent dealt with 10 or fewer different vendors, while 40 percent deal with 11 to 40 different vendors; 16 percent did business with 41 to 100 different vendors. The remainder had a working commercial relationship with 101 to 200 vendors.

Changes from 1997

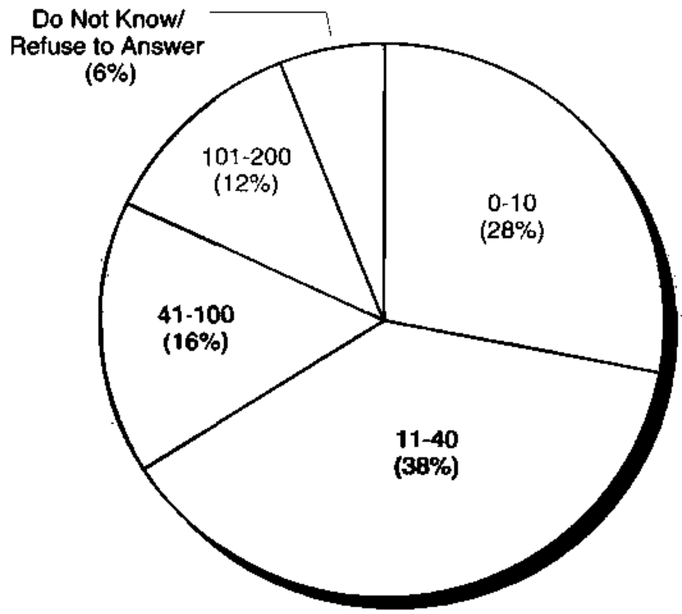
Dataquest next wanted to see how the current situation compared with last year's situation. Therefore, participants were asked whether their current supply base was greater than, less than, or equal to their supply base for 1997. The results are shown in Table 6-1.

About half the participants reported some form of change over the 12-month period, while the other half stated that their supply base size has remained constant.

Of those reporting some form of change, the vast majority stated that the change was a decrease in their supply base size. In total, 34 percent of respondents stated that their supply base size has decreased since 1997. Only 14 percent claimed to have increased their supplier base since last year.

Six participants (or 5 percent) did not know or refused to answer.

Figure 6-1
Number of Suppliers Used by Participants (N = 103)



Source: Dataquest (August 1998)

Table 6-1
Change in the Supply Base Size since 1997

	Number of Respondents	Percentage
Same	48	47
Increased	14	14
Decreased	35	34
Do Not Know/Refuse to Answer	6	5
Total	**103**	**100**

Source: Dataquest (August 1998)

Changes Expected in 1999

Having surveyed the current supplier situation and how it compares with last year's, Dataquest wanted to see how the supply base for 1999 will change compared to the surveyed buyers' current (1998) supply base size. Participants were asked how they expect their supply base to change in 1999 relative to their current (1998) supply base size. Table 6-2 shows the results.

Table 6-2
Expected Changes in the Supply Base Size in 1999

	Number of Respondents	Percentage
Same	47	46
Increased	9	9
Decreased	39	38
Do Not Know/Refuse to Answer	8	7
Total	**103**	**100**

Source: Dataquest (August 1998)

Like Table 6-1, Table 6-2 shows a fairly even split of respondents. About half claimed that they had no plans to change their supply base size in 1999, whereas the other half claimed to be planning some form of change.

Of those planning a change, a whopping 38 percent wanted to reduce their supply base size by this time next year. Only 9 percent were planning to increase their supply base size in the future. Seven percent did not know or refused to answer.

Strategic Suppliers

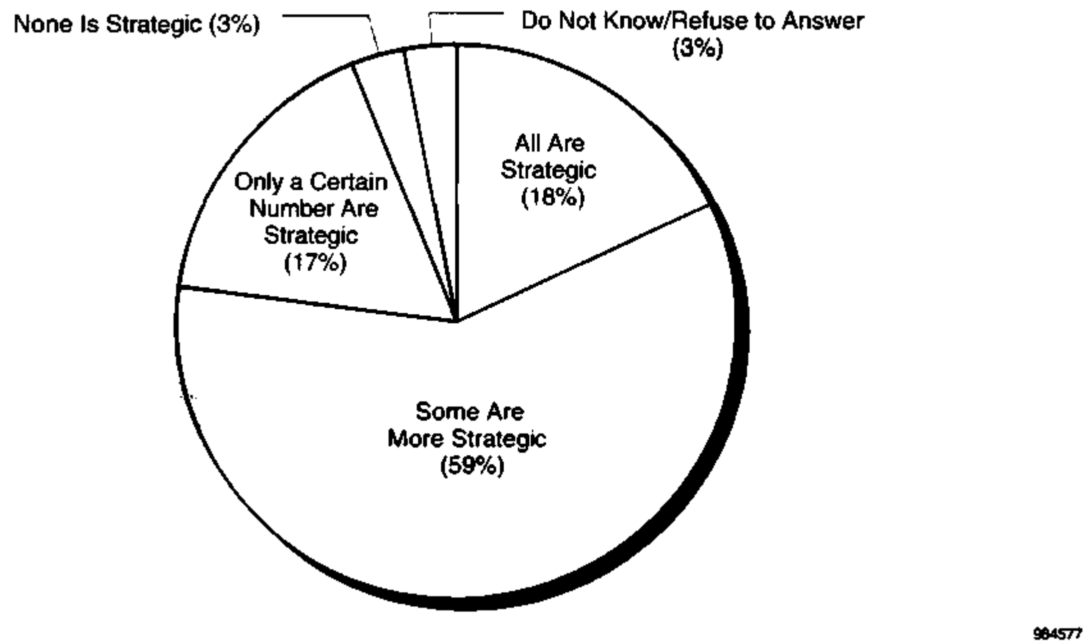
From the results shown in Figure 6-1, it is clear that all of Dataquest's participants deal with two or more suppliers. But how do the respondents treat their suppliers? Do they treat them all the same or do they discriminate and treat some very differently from others?

Dataquest wanted to see whether the respondents practiced some form of supplier discrimination or strategic importance classification. Instead of asking a straight, closed-ended question, which would have solicited only a yes or no response, Dataquest gave the buyers surveyed the chance to pick a phrase that best summed up their supplier strategy. The results of the survey are shown in Figure 6-2.

Just shy of one-fifth of all buyers claimed to treat all suppliers the same: All suppliers were considered strategic to the buyer and its organization. On the other extreme of the spectrum, 3 percent of participants claimed that no suppliers were strategic. One has to wonder about these buyers: Can they possibly believe that they don't need any suppliers to survive?

Dataquest offered two options to those participants who have chosen to designate some portion of their supply base as strategic at the expense of other suppliers. The phrases employed were "Only a certain number are strategic" and "Some are more strategic than others." Essentially the meaning of both phrases is identical: The difference was more in tone than in meaning. Grouping both phrases together, a whopping 78 percent of respondents admitted to deeming a portion of their supplier base strategic.

Figure 6-2
Strategic Suppliers versus Regular Suppliers (N = 103)



Source: Dataquest (August 1998)

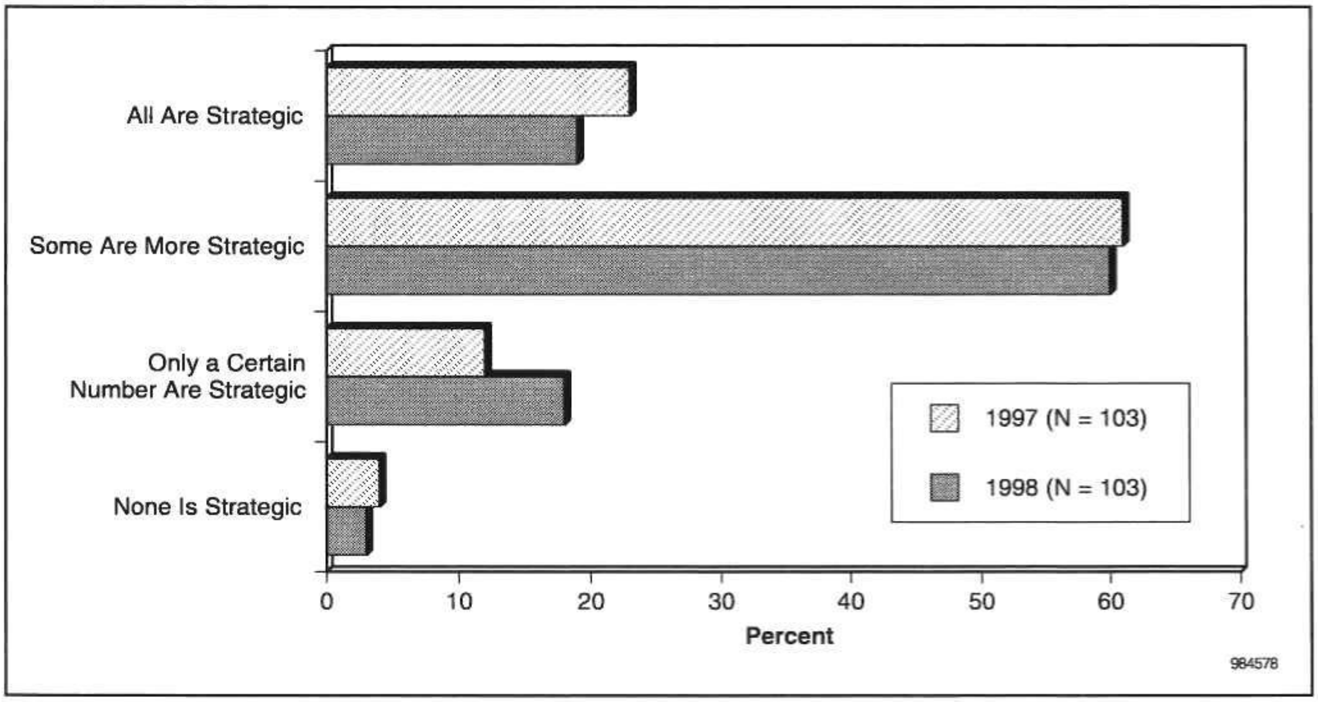
Comparison of Strategic Suppliers, 1997 and 1998

When Dataquest conducted its 1997 semiconductor user wants and needs survey, participants were asked the same question about whether they considered some suppliers strategic (as in Figure 6-2). Dataquest has graphed both sets of results and plotted them for comparison purposes in Figure 6-3.

Figure 6-3 shows that there are many similarities between the results obtained from the two different groups surveyed by Dataquest over the 12-month period. In both cases, nearly identical results were obtained for two phrases: 4 percent of buyers in 1997, versus 3 percent in 1998, said that "none is strategic"; 61 percent of buyers in 1997, versus 60 percent in 1998, said that "some are more strategic than others."

There was a greater difference reported on the other two phrases. The number of respondents who claimed that all suppliers were strategic has fallen from 23 percent in 1997 to 19 percent in 1998. By contrast, those reporting only a certain number as strategic has risen from 12 percent in 1997 to 18 percent in 1998.

Figure 6-3
Strategic Suppliers, 1997 and 1998



Source: Dataquest (August 1998)

Chapter 7

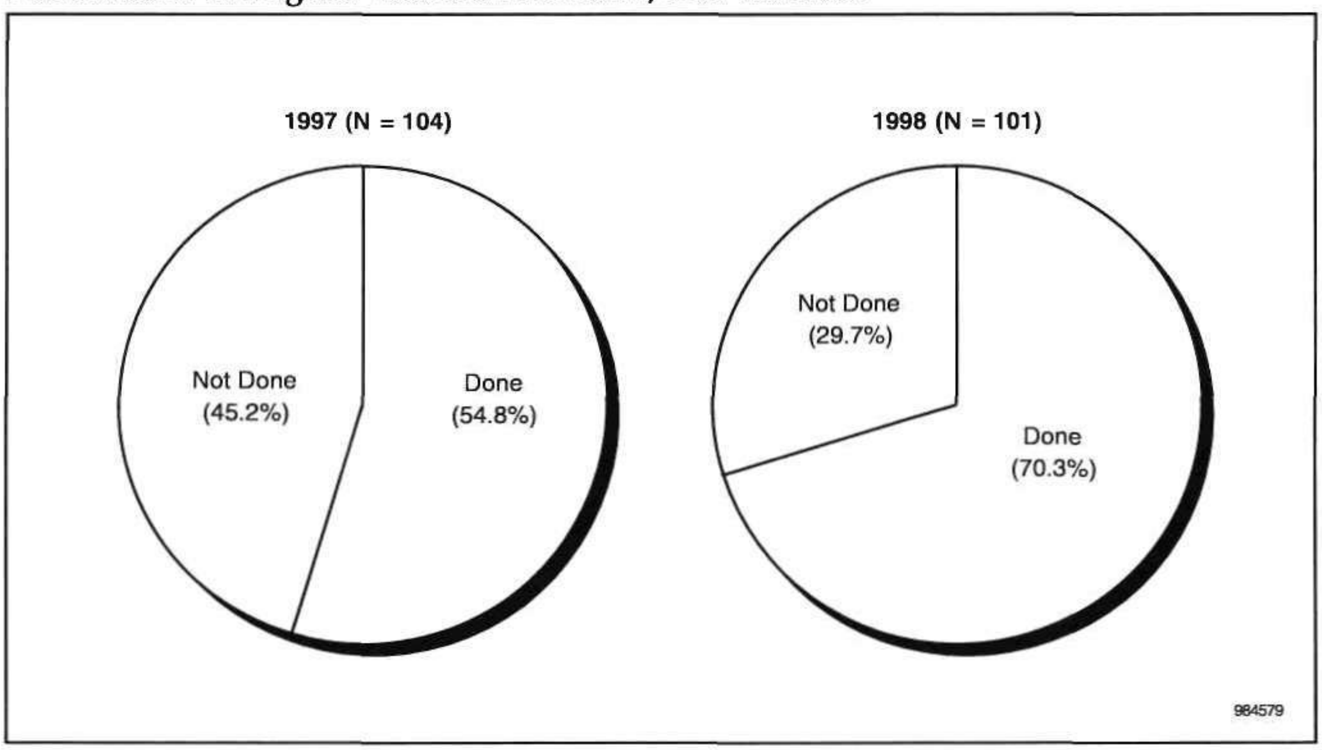
Are Vendor-of-Choice Programs Going the Way of the Dinosaur?

Among the most far-reaching changes over the past five years or so impacting suppliers of all products are vendor-of-choice (VoC) or similar programs. VoC programs involve a regular review of supplier compliance with agreed-on goals as part of efforts to improve supplier performance. The concepts of strategic vendors, vendor reduction, and TCO all involve VoC and are all dependent on a formal VoC program in one form or another.

Do They or Don't They?

Dataquest wanted to see what percentage of the surveyed buyers actually conduct formalized, regular vendor measurement, and whether that percentage has changed since our last survey. In other words, Dataquest sought to discover whether buyers had changed their outlook on vendor-of-choice programs. As shown in Figure 7-1, more than half (55 percent) of the respondents performed regular vendor reviews in 1997, and in 1998 more than 70 percent of respondents had vendor evaluation programs in place, a significant increase. This type of response continues to highlight both the importance of this type of procurement practice and the opportunity it offers. Vendor evaluation programs are important in that many semiconductor suppliers are now being regularly reviewed for improvement on a variety of sourcing variables. Such programs present an opportunity for users to lower total costs by beginning or maintaining some sort of VoC program.

Figure 7-1
Performance of Regular Vendor Evaluation, 1997 and 1998



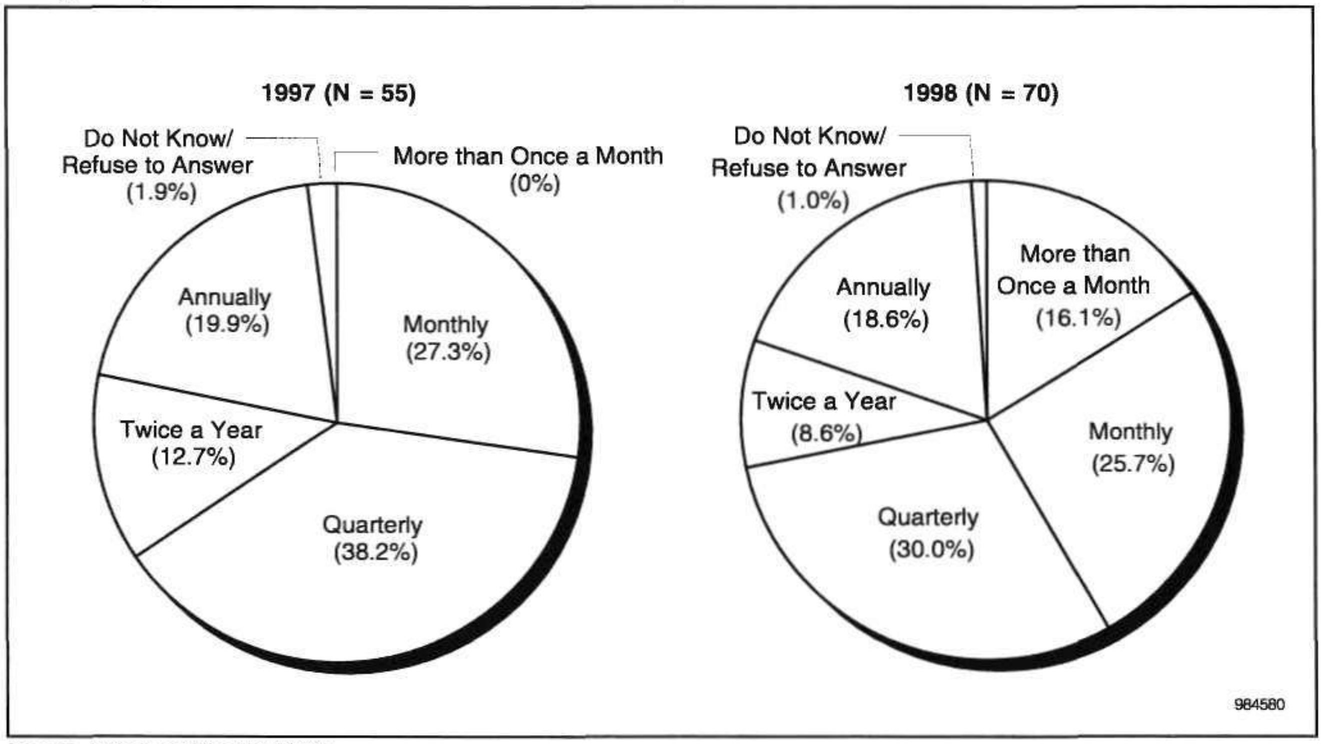
Source: Dataquest (August 1998)

Frequency of VoC

The frequency of vendor review often is cited as a critical part of the overall review process. Reviews that are too frequent are too time-consuming in relation to the benefits gained; those that are not regular enough can be so infrequent that they do not reveal any meaningful improvement. Each company needs to determine the frequency of vendor review that will provide the most cost-effective improvement schedule for both suppliers and the company itself. Thus, Dataquest wanted to see what the frequency distribution was for the surveyed buyers currently and how that frequency had changed.

Figure 7-2 shows that a quarterly schedule for reviews remained the most popular frequency for those respondents that perform reviews, characterizing close to one-third (30.0 percent) of the sample. The next most popular frequency continued to be monthly, with more than one-quarter of the sample (25.7 percent) following this rigorous schedule. A little over 25 percent (27.2 percent) of those that review their supplier base do so every six months or annually; these companies either have very good relations with their suppliers or are in relatively stable markets that do not require frequent performance reviews. What was different from last year's survey was the relatively high percentage (16.1 percent) of the respondents that conducted supplier reviews more than once a month. This practice of ultrafrequent reviews is now required by some companies in fast-changing markets where rapid supplier support is needed.

Figure 7-2
Frequency of Performance Evaluation (N = 70)



Source: Dataquest (August 1998)

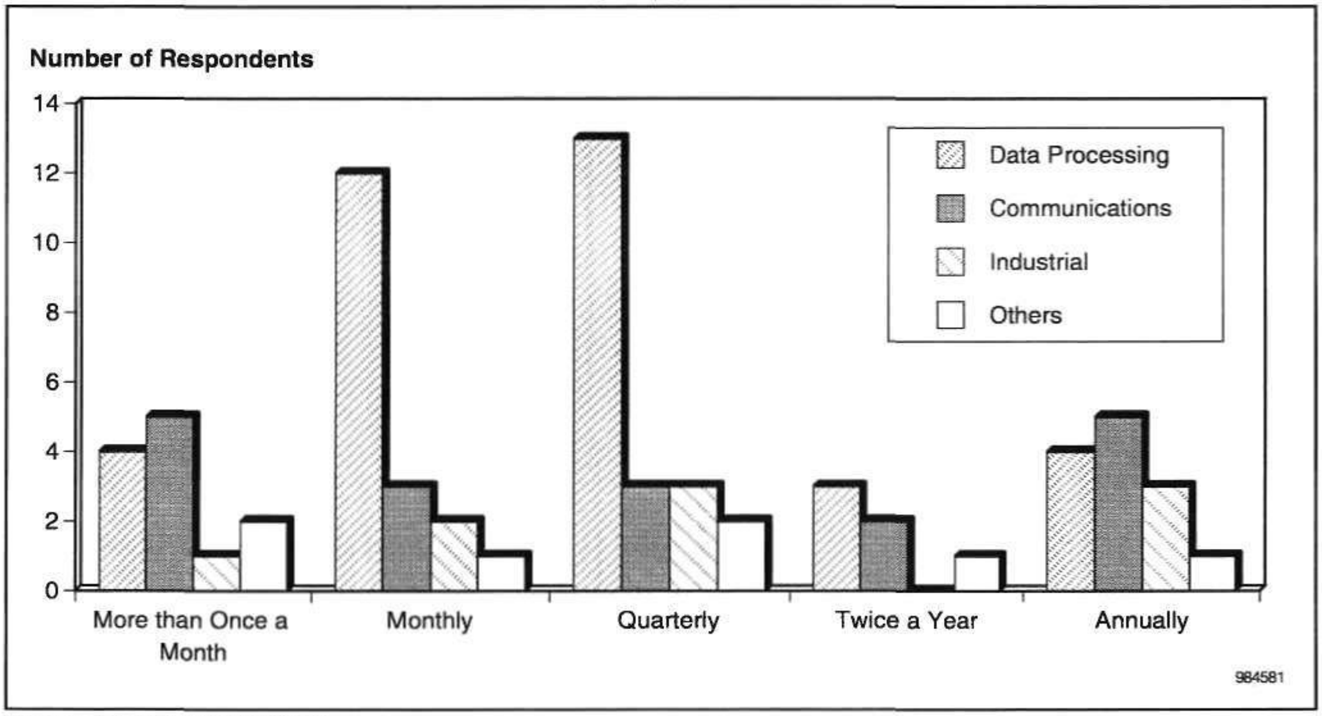
In 1997, reviews were conducted quarterly or more frequently by 65.6 percent of respondents; in 1998, 71.8 percent of respondents were on this schedule. This significant shift to more frequent reviews strongly highlights the need for good communications between both suppliers and the internal sourcing (design, test, procurement) groups within a user company. It also highlights one way in which current uncertain market conditions have directly affected business practices.

It was interesting to note that respondents were evenly split over which suppliers they reviewed. Emphasizing the need for each company to determine what is cost-effective, less than half (43.5 percent) of the respondents that performed reviews evaluated only strategic suppliers, while more than half (56.5 percent) reviewed all suppliers. This finding compares with last year's response indicating a 50-50 split between sharing information with all suppliers and sharing information only with strategic suppliers.

Frequency by Application

Figure 7-3 highlights how the volatility of the data processing market influences the frequency of supplier reviews. A solid 64 percent of companies with monthly or quarterly reviews come from this very competitive market. After that spike in review frequency, the rest of the sample is relatively equal across applications in the timing of review periods.

Figure 7-3
Frequency of Performance Evaluation by Application (N = 70)



Source: Dataquest (August 1998)

Suppliers That Are Tracked

As was the case last year, the vast majority (93 percent) of buyers use both strategic and nonstrategic vendors. Of those, a strong majority of 70.3 percent also regularly conducted a VoC program. Dataquest then asked this 70 percent to indicate which vendors these buyers evaluated on performance. Table 7-1 shows the results.

It can be seen that the overall level of vendor evaluations rose since last year, with more than half (56.5 percent) of respondents now evaluating their total vendor base, compared with 49 percent last year. It is also encouraging to see that the number of buyers responding that they did not know or refused to answer has gone down to zero in 1998.

Management's View

Although VoC programs are critical to those directly involved, they are sometimes given only lip service by the rest of management within a participating company. We again asked the sample whether their VoC program was a priority for the nonpurchasing management of their companies. Figure 7-4 shows that, for most, the rest of management is either actively (37.7 percent) or partly (23.2 percent) involved, while one-fifth (20.2 percent) of the respondents still had no outside management involvement in this critical area. Although it is encouraging that more than 75 percent of the sample saw management outside of purchasing take VoC programs as some sort of a priority, it is still disconcerting that 20 percent of companies that have VoC programs do not have buy-in from management outside of purchasing. It is also problematic that the overall percentage of active or passive management involvement has declined since our last survey. This result may be a sign that some managers don't see the direct impact of VoC programs on their organization.

VoC Priority by Application

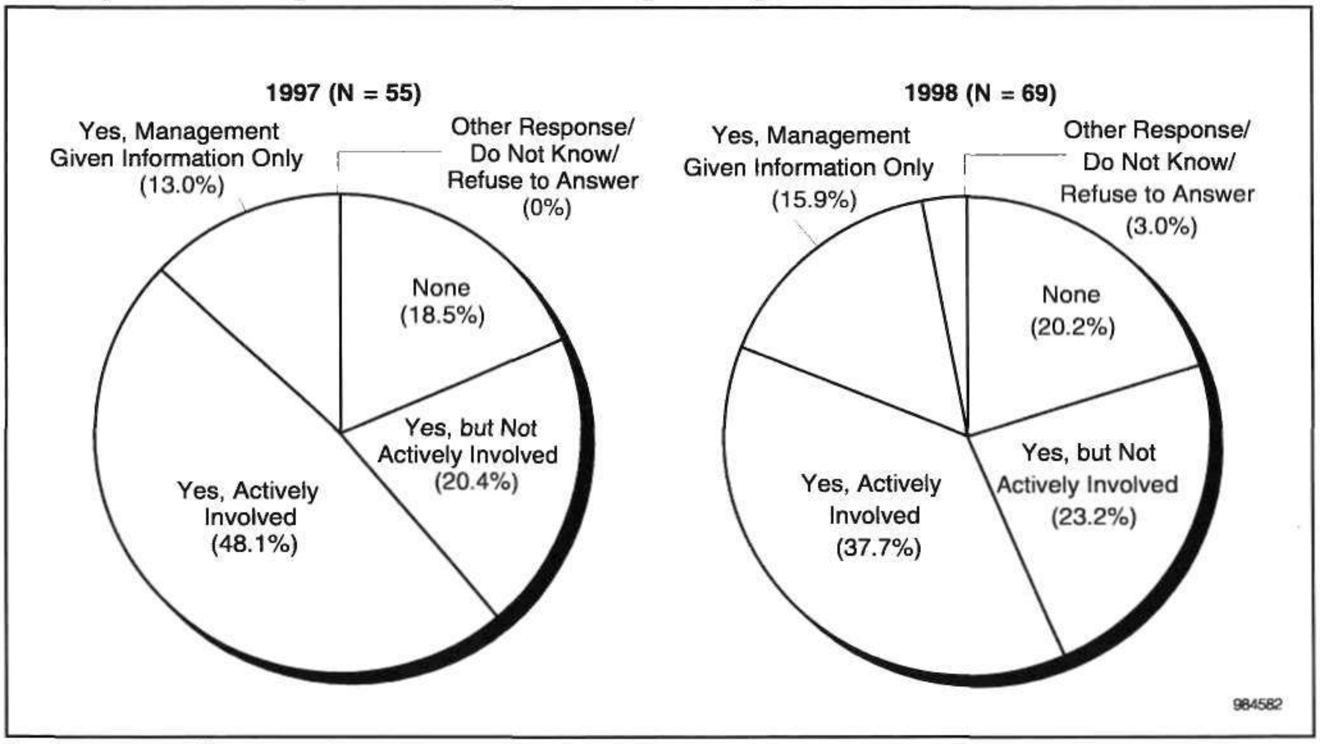
Figure 7-5 illustrates that the aggregate data is roughly supported by all the applications polled in our recent survey. Although the overall average of actively involved nonpurchasing management was 23.2 percent, the level for the communication respondents was 44 percent. For the predominant data processing application, 37 percent of respondents stated that outside management was actively involved with VoC activity, the same level as the overall group average.

Table 7-1
Vendors Evaluated Regularly

	Number of Respondents 1997	Number of Respondents 1998	Percentage 1997	Percentage 1998
All Vendors	28	39	49	56.5
Only Strategic Vendors	28	30	49	43.5
Do Not Know/Refuse	1	0	2	0

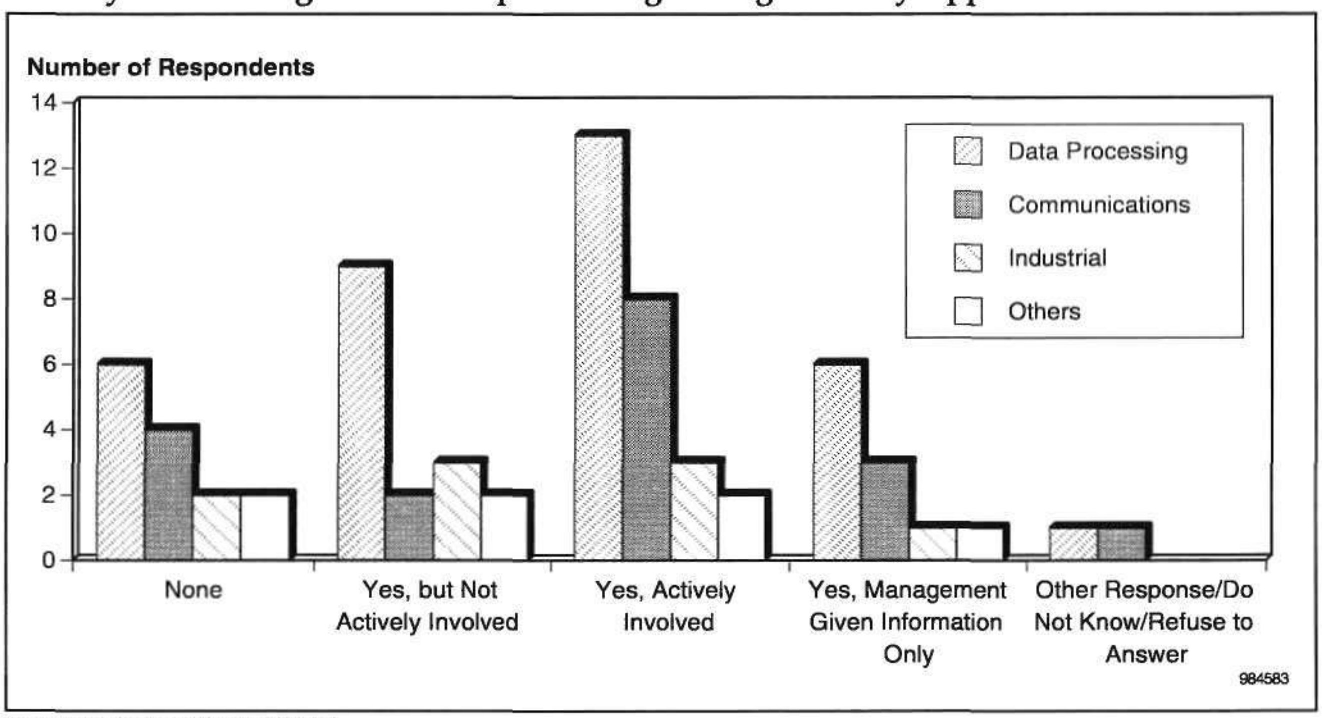
Source: Dataquest (August 1998)

Figure 7-4
Priority of VoC Program for Nonpurchasing Management



Source: Dataquest (August 1998)

Figure 7-5
Priority of VoC Program for Nonpurchasing Management by Application



Source: Dataquest (August 1998)

Chapter 8
What Matters: Importance versus Satisfaction

There are many factors that create a good working relationship between the buyer and the seller, and the vendors' ability to perform what's needed by their customers when it matters is crucial. However, it is often difficult for vendors to assess how they're doing and which of many issues matters most to their customers (the buyers). This chapter attempts to gauge the importance to buyers of key procurement issues and to measure their satisfaction levels.

For ease of analysis, this chapter has been broken into seven subsections. Each subsection covers a key purchasing topic, and the survey participants were asked to rate importance and satisfaction levels for a list of related criteria. The seven subsections are: delivery issues, quality issues, responsiveness issues, technical support issues, flexibility issues, total cost of ownership issues, and price issues.

The participating buyers were asked to rate the importance of a criterion and also how satisfied they were with their vendors on that criterion. The scale of measurement was 1 to 5, with 1 being the least important or least satisfied and 5 being the most important or most satisfied. All 103 survey participants responded, and their mean score is plotted.

Delivery Issues

Delivery issues were examined in terms of three issues: logistics, lead times, and on-time delivery. The mean scores for each of these is plotted in Figure 8-1.

As can be seen in Figure 8-1, on-time delivery was ranked the most important of the three criteria, receiving a mean score of 4.80 for importance. That criterion also has the highest buyer satisfaction rating, at 3.75. That said, however, on-time delivery did have the highest importance versus satisfaction delta of the three criteria, meaning that suppliers still have some work to do to match buyers' expectations.

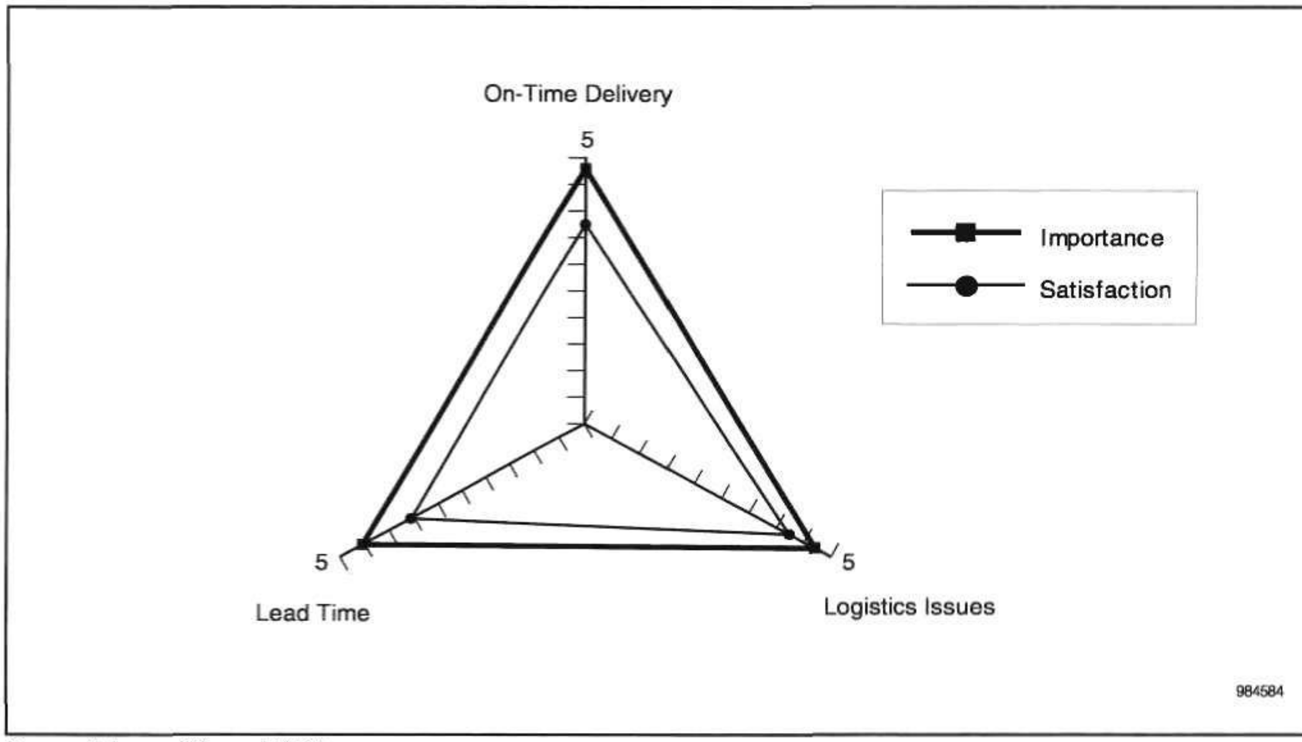
The next most important criterion of the three was lead time. This issue attained a buyer importance ranking of 4.54, but a satisfaction rating of only 3.56. Logistics issues had a mean buyer importance ranking of 4.20 and a mean satisfaction ranking of 3.73; thus, if deltas alone are examined, this criterion had the lowest difference between buyer importance and satisfaction.

Quality Issues

Dataquest divided quality issues into three parts—namely product reliability, system integration, and environmental issues. The mean results of respondents' rankings are shown in Figure 8-2.

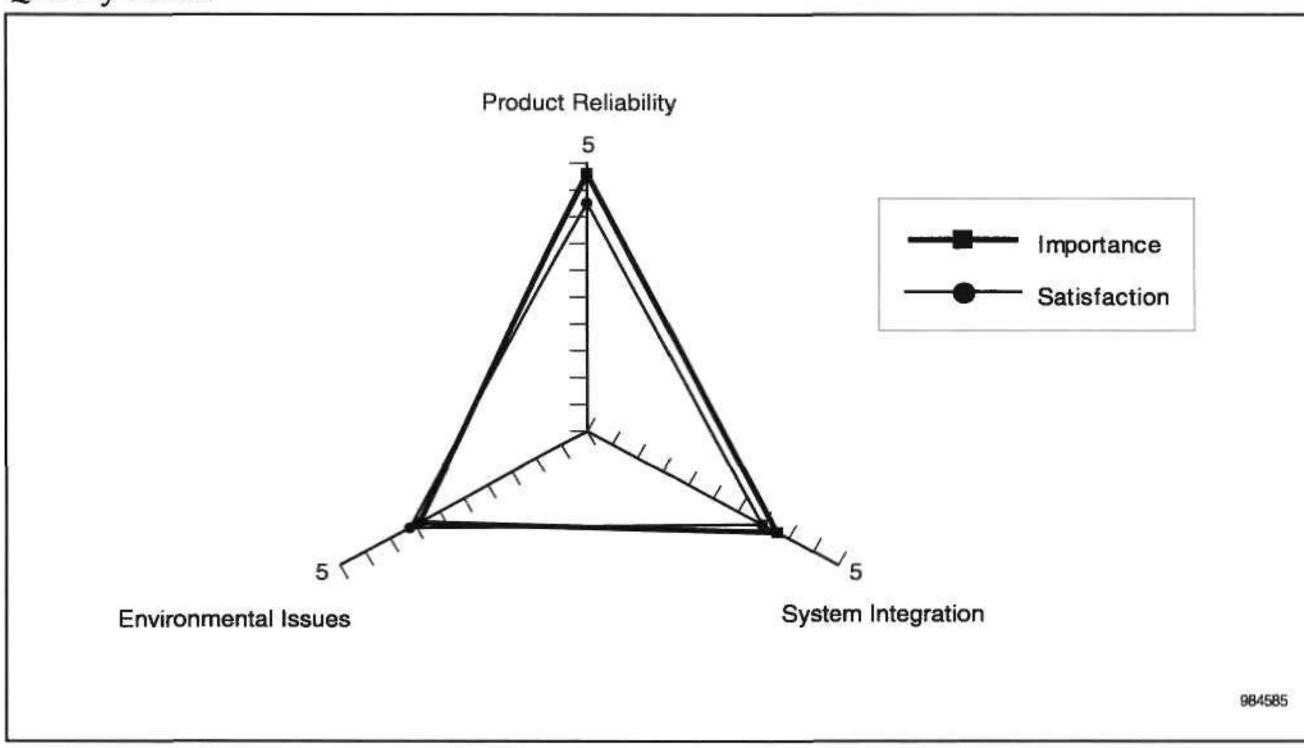
From the results in Figure 8-2, it appears clearly that the most important of the three factors to the surveyed buyers was reliability. This factor attained a mean score of 4.81 for importance and a corresponding mean score of 4.26 for buyer satisfaction.

Figure 8-1
Delivery Issues



Source: Dataquest (August 1998)

Figure 8-2
Quality Issues



Source: Dataquest (August 1998)

System integration was the next most important characteristic, scoring 3.77 for buyer importance and 3.47 for buyer satisfaction. This factor is far behind reliability for both importance and satisfaction. In third place for importance came environmental issues, at 3.42 for importance to the surveyed buyers. This criterion, however, was the only one of the three on which suppliers surpassed themselves, with the criterion scoring higher in buyer satisfaction (3.61) than in buyer importance (3.42).

Responsiveness Issues

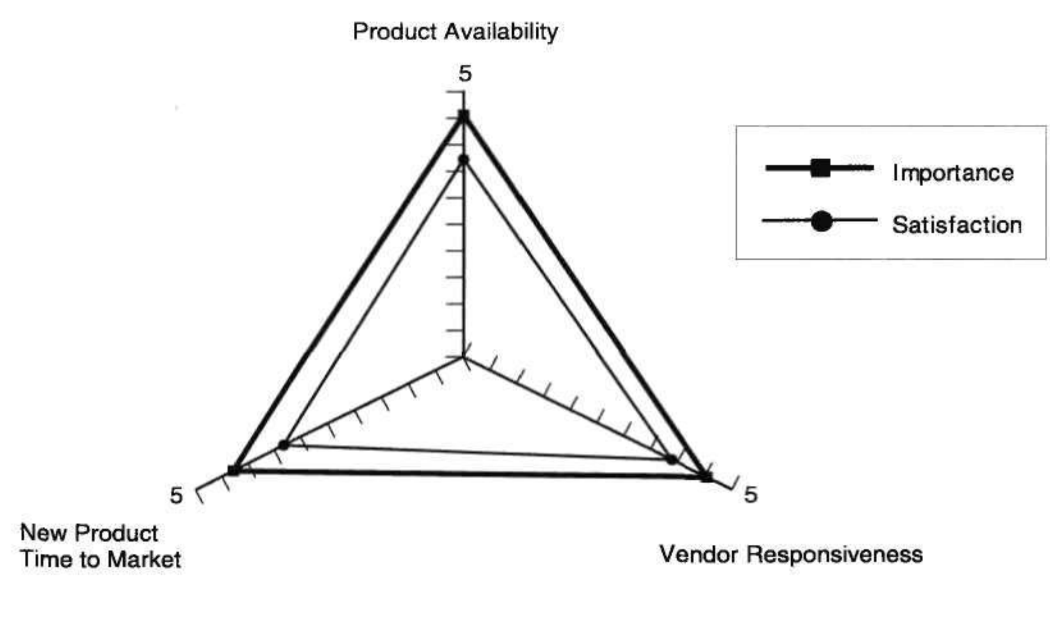
Responsiveness issues comprised product availability, vendor responsiveness, and the speed at which new products are brought to market. Once again, Dataquest calculated the mean scores, and the results are plotted in Figure 8-3.

This should be the area where suppliers continually wow their customers (the buyers), as it is an area over which suppliers have total control. However, let's see how the buyers rated their suppliers' performance.

All three subsections within responsiveness ranked above 4 for importance, with availability of product getting 4.56 out of 5, vendor responsiveness 4.54 out of 5, and speed at bringing new products to market 4.28 out of 5.

However, scores of satisfaction level were considerably lower. None of the mean scores was above 4, and all the buyers surveyed reported dissatisfaction with their vendors' actual performance versus buyers' expectations. Vendors: Wake up, smell that coffee, and get working!

Figure 8-3
Responsiveness Issues



Source: Dataquest (August 1998)

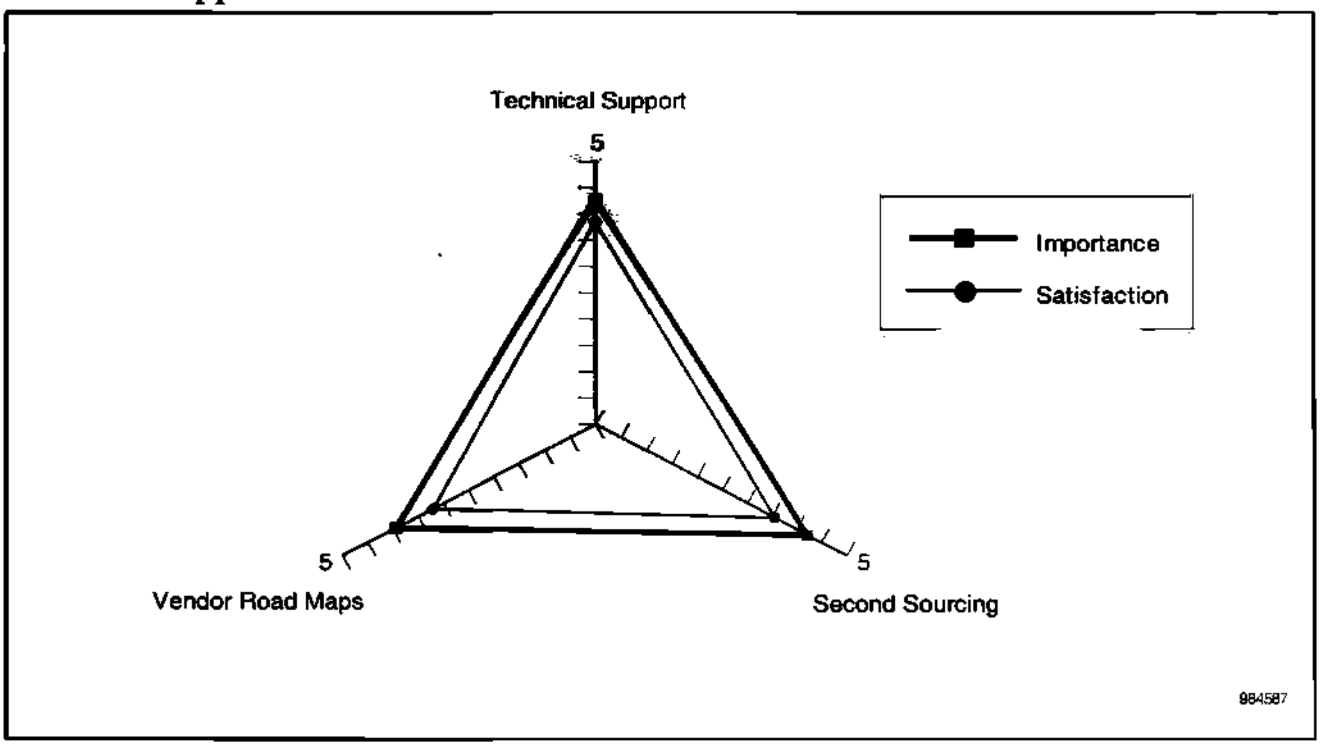
Technical Support Issues

This set of issues was made up of three parts: vendor product changes (or road maps), technical support, and second-sourcing issues. The mean scores have been plotted in Figure 8-4.

Of the three, technical support was the most important, with second-sourcing coming in a close second. Managing supplier road map/product changes was the least important of the three. And, in terms of satisfaction, the results were the same. Buyers were most satisfied with their supplier technical support, then with second-sourcing, and lastly with road map issues.

At least these results indicate that both buyers and suppliers are singing from the same prioritization hymnal, but the suppliers are still singing slightly off-key to the buyers' ears. Let's hope both groups reach a higher level of harmony soon.

Figure 8-4
Technical Support Issues



Source: Dataquest (August 1998)

Flexibility Issues

Dataquest broke flexibility issues into three separate criteria: vendor flexibility, managing the price variation among different vendors, and long-term agreements or partnerships. The mean scores for each are plotted in Figure 8-5.

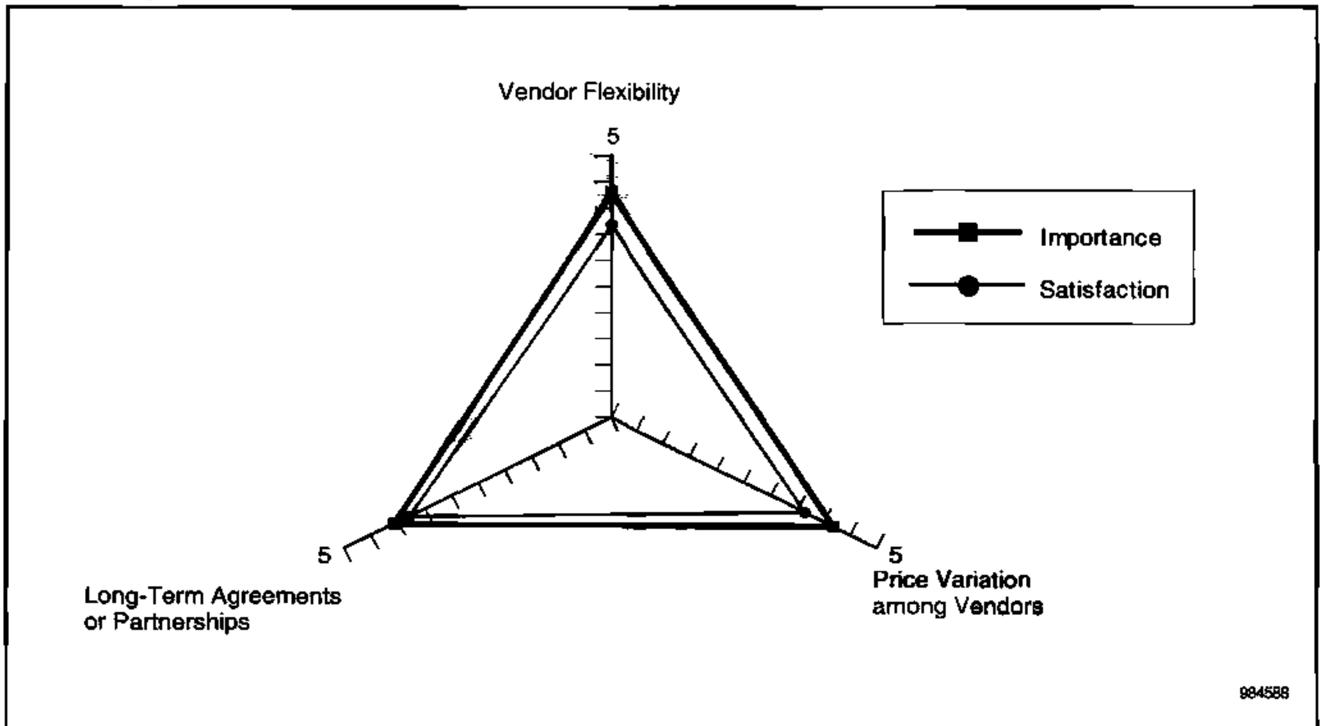
Of the three subsections under flexibility issues, Figure 8-5 shows clearly that vendor flexibility itself was most important to the buyers surveyed. That criterion attained a mean buyer importance ranking of 4.30. By contrast, the buyer satisfaction ranking against this criterion was only 3.68.

It is always a tricky business for buyers to manage the price variations for a given semiconductor device when it is bought from a multiple of different vendors. Not surprisingly, buyers ranked this criterion as 4.17 in importance but only 3.63 (the lowest of the three) in satisfaction.

The criterion of long-term partnerships or agreements was the least important to buyers at the moment, receiving a mean buyer importance ranking of 4.07. However, the satisfaction ranking for this criterion was 3.79, giving this criterion the lowest importance/satisfaction delta of the three.

The results for the issue of long-term partnerships or agreements are not very surprising. In times of excellent semiconductor availability, buyers are less preoccupied with long-term contracts and commercial agreements. By contrast, in times of oversupply, suppliers are only too willing to tout the trumpet of long-term cooperation.

Figure 8-5
Flexibility Issues



Source: Dataquest (August 1998)

Total Cost of Ownership Issues

The three subsections that make up TCO are TCO itself, inventory control, and vendor base reduction. The mean scores for this section are plotted below in Figure 8-6.

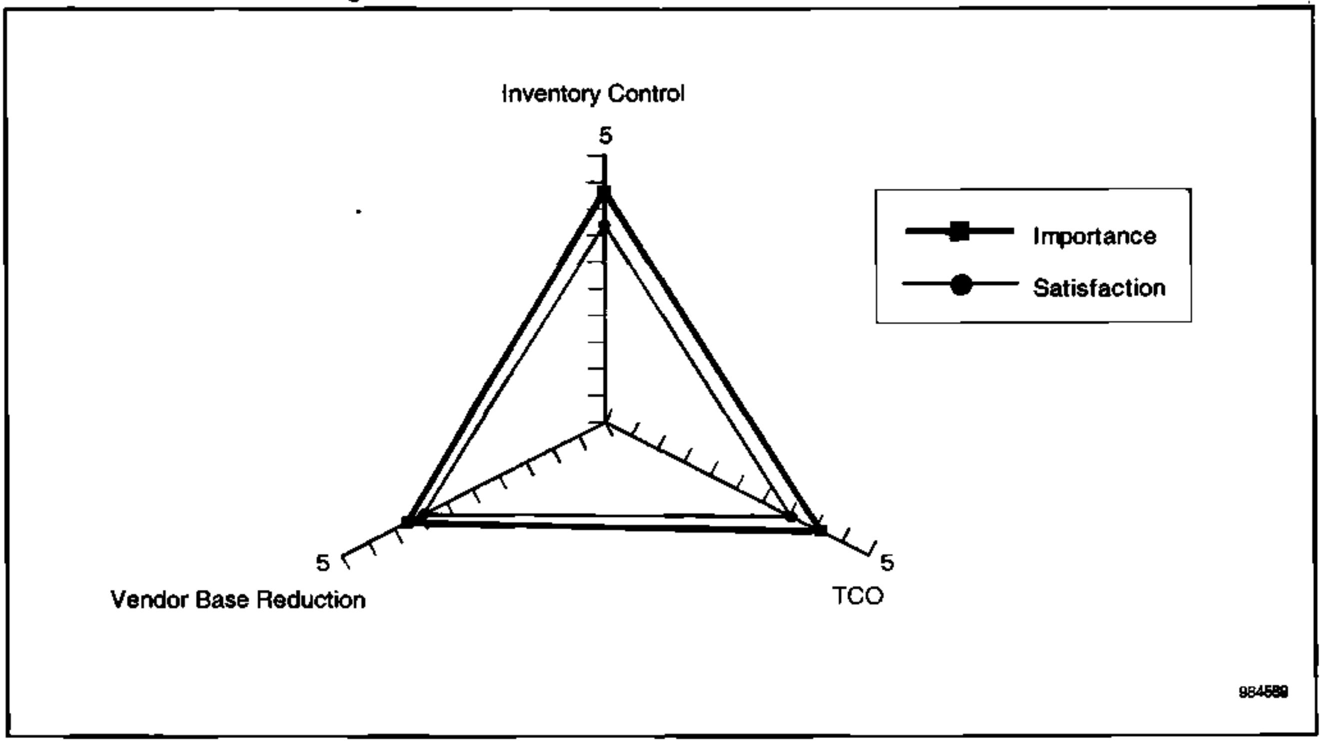
From Figure 8-6, it can be seen that inventory control was the most important of these issues to buyers (with a mean score of 4.33) and also had the highest satisfaction rating at 3.70. Next came TCO itself, with a mean score of 4.10. TCO also came in second place for satisfaction, its mean score being 3.54.

Of the three TCO issues, vendor base reduction was of least importance to buyers. It received a mean score of just 3.76 and a mean satisfaction ranking of 3.45.

On first glance, this result may seem strange. However, given the level of semiconductor capacity oversupply, there is currently little emphasis on reducing the number of suppliers. Far more important to buyers in times of oversupply is "supplier sparring"—that is, playing one vendor off against another in order to achieve the best overall result. Thus, factors like reducing lead-time and minimizing total cost of ownership are far more important to buyers.

When the days of milk and honey end and the grim reality of undersupply returns, buyers will be in a weaker negotiating position and thus will probably return to prioritizing vendor base size.

Figure 8-6
Total Cost of Ownership Issues



Source: Dataquest (August 1998)

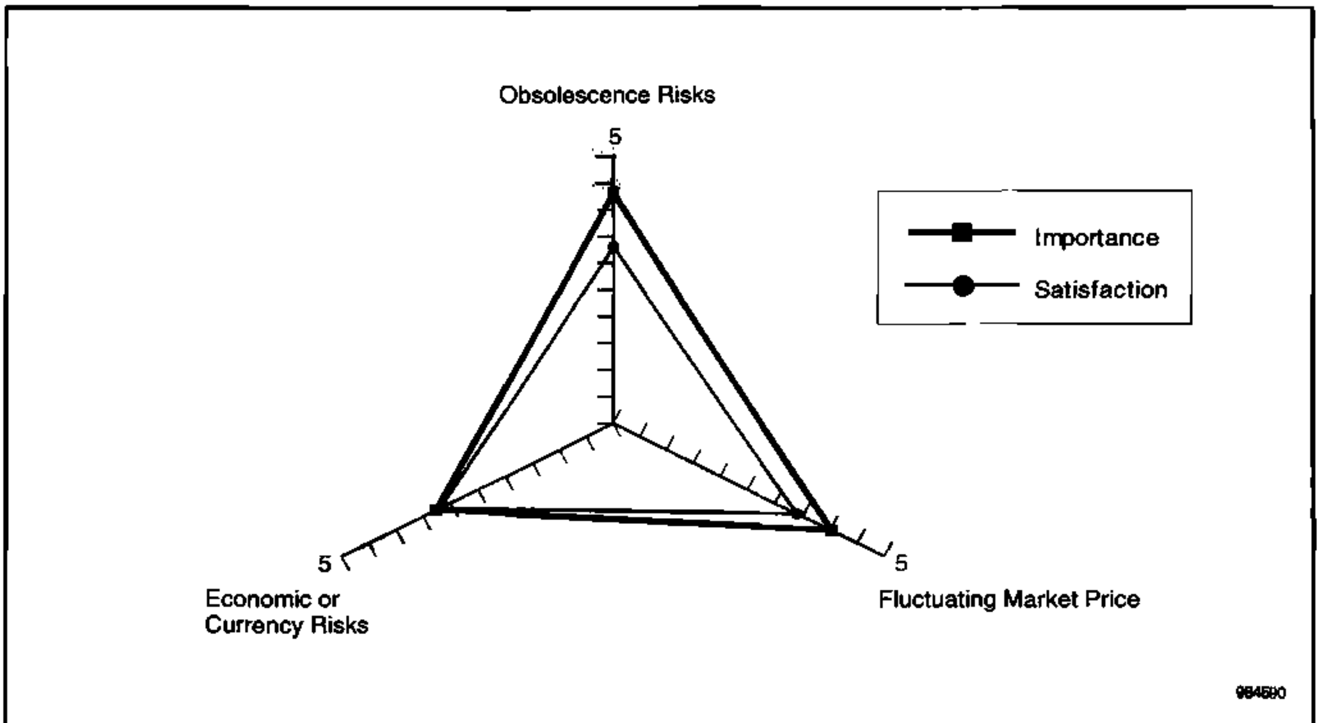
Price Issues

The last set of procurement issues covered by Dataquest in this survey was price issues. Price issues comprised fluctuating market price, obsolescence risk, and economic or currency risks. Once more, the mean results were plotted and the resulting graph is shown in Figure 8-7.

Of the three pricing issues, obsolescence risk ranked No. 1 in importance, receiving a mean score of 4.31. By contrast, the satisfaction ranking for this issue was only 3.31. Market price fluctuations had a mean importance score of 4.02, giving this issue the second highest importance of the three criteria, and this issue had the highest satisfaction rating at 3.40.

Economic or currency risks constituted the least important of the three criteria for the buyers surveyed, receiving a mean score of 3.26. Additionally, while this issue also ranked the lowest of the three in terms of buyer satisfaction (at 3.18), it had the smallest delta for importance versus satisfaction.

Figure 8-7
Price Issues



Source: Dataquest (August 1998)

Chapter 9
Where Does Trust Fit In Today?

Over the years, supplier-buyer relations have run the gamut. At times, suppliers and buyers have almost seemed to be in warring camps, with each side out to beat their opponents. At other times, the mood has been more like a lovefest, with buyer companies bearing in mind that suppliers have feelings, too, and should not be seen as the enemy. As the pendulum continues to swing between these extremes, it now appears that the most pragmatic approach to lowering overall costs and providing adequate revenue to suppliers correlates directly to the level of trust between the parties. Despite the current oversupplied market, the bottom line still holds: The more trust, the better the business relationship; total costs are lower, and revenue streams are more consistent.

Critical in gaining and maintaining trust between buyer and seller is the level of information exchange. VoC programs are regularly used by Dataquest's sample of semiconductor users. A linchpin of trust retention involves user feedback about VoC findings to the supplier, with a program of scheduled improvement where warranted.

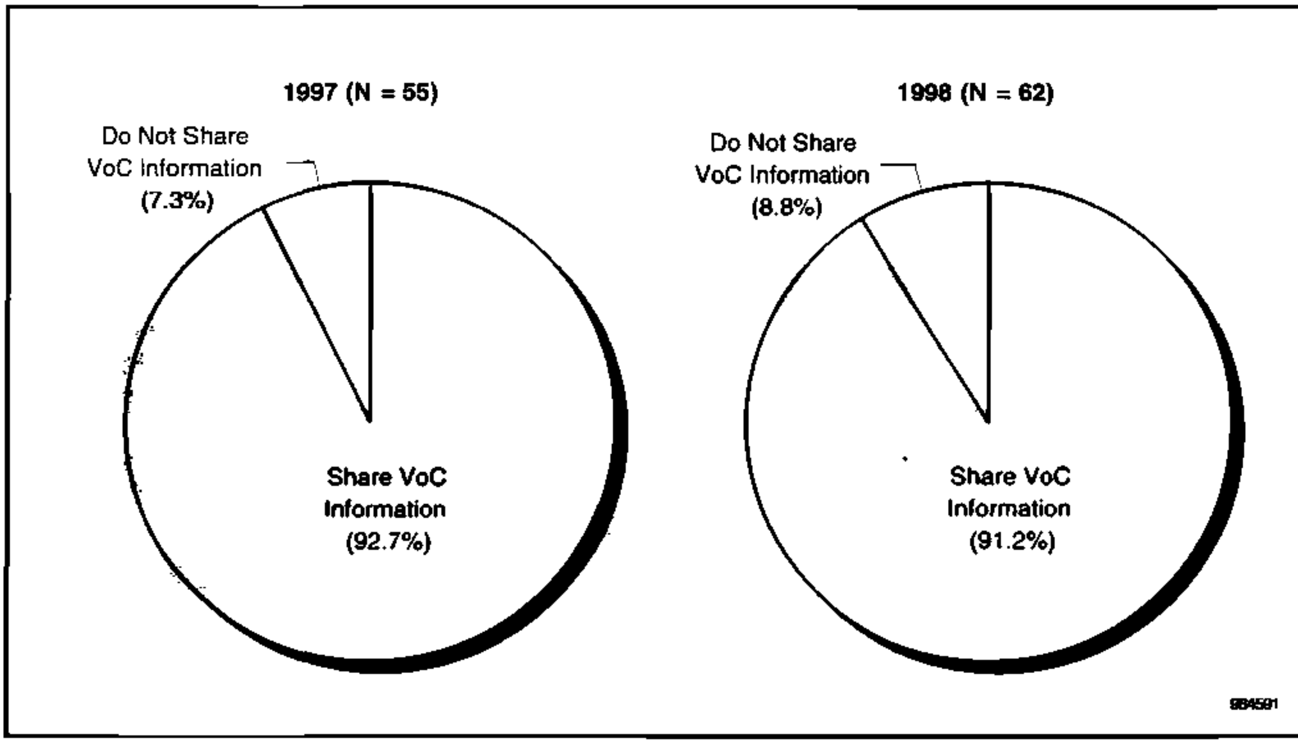
Vendor-of-Choice Feedback to Suppliers

Dataquest asked the buyers surveyed whether they give VoC feedback to their vendors. As shown in Figure 9-1, a strong majority of more than 90 percent of the sample involved with VoC programs share their findings with their suppliers. Like last year's 93 percent response rate, this result was expected, because the main focus of VoC is the goal of improving performance through agreed-on metrics. What is interesting is the finding that 8.8 percent of VoC participants keep the information to themselves. This practice appears to contradict the purpose of the VoC concept, but the shift toward sharing once-confidential information can be an incremental process for some companies.

How Is Information Shared?

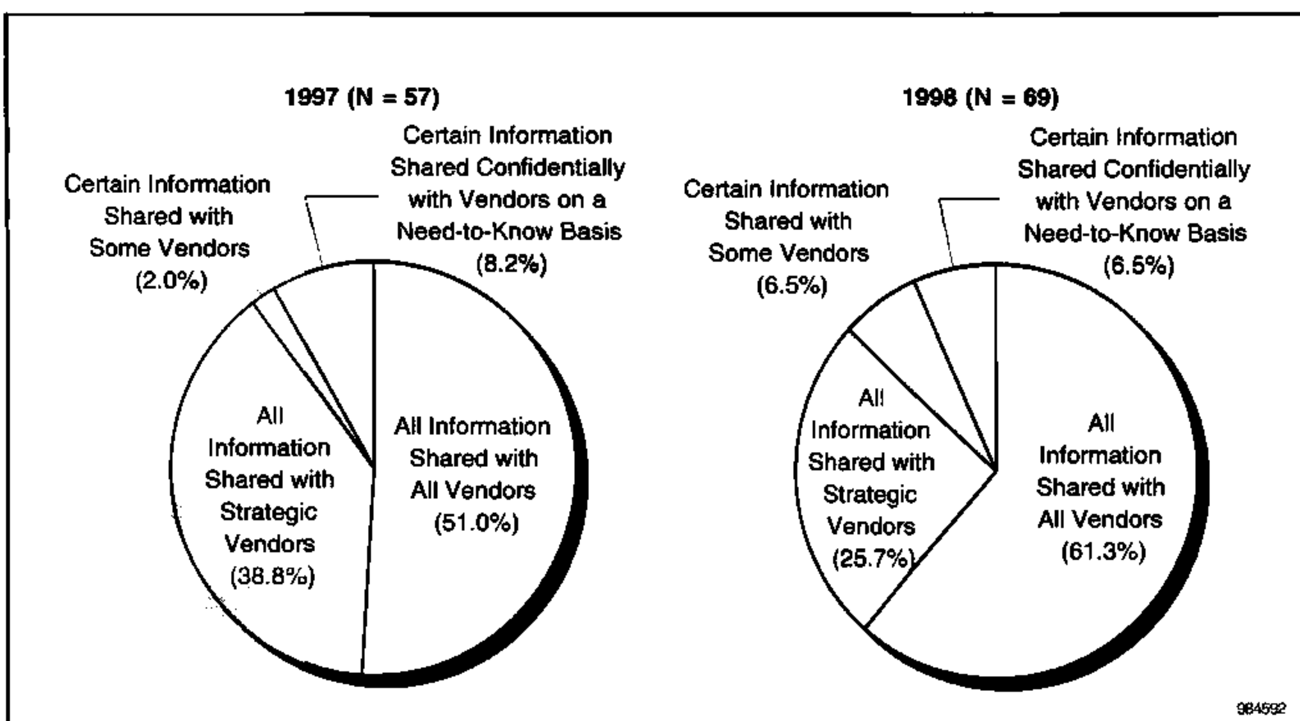
How VoC information is shared often involves the type of information and with whom it is shared. Close to two thirds (61.3 percent) of the respondents with VoC programs share all the information gathered with all suppliers, as shown in Figure 9-2, while more than a quarter (25.8 percent) of the respondents share information only with their strategic suppliers. A much smaller percentage shares limited information with selected suppliers. While 6.5 percent share certain information confidentially with vendors on a need-to-know basis only, another 6.5 percent of the respondents share select information with only some suppliers. Apparently old habits are hard to break in the sharing of information, with some users reluctant to share all with their supply base. One would think that more vendors will shift toward sharing all information as the process becomes more comfortable.

Figure 9-1
VoC Feedback to Vendors



Source: Dataquest (August 1998)

Figure 9-2
Level of VoC Feedback to Vendors



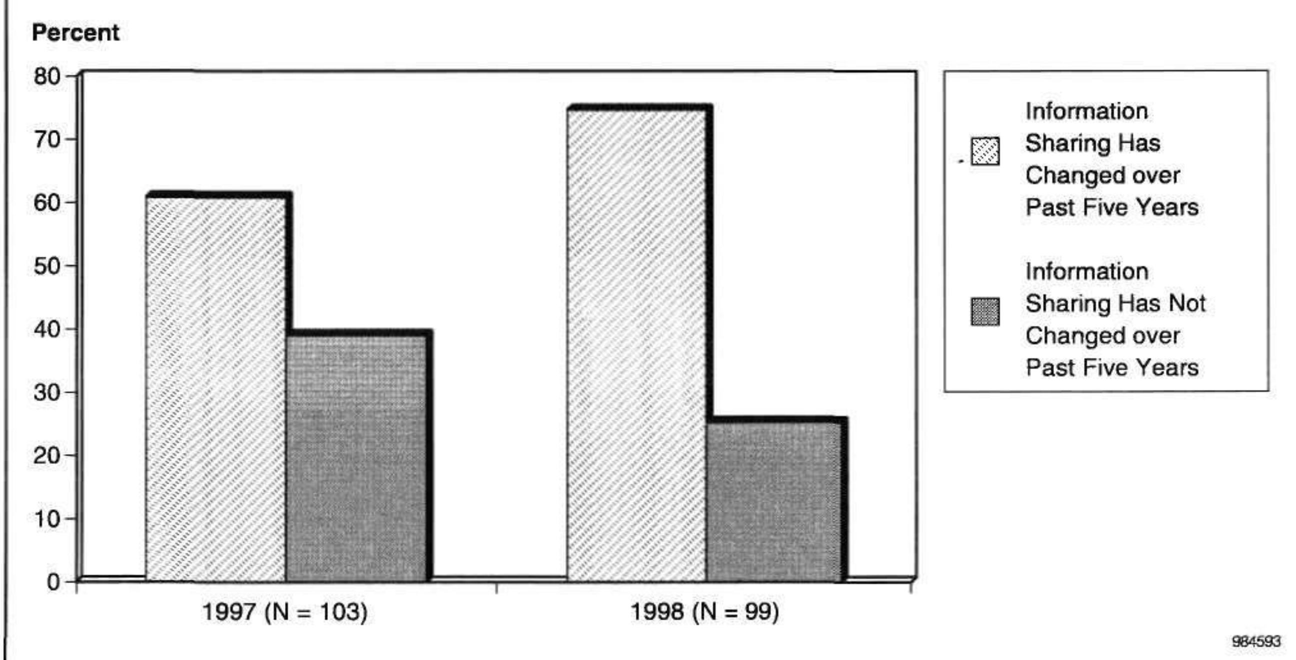
Source: Dataquest (August 1998)

Along these lines, Dataquest again asked the sample to note how the practice of sharing information has changed over the past five years. Figure 9-3 shows that whereas more than 60 percent of last year's study had changed their information-sharing practices over the past five years, a strong majority (74.7 percent) of the current group of respondents had. This improvement in feedback level correlates well with the overall trend of increased communications at all levels of user/supplier relationships.

Value and Goal Sharing

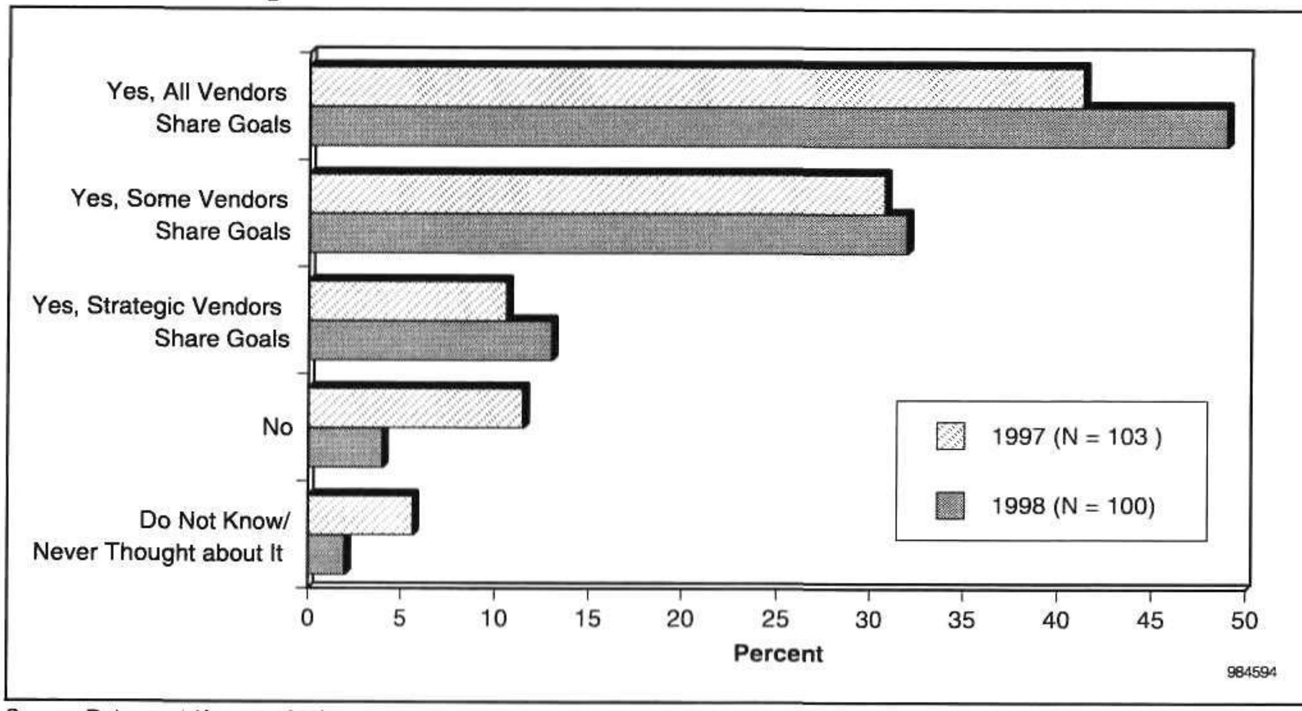
In order for a VoC program to provide benefits to both the user and supplier, both parties must basically share the same goals. Close to half (49 percent) of the respondents felt that all their vendors shared the same goals, while close to one-third (32 percent) noted that some did (see Figure 9-4). The percentage of respondents who noted that their strategic suppliers (13 percent) shared the same market goals was nearly three times those who noted that their suppliers did not share similar goals (4 percent). Compared with last year's study, in which 83 percent had some level of shared goals, this year's strong 94 percent level highlights the relatively quick adoption of one of the key areas of a VoC program.

Figure 9-3
Changes in VoC Feedback to Vendors



Source: Dataquest (August 1998)

Figure 9-4
Vendors' and Respondents' Shared Goals

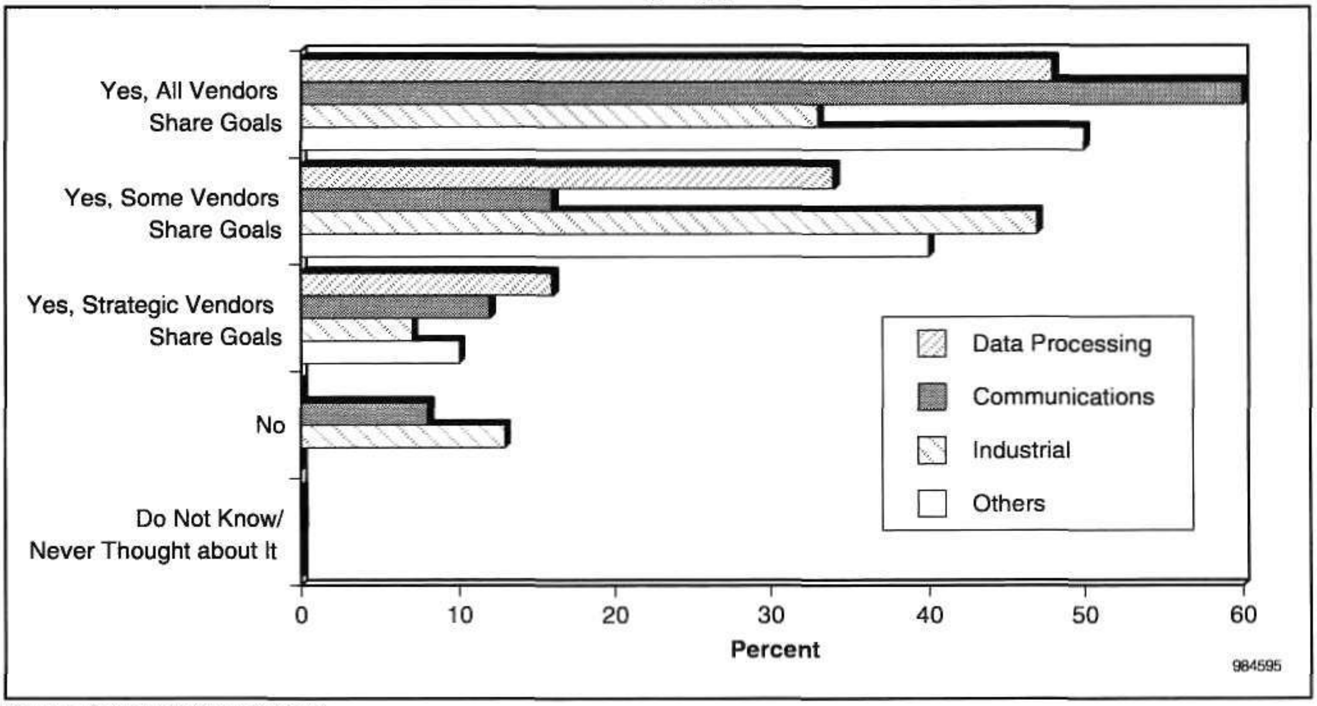


Source: Dataquest (August 1998)

Goal Sharing by Application

Figure 9-5 shows that a solid 60 percent of the communications segment of the respondents share similar goals with all suppliers that tie in with the proprietary nature and long system life of most communication systems. On the other end of the spectrum, only 33 percent of the industrial segment totally shares the same goals with their supply base and 13 percent of the industrial respondents do not share any goals with their suppliers. Although it is a varied application segment, the industrial market has some room for improvement in communicating their plans to their suppliers.

Figure 9-5
Vendors' and Respondents' Shared Goals, by Application



Source: Dataquest (August 1998)

Chapter 10

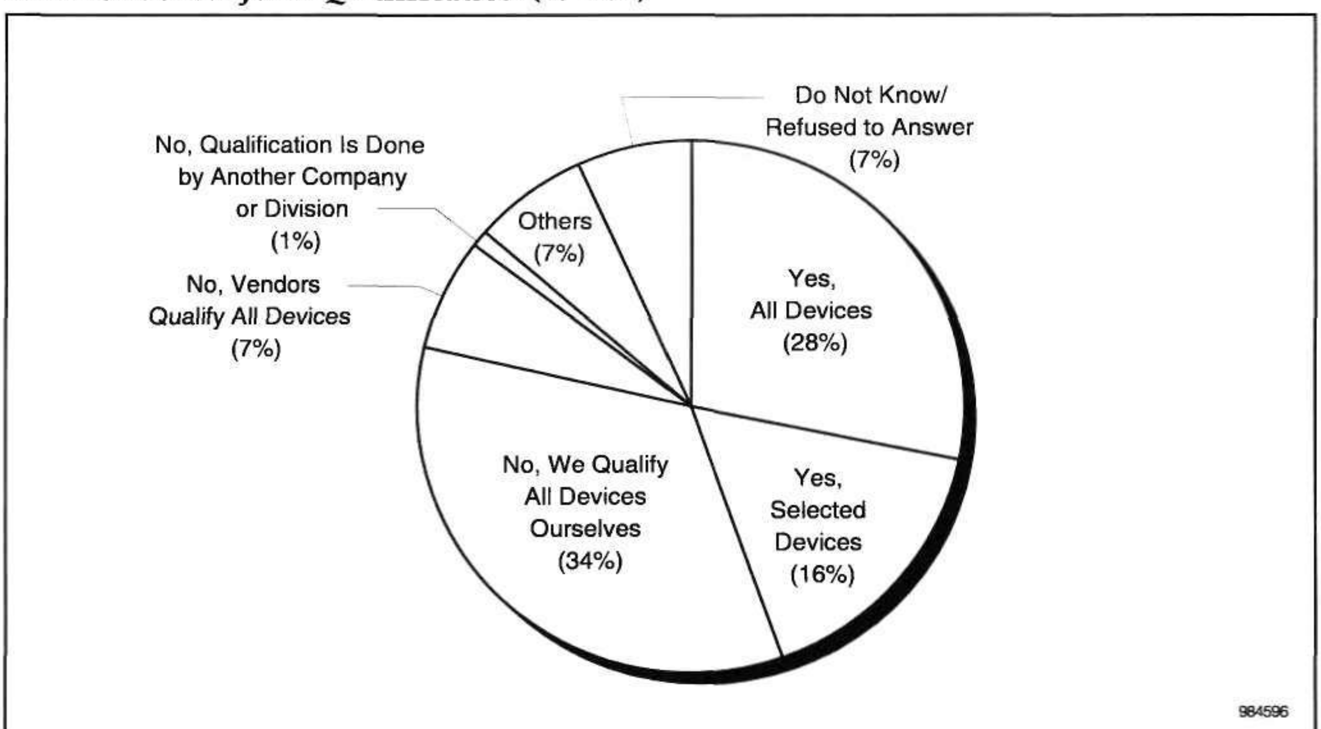
Productivity or Pipe Dream: Supplier and Buyer Joint Qualification

In the current market where price cuts predominate, the concept of having buyer and seller on the same side with similar goals and benchmarks may sound a bit odd. However, when both semiconductor customer and vendor at least know each other's technology road maps and planned market focus, many of the problems involving new product development, phasing products in or out, and competitive pricing are solved proactively rather than reactively. Thus, joint development can provide the semiconductor user with a time-to-market or technology edge over the competition.

Joint Qualification: Yes or No

A key aspect of semiconductor suppliers and users working as a team is the joint qualification of devices used. Dataquest again asked the sample whether they jointly qualified or approved semiconductors with their vendors. Figure 10-1 shows that slightly less than half (47.9 percent) of the respondents either jointly qualified all devices (28.2 percent) or at least jointly qualified selected critical devices (16.5 percent). At one end of the spectrum, more than one-third (34.0 percent) of the respondents qualified all devices internally, while at the other end, a small fraction (6.8 percent) had their suppliers qualify all products. The relatively high percentage of companies using joint qualification highlights the importance of this practice to the respondents. Companies that internally qualify all their parts are (with a few exceptions) generally smaller and may not have the resources in place yet to complete joint qualification procedures.

Figure 10-1
Semiconductor Joint Qualification (N = 96)



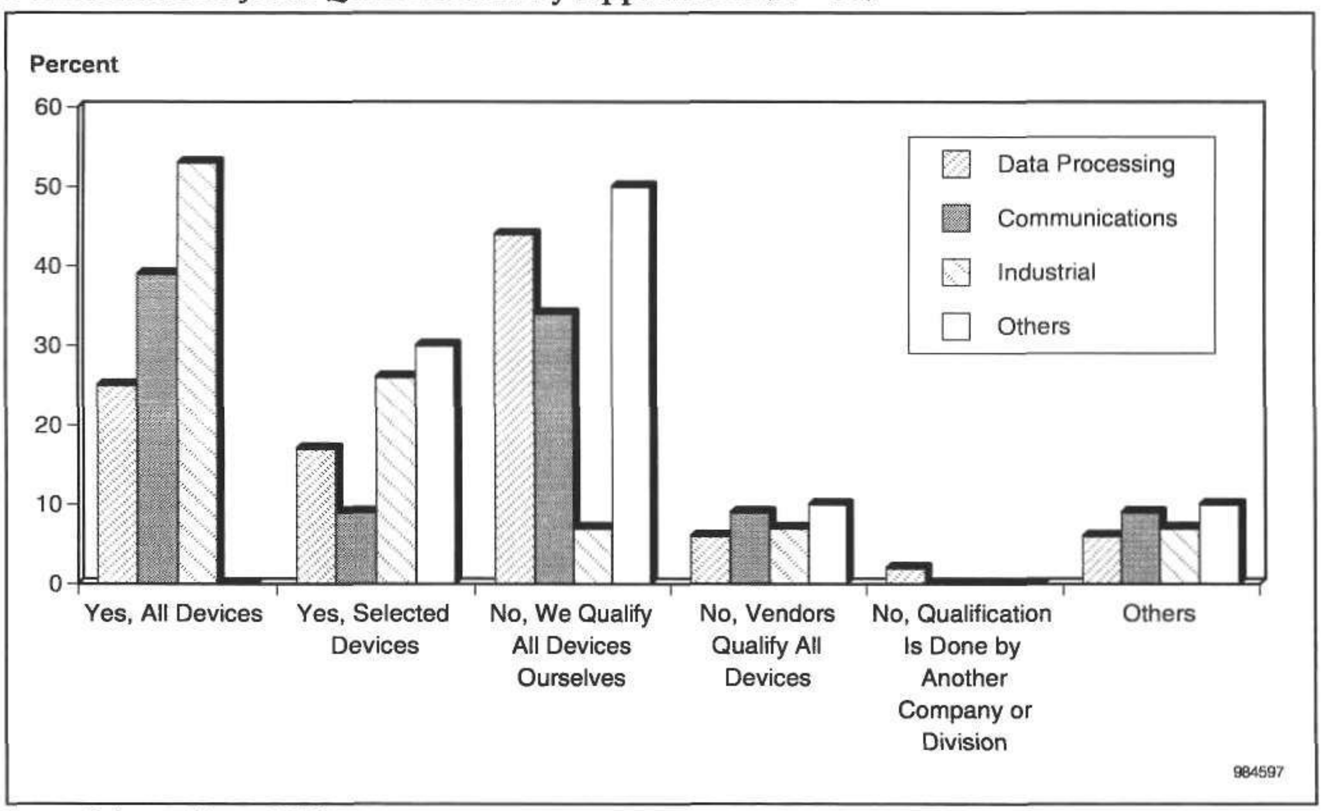
Source: Dataquest (August 1998)

Some semiconductor devices are more likely to be jointly qualified than others, because of the level of customization required, such as special testing.

Joint Qualification by the Markets

Figure 10-2 shows that the relatively high level of internally qualified devices predominantly come from the data processing (DP) application companies (44 percent), although 50 percent of respondents in the small "other" category used internal qualification. On the other side of the spectrum are the communications and industrial applications companies, of which have 39 percent and 53 percent, respectively, use joint qualification. Possibly part of the reason DP application companies predominantly qualify devices internally is the relatively short life cycle of products in this market compared with the longer life cycles of communications and industrial applications.

Figure 10-2
Semiconductor Joint Qualification by Application (N = 96)

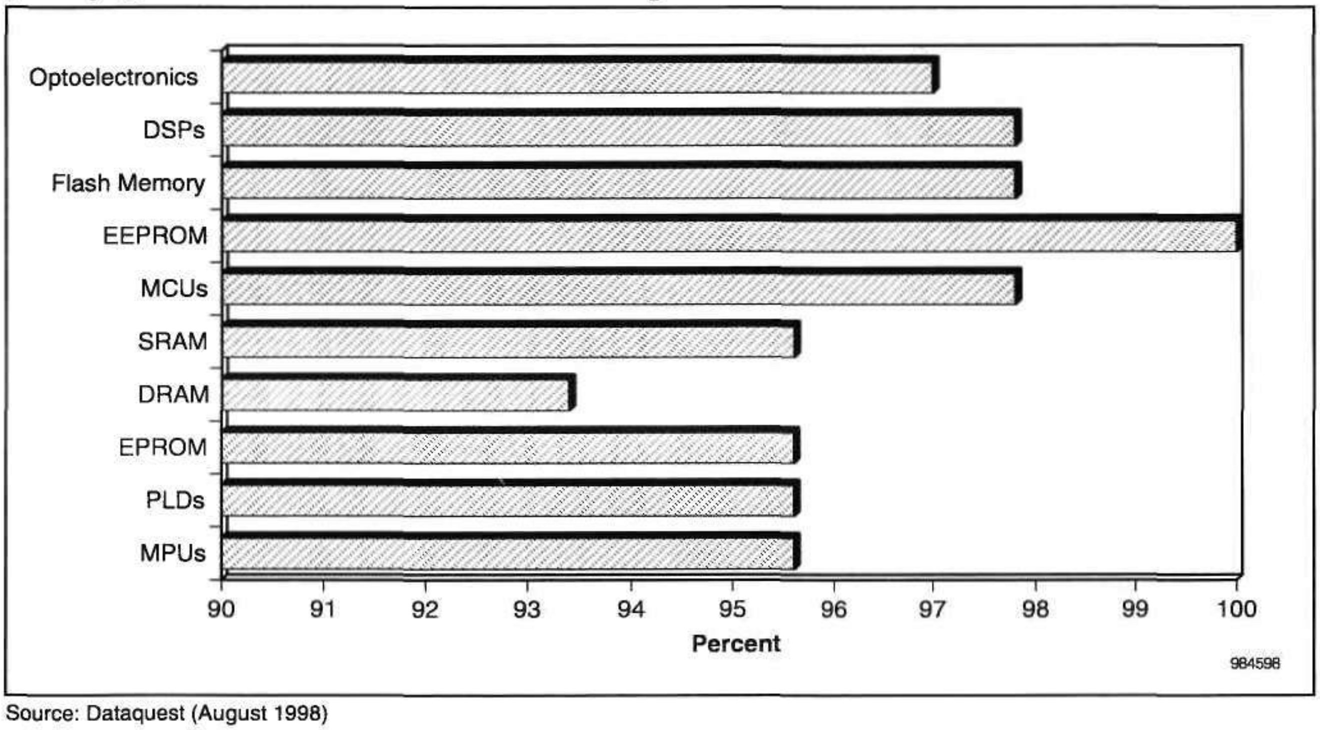


Source: Dataquest (August 1998)

Joint Qualification by Device Family

Dataquest asked those respondents whose companies did jointly qualify parts which parts families were included in the process. As shown in Figure 10-3, the averages were tightly grouped, with no more than 7 percentage points separating the highest and lowest jointly developed family. EEPROMs take the highest joint qualification rank, with 100 percent of those respondents whose companies jointly qualify all or some of their devices saying they jointly qualify all EEPROM devices. On the low end of the range, 93.4 percent of DRAM users jointly qualify these parts. The percentage scores of the other eight product families fall in between these relatively high numbers. There appears to be a slight correlation between the level of joint qualification and the level of customization needed by product type. For example, DSPs and controller chips have a higher joint qualification rate than DRAM devices. This finding ties in with the customization required of most DSPs and controller chips compared with a standard commodity DRAM—although DRAM products are becoming increasingly application-specific. It is interesting to note the relatively high level of joint qualification that is going on for those now in the process.

Figure 10-3
Jointly Qualified Devices—Level of Participation

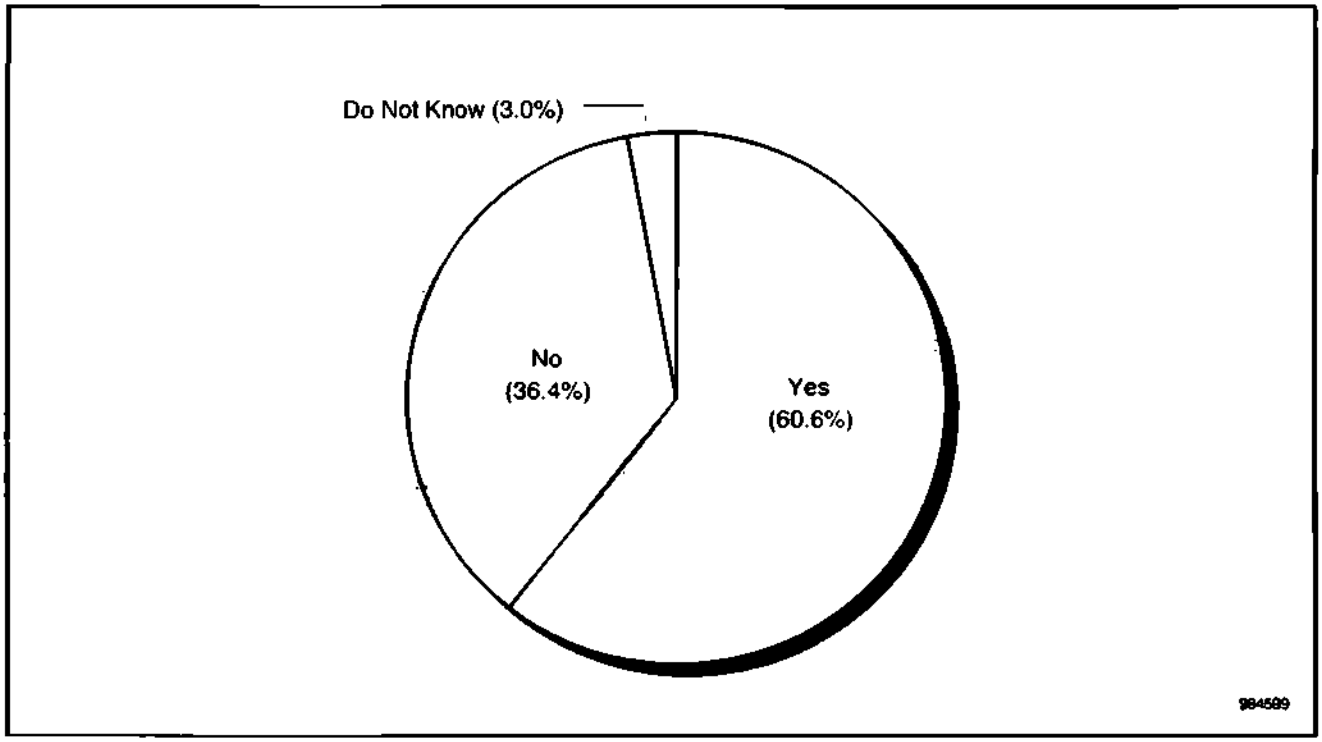


Source: Dataquest (August 1998)

If Not Now, When?

Dataquest next asked the respondents that currently do not jointly qualify semiconductors whether they planned to do so within the next year. Figure 10-4 shows that close to two thirds (60.6 percent) of those not jointly qualifying plan to begin the process during 1999. The majority of the companies expecting to begin the joint qualification process are larger companies with semiconductor purchase levels over $10 million. The rest of the companies, which expect to continue to qualify parts on their own, appear to be in niche markets where customer-specific requirements at the hardware level are not perceived as critical.

Figure 10-4
Plans for Joint Qualification (N = 33)



Source: Dataquest (August 1998)

Chapter 11

Roundup: Conclusions and Comparisons

The 103 companies surveyed account for 4 percent of total North American semiconductor spending, based on Dataquest's revenue results for 1997. The companies surveyed ranged from small and medium-size companies to some huge organizations, and they were split among data processing (48 percent), communications (25 percent), industrial (14 percent), and others (13 percent). This split more or less aligned the survey respondents with Dataquest's consumption by application area. Thus, the findings of the report are fairly representative of the views and feelings of the North American buying community.

It was found that few buyers (13 percent) maintained actual inventory levels lower than their targets. The vast majority of buyers (87 percent) were running with inventory levels either at or above their target. So, clearly, any help that suppliers can give to users on this front will definitely separate them from their competition!

Importance versus satisfaction ratings always unearth interesting findings, and the users in this survey certainly were not shy. Although most vendors did not exceed expectations, the buyers all ranked their vendors above 3 on a scale of 1 to 5 (with 5 being the highest rating). However, there is plenty of work to be done; users have high standards and do not like to be disappointed. Also, given the continued excess of semiconductor capacity, the vendors that perform best will be rewarded. Those who do not will be passed over. In today's market, there are many fish in the sea.

Much is said about total cost of ownership. Although buyers clearly want the best overall deal for their companies, only half of those surveyed admitted that they actually measure TCO formally. However, the importance and satisfaction section showed that this was an area in which buyers wanted more from their vendors.

Likewise, questions about distribution and spot market channels as sources of supply yielded some interesting results. Charting the range of procurement spending through distribution channels showed that the results formed a standard distribution, with 5 percent of participants using the distribution channel for 0 to 10 percent of their total semiconductor spending and 10 percent using the distribution channel for 90 to 100 percent of their requirements. Only 49 percent admitted to using the spot market to obtain products. The most popular device bought in the spot market was DRAM, with SRAM coming close behind. The over-supplied market has succeeded in making this volatile commodity the top sourced product family in the spot market, primarily because of the ultra-low pricing. The attraction of low pricing was reflected in the current 18 percent of users going to the spot market when the price was cheaper compared with only 3 percent of all respondents last year.

The survey revealed some interesting information about the current vendor base size, how it has evolved from 1997, and how it is expected to change in 1999. Even more interesting, it was impressive that 97 percent of respondents now had some strategic vendors or had only strategic vendors. This finding indicates a relatively high level of professionalism and sophistication in the buyers surveyed.

VoC programs or other forms of vendor measurement were used by well over half of the respondents. Of those who use vendor measurement, 56 percent measured all vendors, and 44 percent measured only strategic vendors. Measurement was usually conducted monthly, quarterly, or semiannually, with the quarterly review the most frequently employed.

Dataquest discovered that more than 90 percent of those who conduct VoC programs share the findings with their vendors. More than 60 percent shared findings openly with all suppliers, and 25 percent shared findings only with strategic suppliers.

The process of joint qualification of semiconductor devices was practiced by less than half (44.7 percent) of the respondents, which was slightly lower than last year's 59.6 percent response. There was a slight increase in the internally qualified devices, up to 34 percent from a comparable 31 percent noted last year.

Overall, this study highlights how semiconductor suppliers can shine in an otherwise bleak market noted for ultralow prices and abundant supply chains. With low prices and high quality as givens, suppliers that focus on on-time delivery, supplier responsiveness, and inventory control will solve many user problems and lower the overall cost of material—just what a stressed customer needs.

For More Information...
Inquiry Hotline +1-408-468-8423
Internet address scndinquiry@dataquest.com
Via fax +1-408-954-1780
Dataquest Interactive http://www.dataquest.com

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA

Worldwide Headquarters
Dataquest/Gartner Group
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: +1-408-468-8000
Facsimile: +1-408-954-1780

East Coast Research Center
Gartner Group Lowell
900 Chelmsford Street
Tower Two, Floor Nine
Lowell, Massachusetts 01851
United States
Phone: +1-978-446-0006
Facsimile: +1-978-323-6933

EUROPE

European Headquarters
Gartner Group Ltd.
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44-1784-431-611
Facsimile: +44-1784-488-980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33-1-41-35-13-00
Facsimile: +33-1-41-35-13-13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49-89-42-70-4-0
Facsimile: +49-89-42-70-4-270

JAPAN

Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153-0042
Japan
Phone: +81-3-3481-3670
Facsimile: +81-3-3481-3644

ASIA/PACIFIC

Asia Headquarters
Gartner Group Hong Kong
Suite 5904-7, Central Plaza
18 Harbour Road
Wanchai
Hong Kong
Phone: +852-2824-6168
Facsimile: +852-2824-6138

Pacific Headquarters
Gartner Group Pacific
80 Alfred Street - 6th Floor
Milsons Point, NSW 2061
Australia
Phone: +61-2-9941-4860
Facsimile: +61-2-9941-4868

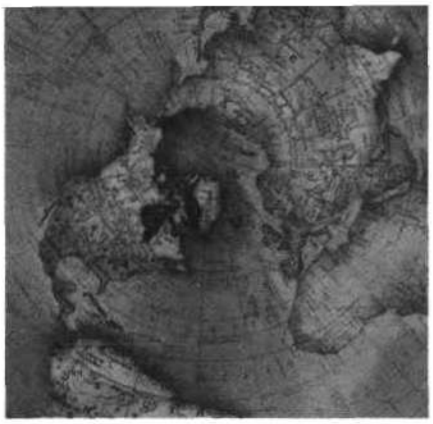
Korea
Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: +82-2-551-1331
Facsimile: +82-2-551-1330

Taiwan
Gartner Group Taiwan Ltd.
11F-2, 188, Section 5
Nan King East Road
Taipei 105
Taiwan R.O.C.
Phone: +886-2-2756-0389
Facsimile: +886-2-2756-2663/4122

Thailand
Gartner Group Thailand Ltd.
29 Vanissa Building, 12F
Soi Chidlom, Ploenchit Road
Pathumwan, Bangkok 10330
Thailand
Phone: +662-655-0577
Facsimile: +662-655-0576

Singapore
Gartner Group/DQ Research Pte Ltd.
6 Temasek Boulevard #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: +65-333-6773
Facsimile: +65-333-6787

Dataquest
A Gartner Group Company



Dataquest

Focus Study: 1998 Semiconductor Industry Capital Spending Overview

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9801
Publication Date: February 2, 1998
Filing: Reports

Focus Study: 1998 Semiconductor Industry Capital Spending Overview

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SSPS-WW-FR-9801
Publication Date: February 2, 1998
Filing: Reports

Table of Contents

List of Tables

Chapter 1
Executive Summary

Overview

Capital spending patterns of semiconductor suppliers (or potential suppliers) is a good gauge on how a company responds to market competition and what its plans are. Semiconductor users utilize this information to compare their strategic plans with their supply base in order to make adjustments on long-term arrangements if divergent spending levels occur.

Analysis done by Dataquest's Semiconductor Equipment, Manufacturing, and Materials Worldwide program here highlights the major trends of semiconductor company capital spending along with a capital spending forecast. Capital spending on semiconductor equipment directly relates to semiconductor unit supply. Knowledge of the industries' capital spending in comparison with aggregate end market demand trends can help in semiconductor price negotiations. For example, if a large level of capital spending is not offset by a like increase in unit demand, the potential for an over supplied market exists. Early knowledge of the situation can benefit users during price or delivery negotiations.

Midyear 1997: Technology Investment and Slow Growth Ahead

Overcapacity in the DRAM market has now affected most areas in semiconductor manufacturing. The second half of 1997 was difficult: bookings collapsed, expansions delayed, and capital spending budgets cut. The bookings decline has put pressure on backlog levels, and the industry shipped down backlog to more normal levels. The first half of 1997 showed sequential strength from the second half of 1996 as chip companies initiated strategic investment plans in leading-edge technology.

Once these projects are completed with the minimum phase, we expect to enter a "pause" in growth because the overcapacity has yet to be resolved. The fundamentals have not changed much in the last six months, and Dataquest believes that several factors will stall the current momentum in the recovery.

Dataquest believes that the next 12 to 15 months will be a period of sluggish growth characterized by stops and starts before a sustainable recovery is established. Dataquest is therefore continuing to be cautious for 1998, with technology investments continuing to be the focus.

Wafer Fab Equipment Industry Status and Forecast

A year ago, Dataquest projected that the first half of 1997 would show sequential strength from the second half of 1996 as chip companies initiated strategic investment plans in leading-edge technology. We also stated that, once these projects were completed with the minimum phase, we would enter a "pause" in growth, because we expected that the overcapacity would not yet be resolved.

Indeed, the first-half strength came in slightly better than expected and at the top end of the forecast range. As a result of the strong first half, Dataquest adjusted the 1997 wafer fab equipment forecast. A decline of slightly more than 9 percent when compared to calendar year 1996 is now expected.

Dataquest believes the next 12 to 15 months will be a period of sluggish growth before a sustainable recovery is established. Dataquest is therefore continuing to call for 1998 to be a single-digit growth year (specifically, 7 percent), with technology investments continuing to be the focus.

We would expect supply/demand dynamics to be fully corrected by early 1999, driving a resumption of growth, with the wafer fab equipment market growing to over $38 billion in the year 2000, from the $21 billion level in 1998. The worldwide wafer fab equipment market is forecast to grow at a 12.8 percent compound annual growth rate (CAGR) between 1996 and 2002.

Even in the face of strengthening semiconductor demand, Dataquest has a conservative view of the recovery. Why? The answer is that the fundamentals of the overcapacity simply do not allow a large-volume spending recovery to occur before very late in 1998, even in the mainstream logic sector.

The Future: Why Are We Concerned about This Downturn Lasting into 1998?

We have several concerns: the capital spending ratio is still too high, overcapacity in the DRAM market continues, silicon shipment rates to chip producers are still below the peak of second quarter 1996, the number of new fabs on the horizon has significantly decreased, and the foundry industry supply is ahead of demand at 0.35-micron.

Capital Spending Ratio Still Too High

In 1997, for the third year in a row, the capital spending ratio as a percentage of semiconductor revenue will exceed 25 percent. The last years before 1995 that saw these levels were 1984 through 1985. We believe the equilibrium level is closer to 22 percent currently, indicating that the industry is still overspending today. This overspending is expected to impact the recovery in 1998.

Overcapacity in the DRAM Market Continues

Korean DRAM manufacturers recently announced further production cutbacks, but DRAM price-per-bit declines in the past months are indicative of oversupply. A fundamental silicon consumption analysis in the sector still points to overcapacity until the end of 1998. Acceleration of the 64Mb DRAM or an acceleration of shrinks in the 16Mb part would only extend the period of overcapacity into 1999.

Silicon Shipment Rates to Chip Producers Still below Peak of Q2/96

At the peak in mid-1996, the silicon area shipment rate was at about 950 million square inches (MSI) per quarter. In the following six months of 1996, heading into 1997, the silicon area shipment rate dropped by over 20 percent to about 750 MSI per quarter. Since this time, the wafer industry has been on a recovery track, but the run rates are still some 5 to 10 percent below the peak last year, indicating unused chip capacity. Coupling this with the fact that Dataquest believes the industry added significant capacity in the last 12 months leads us to conclude that factory utilization rates globally are still below 80 percent. We estimate that the industry will add about 9 to 11 percent net to the installed capacity base in 1997 in terms of square inches of silicon, while only a 4 to 5 percent increase is needed to meet production demand.

Where Are the Fabs?

Dataquest has looked at our most recent fab database, and we note that only 27 new fabs are planned for a 1998 start. At this time last year, there were 56 planned for the following year. This pattern of a decreasing number of new fabs in the second stage of a slow market is quite normal, because the pattern for new fabs generally lags the equipment slowdown by about a year. In the first slow years of the last cycle, 1990 and 1991, there were about 45 new fabs that came on line, versus 39 during 1989. Fewer than 30 fabs per year came on line in 1992, 1993, and 1994. Dataquest expects that both 1998 and 1999 will see new fab construction fall below 30 once again.

This means that large orders will be harder to come by until the fundamentals of overcapacity are resolved.

Foundry Industry Supply ahead of Demand at 0.35-Micron

The fifth concern is less a concern than an issue that may create unrealistically high expectations in the near term—the strength of the foundry industry. This market is experiencing strong demand growth.

In 1996, a year of transition for the foundry industry, the market moved rather quickly from capacity constraint to oversupply. This change was evident in the price declines that began about midyear and that have continued through the first half of 1997. Foundry wafer prices fell about 30 percent in that period, on average.

The sweet spot of the foundry market is now 0.5 micron, with many integrated device manufacturers (IDMs) beginning to off-load production of 0.6- and 0.7-micron products, while fabless companies are beginning the transition to 0.35 micron. Demand is ramping quickly for 0.35-micron foundry services, but so is supply. Although Dataquest would not characterize the 0.35-micron foundry market as being in oversupply, it is not accurate to say there is a shortage of supply, either. In fact, both are ramping, with supply leading demand by about five months. This means that, although the market has the feel of tight supply, there is real competition for market share among suppliers, resulting in a soft pricing environment that can be expected to continue into 1998.

Foundry capacity supply and demand can be used as a proxy for mainstream logic capacity investment. Plans are already in place to supply the market adequately through 1999. This picture shows a fundamental driving force for steady growth but not the accelerating capital spending growth required to drive the industry to and over 20 percent annual growth rates. In short, it is not a market expected to boom. The key is that the industry needs a capacity driving force to resume sustainable high-growth prospects—and for that, it needs the DRAM market.

Silicon Wafer Forecast Overview

Dataquest anticipated that the second half of 1996 would be weaker in silicon demand, based on the migration from 4Mb to 16Mb DRAMs mentioned in earlier forecasts. However, starting about August, the silicon market flat out collapsed, with run rates by the end of 1996 about 20 percent below those of just six months earlier. These dynamics can mostly be explained by the activities in the DRAM market and inventory trends. As a result, the long-term absolute area shipment level as measured in MSI showed 6.5 percent growth in calendar year 1996.

Theoretically, silicon consumption into the DRAM sector should be recovering now, and indeed we are seeing recovery as expected. Dataquest's MSI growth forecast overall for 1997 is just over 5 percent, reflecting a constant 5 to 8 percent sequential unit increase per quarter. With end-use semiconductor and electronic equipment demand strengthening, we would expect to return to double-digit MSI growth rates in 1998.

The silicon market, driven by a strong long-term picture for semiconductor unit demand in general, will grow faster over the next six years than the last six years. As the industry transforms into a 200mm baseline, the outlook for silicon wafer manufacturers becomes brighter. Silicon manufacturers have answered the call for 200mm capacity with significantly increased capital outlays. Activity in 300mm wafer development has accelerated, particularly in Japan with the Semiconductor Leading Edge Technologies Inc. (Selete) consortium. Increased visibility of the International 300mm Initiative (I300I) has also contributed to the first 300mm pilot fab announcements. Dataquest still expects only pilot volume activity in 300mm wafers through the year 2000.

Sales of merchant epitaxial wafers by the wafer suppliers accounted for 15 percent of unit shipments. About 69 percent of these wafers were used for CMOS logic applications, while only 2 percent were used for DRAM products. The remainder were shipped into the power/discrete device segments. By 2002, Dataquest expects that fully 24 percent of merchant epitaxial silicon will be used for DRAMs, primarily driven by two factors. The CMOS logic application remains dominant at 51 percent. The overall epitaxial wafer market will experience a 16.0 percent CAGR from 1996 through 2002.

Dataquest Perspective: Fundamentals Dictate Turning Down the Optimism

Optimism is currently rampant in the industry, but the fundamentals have not changed much in the last six months. The fundamentals of the overcapacity of today simply do not allow a large volume-spending recovery to occur before mid-1998, even in the mainstream logic sector, which has traditionally been the part of the market less affected by the cycle. The DRAM market is needed to fuel a sustainable recovery. Therefore, Dataquest believes that the wafer fab equipment market will be in for sluggish business conditions through 1998. The next 12 to 15 months are expected to be dominated by strategic investment by IC manufacturers that includes production location positioning and investment in new technology.

The move to put 0.25-micron manufacturing capability in place, coupled with the retooling of fabs to migrate capacity away from DRAM to logic, will continue to be the main focus of investment in equipment into 1998. Equipment areas such as chemical mechanical polishing, epitaxial reactors, and deep-UV lithography are expected to be strong investment areas. The accelerated commitment to build 300mm pilot lines should provide some supporting strength in 1998.

We have factored in an infrastructure investment in equipment for late 1997 through 2000, 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 to run silicon by 1999. However, Dataquest believes that a significant 300mm equipment market will wait until well after 2000, as the industry will exhibit the traditional "double hump" sales pattern for emerging technology.

The current optimism in the equipment market may be warranted when viewing U.S. and European equipment suppliers. These suppliers are better positioned to take advantage of the current interest in buying technology. Quick action by many equipment companies to control costs and manage growth meant that the industry weathered the downturn extremely well. This has provided the environment and opportunity for acquisitions and has led to some industry consolidation.

Dataquest's outlook for the silicon wafer market is more optimistic. The end-unit semiconductor demand remains strong, so the silicon wafer manufacturers should lead in a sustainable recovery relative to the wafer fab equipment market by about a year. Recovery began in silicon unit growth in the first quarter of 1997, with double-digit growth returning in 1998.

The silicon market has become recognized again as strategic in the semiconductor manufacturing infrastructure. Will this continue? Dataquest believes it will, as long as silicon suppliers continue to concentrate on value-add processes and techniques, as the equipment manufacturers have done, as well as adequately and intelligently plan capacity additions.

Project Analyst: Mark Giudici

Contributing Analysts: Ellie Babaie, Joe D'Elia, Ron Dornseif, Clark Fuhs, Mike Glennon, James Hines, C.S. Kim, Ben Lee, Takashi Ogawa, Klaus Rinnen, Beth Sargent, James Seay, George Shiffler, Yoshihiro Shimada, J.H. Son, and Jerry Yeh

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 1995, 1996 was a year that turned from growth to decline, but the net effect was just over 15 percent growth in capital spending. There were two distinctly different markets in the past year. The first half was marked by many fab announcements, aggressive spending plans, and good bookings levels for equipment. The second half was the opposite: bookings collapsed, expansion delayed, capital spending budgets cut.
- Dataquest's forecast for 1997 calls for an 8.5 percent decline in capital spending, with a relatively modest growth of 8.5 percent in 1998. This reflects our belief that industry overcapacity will delay a sustainable capital spending growth pattern until at least late 1998.
- We would expect supply/demand dynamics to be fully corrected by early 1999, driving a robust resumption of growth in capital spending growing to just under $80 billion in the year 2000, from just under $45 billion in 1998.
- Capital spending in the Americas region grew at an industry-average 3.5 percent in 1996, as a mix of companies both cut and accelerated spending. We expect that investment in advanced technology, coupled with the earlier capacity upturn from the advanced logic segment and strategic investments, will not only stabilize the region's spending in 1997, but will cause it to actually grow in spite of a decline in worldwide spending. The Americas region will lead the market's recovery in 1998 and 1999 as it did in 1993. We expect the Americas region to have the highest CAGR in capital spending for the period from 1996 to 2002 as foreign multinationals and foundry company invest in capacity in the United States.
- Japan's 7 percent decline in capital spending in 1996 was really an 8 percent increase on a yen basis. Japanese companies had already ordered equipment when they realized that the DRAM market had once again fallen victim to a harsh price fall. Although they had reviewed spending toward the second half of the year and adjusted downward, the total spending for 1996 ended up showing an increase in yen.

- The cutback in Japan continues into 1997, but in the second half of the year, some Japanese companies may increase spending, while most others view 1998 as the year of recovery in capital expenditure. As Japanese companies try to accelerate 0.25-micron fabs for next-generation products, their spending into the domestic sites will increase in proportion to other regions, but the Japanese region on the whole will show milder growth in capital spending in the foreseeable future. Japanese companies will refurbish their fabs for "portfolio" production (mixed product manufacturing)—there will be less dedicated DRAM, or logic, fabs. Most fabs will be ready to produce any product, following closely the trends in the market.
- For Europe, 1997 is a year of 9.3 percent positive spending growth while the worldwide market is in decline. Dataquest is expecting Europe to be a reflection of the overall worldwide market because there is a good mix of multinational investment in the region. Europe is currently at equilibrium with the world, with a stable percentage of the demand and production mix. This stability is what has attracted more companies to produce in the region.
- The often erratic but long-term semiconductor capital spending growth in the Asia/Pacific region continued at a market-leading pace of 37 percent growth in 1996. However, the tide has turned in the DRAM area, and Dataquest is forecasting the Asia/Pacific region to be hit hardest in 1997, with a 23 percent decline in capital spending and a flat-to-down 1998 as the foundry industry deals with oversupply and the DRAM market remains weak. Longer term, we expect Asia/Pacific to exhibit growth in capital spending that will be among the most aggressive of any region but that will be much closer to overall market growth rates than in the recent past.
- The foundry industry is now a *strategic* industry rather than simply a tactical one, but it is now also an industry that has become susceptible to the general industry overcapacity. The supply/demand picture at 0.35-micron shows that, although demand is strong, the supply base is about 5 months ahead of demand for the leading-edge 0.35-micron technology through 1999. Evidence supporting this can be seen in the continued pricing pressure. There is really no room for new spending here.

Capital Spending Methodology and Tables

Dataquest's forecast process has several cornerstones, including semiconductor production by region, a worldwide database of existing and planned fabs, and independent comprehensive surveys of the equipment and semiconductor companies.

The survey results are one input into our several forecasting models, which include analysis of trends in semiconductor production, raw silicon consumption, spending ratios, investment cycles, new fab and expansion activity, stepper-to-DRAM price-per-bit analysis, and semiconductor revenue per square inch.

A list of the top 20 capital spending semiconductor companies and their projected spending in 1996 is presented in Table 2-1; spending for 1997 is presented in Table 2-2.

Capital spending details by region are provided in two tables in this chapter. Table 2-3 shows historical semiconductor capital spending by region for 1990 through 1996. Table 2-4 shows the capital spending forecast by region for 1996 through 2002.

Table 2-1
Semiconductor Capital Spending—Top 20 Spenders,Comparison of 1995 and Final 1996 Worldwide Capital Spending (Millions of U.S. Dollars)

1995 Rank	1996 Rank	Company	1995	1996	Change (%)	Share (%)
1	1	Intel	3,550.0	3,000.0	-15.5	6.7
3	2	LG Semicon	2,258.1	2,732.4	21.0	6.1
5	3	Samsung	1,946.6	2,235.6	14.8	5.0
9	4	Hyundai	1,492.0	2,111.4	41.5	4.7
12	5	Texas Instruments	1,079.3	1,898.0	75.9	4.3
4	6	NEC	2,010.1	1,792.2	-10.8	4.0
14	7	Micron Technology	960.0	1,600.0	66.7	3.6
6	8	Toshiba	1,624.1	1,562.5	-3.8	3.5
10	9	IBM Microelectronics	1,150.0	1,550.0	34.8	3.5
2	10	Motorola	2,530.0	1,416.0	-44.0	3.2
8	11	Hitachi	1,497.6	1,353.8	-9.6	3.0
16	12	Siemens	850.0	1,300.0	52.9	2.9
7	13	Fujitsu	1,592.1	1,263.8	-20.6	2.8
13	14	SGS-Thomson	1,001.0	1,180.0	17.9	2.7
11	15	Mitsubishi	1,118.2	988.0	-11.6	2.2
17	16	Matsushita	846.6	884.6	4.5	2.0
18	17	Chartered Semiconductor	786.7	872.4	10.9	2.0
44	18	Winbond Electronics	117.8	846.8	618.9	1.9
22	19	Taiwan Semiconductor Mfg. Co.	583.9	796.0	36.3	1.8
15	20	Philips	959.0	700.0	-27.0	1.6
		Total Top 20 Companies	**27,953.0**	**30,083.4**	**7.6**	-
		Total Worldwide Capital Spending	**38,689.1**	**44,514.2**	**15.1**	-
		Top 20 Companies' Percentage of Total	**72.3**	**67.6**	-	-

Source: Dataquest (July 1997)

Table 2-2
Semiconductor Capital Spending—Top 20 Spenders, Comparison of 1996 and Projected 1997 Worldwide Capital Spending (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996	1997	Change (%)	Share (%)
1	1	Intel	3,000.0	4,500.0	50.0	11.0
2	2	LG Semicon	2,732.4	2,031.6	-25.6	5.0
4	3	Hyundai	2,111.4	1,749.4	-17.1	4.3
12	4	Siemens	1,300.0	1,700.0	30.8	4.2
3	5	Samsung	2,235.6	1,693.0	-24.3	4.2
6	6	NEC	1,792.2	1,586.3	-11.5	3.9
9	7	IBM Microelectronics	1,550.0	1,400.0	-9.7	3.4
14	8	SGS-Thomson	1,180.0	1,380.0	16.9	3.4
8	9	Toshiba	1,562.5	1,294.1	-17.2	3.2
11	10	Hitachi	1,353.8	1,242.0	-8.3	3.0
5	11	Texas Instruments	1,898.0	1,100.0	-42.0	2.7
13	12	Fujitsu	1,263.8	1,085.3	-14.1	2.7
17	13	Chartered Semiconductor	872.4	976.4	11.9	2.4
19	14	Taiwan Semiconductor Mfg. Co.	796.0	907.0	13.9	2.2
15	15	Mitsubishi	988.0	876.6	-11.3	2.2
18	16	Winbond Electronics	846.8	873.6	3.2	2.1
16	17	Matsushita	884.6	834.9	-5.6	2.0
10	18	Motorola	1,416.0	800.0	-43.5	2.0
38	19	Nan Ya Technology	364.0	728.0	100.0	1.8
22	20	United Microelectronics	600.0	700.0	16.7	1.7
		Total Top 20 Companies	**28,747.4**	**27,458.2**	**-4.5**	-
		Total Worldwide Capital Spending	**44,514.2**	**40,743.4**	**-8.5**	-
		Top 20 Companies' Percentage of Total	**64.6**	**67.4**	-	-

Source: Dataquest (July 1997)

Table 2-3
Worldwide Capital Spending by Region—Historical, 1990 to 1996 (Includes Merchant and Captive Semiconductor Companies) (Millions of U.S. Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1990-1996
North America	4,320	3,895	4,135	4,943	7,194	12,243	12,668	19.6
Percentage Growth	12.7	-9.8	6.2	19.5	45.5	70.2	3.5	-
Japan	5,732	5,702	3,958	4,413	6,667	9,912	10,238	10.1
Percentage Growth	5.9	-0.5	-30.6	11.5	51.1	48.7	3.3	-
Japan (¥B)	826	787	500	491	679	931	1,114	5.1
Percentage Growth	10.4	-4.7	-36.4	-2.0	38.3	37.1	19.7	-
Europe	1,598	1,248	1,188	1,738	2,504	4,099	4,627	19.4
Percentage Growth	33.4	-21.9	-4.8	46.3	44.0	63.7	12.9	-
Asia/Pacific-ROW	1,580	2,300	2,318	3,238	5,720	12,435	16,982	48.6
Percentage Growth	-16.2	45.6	0.8	39.7	76.6	117.4	36.6	-
Worldwide	13,230	13,145	11,599	14,333	22,085	38,689	44,514	22.4
Percentage Growth	7.3	-0.6	-11.8	23.6	54.1	75.2	15.1	-

Source: Dataquest (July 1997)

Table 2-4
Worldwide Capital Spending by Region—Forecast, 1996 to 2002 (Includes Merchant and Captive Semiconductor Companies) (Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1996-2002
North America	12,668	13,984	16,737	19,820	25,896	29,540	32,199	16.8
Percentage Growth	3.5	10.4	19.7	18.4	30.7	14.1	9.0	-
Japan	10,238	8,775	9,571	11,007	15,483	16,757	17,670	9.5
Percentage Growth	3.3	-14.3	9.1	15.0	40.7	8.2	5.4	-
Japan (¥B)	1,114	1,051	1,141	1,312	1,845	1,997	2,106	11.2
Percentage Growth	19.7	-5.6	8.5	15.0	40.7	8.2	5.4	-
Europe	4,627	5,058	5,054	6,466	8,658	9,079	9,905	13.5
Percentage Growth	12.9	9.3	-0.1	27.9	33.9	4.9	9.1	-
Asia/Pacific-ROW	16,982	12,927	12,842	17,039	27,437	35,394	29,842	9.9
Percentage Growth	36.6	-23.9	-0.7	32.7	61.0	29.0	-15.7	-
Worldwide	44,514	40,744	44,204	54,333	77,475	90,770	89,616	12.4
Percentage Growth	15.1	-8.5	8.5	22.9	42.6	17.2	-1.3	-

Source: Dataquest (July 1997)

Recent History: 1996 Was a Very Dynamic Year

The year 1996 ended the recent DRAM-driven expansion cycle. After several high-growth years, peaking with 74 percent growth worldwide during 1995, 1996 moved from growth to decline with a slower 15 percent rate. Most of this growth occurred in the first half of the year, and spending contraction began in the second half of 1996 and spilled into 1997.

The industry is now relying on the continued growth in personal computer unit sales, with added growth in telecommunications and networking products, to create a unit demand picture that will be a healthy backdrop. The wafer fab capacity bubble has burst in all regions and for most semiconductor products, most notably DRAMs, mixed-signal, discrete, and analog. The 1995 spending growth was almost entirely driven by capacity purchases, but 1996 was a year of transition, and 1997 and 1998 will be years of investment in technology.

The first companies to cut back were the U.S. companies, because they tend to be more driven by short-term cost issues. The Japanese companies quickly followed, and the overcapacity in DRAM has caused Japanese companies to quickly tighten the purse strings in hopes of avoiding a more serious price erosion. However, their Korean and Taiwanese counterparts did not fully cooperate until recently. Although Korean companies have already basically announced a 20 to 25 percent cutback in 1997 relative to 1996, the recent move to cut DRAM production significantly means more spending cuts are likely to come.

This above-industry growth for the big three Korean companies has meant that all three are in the top five for capital spending in 1996, and even with initial spending cuts remain among the top five in 1997. As noted earlier, Japanese suppliers of memory cut back investment early in this cycle. Japanese companies as a group spent 3.3 percent more in 1996 in dollar terms, below the overall market with 15.1 percent growth. As a result, only two Japanese companies appeared in the top 10 capital spenders in 1996—NEC and Toshiba Corporation. Most of the other Japanese companies did appear in the second 10. We would note that the yen depreciation has caused Japanese companies' spending to appear smaller in dollar terms, and as a result, Japanese companies are concentrating on their domestic sites in the short term. Intel Corporation still headed the list for 1996, as demand for the microprocessor giant's products continues to be strong on a unit basis. Intel's capital spending actually declined in 1996, however, primarily because yield ramps on its new fabs have been better than expected. The company therefore needs less equipment to produce the same unit volume. Motorola Incorporated, the long-time No. 2 spender, has dropped to No. 10 as the demand for telecom-related chips softened in conjunction with the overcapacity experienced in this area.

A mostly new crowd of Taiwanese companies that entered the DRAM manufacturing business, spending over $1 billion collectively in 1995, increased spending feverishly in 1996 to spend over $2 billion on DRAM capacity. Recent alliances with large Japanese companies have kept spending levels elevated, the most notable being Winbond Electronics Corporation, whose alliance with Toshiba is keeping spending levels essentially flat with 1996. Fully four Taiwanese companies make the top 20 spending list for 1997—joining Winbond and Taiwan Semiconductor Mfg. Co. this year are Nan Ya Technology Corporation, which has a technology agreement with Oki Electric Industries Company Ltd., and United Microelectronics Corporation, which has been very aggressive in the foundry market.

Foundry capacity expansion has now evolved into a major trend. Dedicated foundries TSMC, Chartered Semiconductor Manufacturing Pte. Ltd., and UMC now appear on the list. This industry has transformed into a bona fide business and is no longer a specialized way to use excess capacity. There are several companies that have entered the foundry business as a result of today's overcapacity. Unless these companies commit to the foundry business in the long term, their success in the market will be limited. Gone are the days of the "temporary" foundry. Customers of foundry are now requiring long term relationships and contracts for winning their capacity business.

It is very normal in this type of a downturn to get a pocket of companies that will stay and continue to invest in the infrastructure or that have niches that maintain growth, thus supporting an increase in spending. These companies in 1996 include IBM (advanced 16Mb DRAM to support systems), Texas Instruments Inc. (primarily digital signal processors and logic), TSMC (foundry), Siemens AG (advanced DRAM), Lucent Technologies (modem chipsets and the Cirrus Logic foundry), and Chartered Semiconductor (foundry). Only the foundry companies, along with Siemens, have continued to increase investments this year. Micron Technology Inc. may be the surprise of 1996 to some, particularly since it has delayed the Lehi, Utah, fab. However, the company has been spending aggressively in Boise, Idaho, upgrading the facilities for 200mm production and advanced technology for the 16Mb generation. Micron's spending plans in 1997 have been dramatically curtailed.

Winbond also debuted in the top 20 list, primarily as a result of an alliance to manufacture chips for Toshiba. This is an example of a "strategic" investment pattern, which we believe will be dominant, particularly in many of the projects in 1997.

With the cutback of the big Japanese players in the industry, and some smaller companies continuing to be aggressive in spending plans, the concentration of capital spending by the top 20 has decreased in 1996 by a few percentage points, but it will remain stable in 1997 at just under 70 percent.

The Present: What about 1997?

Capital spending is essentially on track with the forecast scenario painted at the beginning of the year. Dataquest expected the first half of 1997 to show sequential strength from the second half of 1996 as chip companies initiated strategic investment plans in leading-edge technology. Indeed, the first half strength came in slightly better than expected, at the top end of our forecast range, leading us to modify our 1997 forecast upward. We are now expecting a decline of just over 8 percent from 1996, rather than the 14 percent decline predicted six months ago.

Although optimism is rampant in the industry, the fundamentals have not changed much in the last six months. The fundamentals of today's overcapacity simply do not allow a large volume spending recovery to occur before mid-1998, even in the mainstream logic sector, which has traditionally been the part of the market less affected by the cycle. Dataquest believes the industry has just completed the first year of a normal-length slow period, and we expect the next 12 to 15 months to be a period of sluggish growth before a sustainable recovery is established. We expect a softening of spending in the second half of 1997 compared to the first half and continue to call 1998 a high single-digit growth year, with strategic investments into new technologies continuing to be the focus. The accelerated commitment to build 300mm pilot lines will contribute some underpinning strength in 1998—albeit a small contribution.

Technology and strategic investment are the strength in 1997. What do we mean by "strategic" investment? After the industry shut the valve off hard in the middle of 1996, companies had time to re-evaluate their spending plans. Because the end-use markets for semiconductors remained strong, many companies started investing "strategically," positioning themselves for market share increases and the next major ramp in capacity. This positioning can be seen two ways: an aggressive move to put 0.25-micron manufacturing capability in place and a retooling of fabs to migrate capacity away from DRAM to logic. Both factors have been the main focus of investment thus far in 1997 and, indeed, are responsible for a less harsh than expected decline in the first half of this year.

Besides these factors, strategic investments also include any fabs that open up new production market locations and those that are tied to partnerships and joint ventures. Of particular interest are those companies in new alliances, where there are factors that are more important than the capacity being added, such as a strategic development or supply relationship. These two kinds of strategic investments, although capacity related to some extent, are historically less affected by an industry slowdown.

There are many fabs starting or upgrading in 1997 that fall specifically into these categories, including: the U.S. fabs being built by TSMC, Samsung Electronics Company Ltd., and Hyundai Electronics Company Ltd.; the U.K. fab being built by Siemens; the array of initial joint-venture fabs such as IBM/Toshiba, TwinStar, and Motorola/Siemens in the United States; Winbond, Powerchip Semiconductor Corporation, Nan Ya Technology, and Macronix International Company Ltd. in Taiwan, whose activities are tied to Japanese companies; Mosel Vitelic Inc., which is tied to Siemens; and Texas Instruments' venture in Korea (with Anam). These are fabs that will not be stopped but will likely have slower ramp rates than planned.

Dataquest believes there is more downside risk in the market than upside potential over the next two years. The following sections review the concerns that contribute to this belief.

The Future: Why Are We Concerned about This Downturn Lasting into 1998?

Dataquest's longer-term forecast projects that this contraction will be characterized by "start and stops" likely to give it a "W" shape with the second down leg to be in the fourth quarter of 1997. We anticipate about an average length, by historical norms, of at least two years. Despite the continued demand in the semiconductor market, the overspending in the 18 months ending in the middle of 1996 and the still too-high investment levels in DRAM represent a significant lead balloon that will drag and delay the spending recovery into the latter part of 1998.

Overcapacity in the DRAM market has now trickled to most areas in semiconductor manufacturing. In Dataquest's last report, six months ago, we had uncovered a number of facts that gave us concern and issues that needed to be reconciled during 1997 and 1998. These issues provided the basis for our belief that there is more downside risk than upside potential in the next two years, even in the face of a strong end-use demand for semiconductor devices.

How is the market doing with respect to these concerns, and are there new ones? We had three concerns: The capital spending ratio is still too high, overcapacity in the DRAM market continues, and silicon shipment rates to chip producers are still below the peak of second quarter 1996. We have added two more: The number of new fabs on the horizon has significantly decreased and foundry industry supply is ahead of demand at 0.35-micron. The following takes these one at a time.

The Capital Spending Ratio Is Still Too High

In 1997, for the third year in a row, the capital spending ratio as a percentage of semiconductor revenue will exceed 25 percent. The last years that saw these levels were 1984 and 1985. Dataquest believes the equilibrium level is closer to 22 percent now, indicating that the industry is still overspending today. This overspending is expected to affect the recovery in 1998. In the past two market slowdowns, in 1986 and 1991, spending corrected below the equilibrium spending line, allowing supply and demand to close with each other. As a result, the first year of recovery saw double-digit growth. Because overspending continues today, the supply-demand gap should not narrow as much as in prior slowdowns, resulting in a sluggish 1998 in which we are likely to see only single-digit growth.

There are also a few more fabs starting up this year (50) compared to 1996 (47), well above the equilibrium level, which we believe is closer to 35 to 38. From a historical point of view, a high number of fab starts is common in the year following the first year of a slowdown because the pattern for new fabs generally lags the equipment slowdown by about a year. In a downturn, more spending is directed to actually building the fabs, while spending on fab equipment is reduced. In the initial period of recovery, fab construction is lower and the existing fab shells are then equipped. It is not surprising, but frustrating to the equipment industry, to see only 27 fab announcements for 1998.

Overcapacity in the DRAM Market Continues

Although Korean DRAM manufacturers recently announced further production cutbacks, DRAM price-per-bit declines in the past months are indicative of oversupply. A fundamental silicon consumption analysis in the sector still points to overcapacity until the end of 1998. Acceleration of the 64Mb DRAM or an acceleration of shrinks in the 16Mb part would only extend the period of overcapacity into 1999, especially when combined with the seasonal effect for DRAM consumption. Growth of DRAM unit demand is usually very strong in the fourth quarter, driven by holiday sales, but growth is weak in the first quarter. If the point at which supply and demand reach equilibrium is delayed into this season, a DRAM-driven capital spending recovery will likely slip well into 1999.

Dataquest does not believe that PC manufacturers will embrace the 64Mb DRAM until the price per bit is competitive with the 16Mb part and in a configuration that provides the PC manufacturer flexibility in offerings to the market. Currently, prices per bit for the 64Mb DRAM are running at a 20 to 30 percent premium over the 16Mb DRAM. Below this price premium, profitability of the new generation (64Mb) is lower than the current one (16Mb). From a manufacturing perspective, we do not see a crossover happening until late 1999 at the earliest, more likely well into 2000.

Silicon Shipment Rates to Chip Producers Are Still below Peak of Q2/96

At the peak in mid-1996, the silicon area shipment rate was at about 950 million square inches per quarter. In the following six months of 1996, the silicon area shipment rate dropped by over 20 percent to about 750 MSI per quarter heading into 1997. Since then, the wafer industry has been on a recovery track, but the run rates are still some 5 to 10 percent below the peak last year, indicating unused chip capacity. Coupling this with the fact that Dataquest believes the industry added significant capacity in the last 12 months leads us to conclude that factory utilization rates globally are still below 80 percent. Dataquest's estimates are that the industry will add about 9 to 11 percent net to the installed capacity base in 1997 in terms of square inches of silicon, while only a 4 to 5 percent increase is needed to meet production demand.

Where Are the Fabs?

In a recent visit to an equipment company, a marketing manager posed the above question rhetorically to express frustration in finding business for 1998. Taking this question seriously, we looked at our most recent fab database, and we note that only 27 new fabs are planned for a 1998 start. At this time last year, there were 56 planned for the following year. This pattern of a decreasing number of new fabs in the second stage of a slow market is quite normal, because the pattern for new fabs generally lags the equipment slowdown by about a year. In the first slow years of the last cycle, 1990 and 1991, about 45 new fabs came on line versus 39 in 1989. Fewer than 30 fabs per year came on line in 1992, 1993, and 1994. We expect that both 1998 and 1999 will see new fab construction fall to below 30 again.

This means that large orders will be harder to come by until the fundamentals of overcapacity are resolved.

Foundry Industry Supply Is Ahead of Demand at 0.35-Micron

The fifth concern is less a concern than an issue that may create unrealistically high expectations in the near term—the strength of the foundry industry. This market is experiencing strong demand growth.

In 1996, a year of transition for the foundry industry, we saw the market move rather quickly from capacity constraint to oversupply. This change was evident in the price declines that began about midyear and have continued through the first half of 1997. Foundry wafer prices fell about 30 percent in that period, on average. Despite healthy growth in MSI demand of about 14 percent, Dataquest expects the market to be essentially flat in dollar terms for 1997 because of lower prices.

The sweet spot of the foundry market is now 0.5 micron, with many IDMs beginning to off-load production of 0.6- and 0.7-micron products, while fabless companies are beginning the transition to 0.35 micron. Demand is ramping quickly for 0.35-micron foundry services, but so is supply. Although Dataquest would not characterize the 0.35-micron foundry market as being in oversupply, it is not accurate to say there is a shortage of supply, either. In fact, both are ramping, with supply leading demand by about five months. This means that, although the market has the feel of tight supply, there is real competition for market share among suppliers, resulting in a soft pricing environment that can be expected to continue into 1998.

The long-term prospects for the foundry industry remain very strong. Dataquest is forecasting the worldwide foundry market to grow at a CAGR of 19 percent from 1996 through 2001. The success of the fabless model is expected to continue to drive foundry demand growth. Foundry-processed wafers, from both dedicated foundries and IDMs, should amount to over 13 percent of worldwide wafer production on an MSI basis by 2001, and we expect this share to continue to grow in future years.

Foundry capacity supply and demand can be used as a proxy for mainstream logic capacity investment. Plans are already in place to supply the market adequately through 1999. This picture shows a fundamental driving force for steady growth but not the accelerating capital spending growth required to drive the industry to and over 20 percent annual growth rates. In short, it is not a market likely to boom. The key is that the industry needs a capacity driving force to resume the sustainable high growth prospects—and for that, it needs the DRAM market.

Over/Underinvestment Model Also Supports a Late 1998 or Early 1999 Recovery Scenario

A few years ago, Dataquest introduced a model that quantifies the over/underinvestment picture for wafer fab equipment and semiconductor capacity. Although the early 1990s created and sustained a net underinvestment, this was corrected to create about a 36 percent overinvestment by the end of 1995 (see Chapter 3 and Figures 3-1 and 3-2). Clearly this was in the danger zone, and we are seeing the results of this overinvestment today. By the end of 1998, should Dataquest's forecasts for investment and semiconductor demand be on target, we would expect the industry to return to a 9 percent net underinvestment, not quite within the range to set the stage properly for a robust recovery in 1999. Indeed, the results from this model show a delay in the sustainable recovery as a result of the stronger-than-expected 1997.

During 1998, the industry will shift its focus to 300mm shipments in a big way. The majority of growth will come in the second half, but it does give some underpinning to stabilize the market in the first half. The vast majority of the growth placed into our 1998 capital spending forecast comes from the investment in 300mm pilot lines. Dataquest has built this infrastructure investment in our model as nonrevenue-generating spending.

The Americas Market Will Exhibit Strategic Strength Long Term

Capital spending in the Americas region grew at an industry-average 3.5 percent in 1996 as a mix of companies both cut and accelerated spending. We expect that investment in advanced technology, coupled with the earlier capacity upturn from the advanced logic segment and strategic investments, will not only stabilize the region's spending in 1997 but will actually cause it to grow in contrast to the decline in worldwide spending. The Americas region will lead the market's recovery in 1998 and 1999, as it did in 1993. We expect the Americas region to have the highest CAGR in capital spending for the period from 1996 to 2002 as foreign multinationals and foundry companies invest in capacity in the United States.

The relatively strong growth in capital spending had been driven by the growth in PCs, telecommunications, and networking. These key drivers have not disappeared, and these products have seen increasing use as tools to increase productivity in the workplace. Electronic products with increased semiconductor content have created enormous demand for microprocessors, microcontrollers, SRAM, programmable logic and memory, digital signal processors (DSPs), standard logic, and peripheral controllers. The U.S. companies dominate many of these market segments. These segments combined are expected to maintain fairly stable growth rates over the next few years, with PC growth slowing (however, still maintaining an average annual growth rate of 16 percent) and networking and telecommunications expanding. The near-term market for PCs recently showed some softness in Europe and Japan. Although this weakness appears to be seasonal or tied to a product transition to the P6 generations of MPUs, it should command our attention in the coming months. At this time, Dataquest believes our 1997 PC market forecast remains on target, but it now relies more than ever on strong fourth quarter sales.

New consumer digital products and services, such as personal communicators, interactive television, DVD systems, digital cameras, and video on demand, provide the potential for enormous growth in semiconductor sales longer term, especially for highly integrated complex logic and signal-processing chips that will be the core engines of future systems.

The strategic strength of the core logic products enables a healthy and flourishing semiconductor production environment, but it is also less volatile in capital spending. In the boom years of 1994 and 1995, the North American region grew at rates somewhat lower than the market's.

This trait will also enable the North American market to grow in capital spending at faster-than-market rates (or to remain more stable) in the slower years, such as 1997 and 1998. Although worldwide spending is expected to decline by 8.5 percent during 1997, American spending should actually increase by about 10 percent. Dataquest believes that companies will continue to invest strategically in technologically advanced capacity to preserve competitive advantage during 1997. For 1998, our forecast shows just under 20 percent growth in capital spending for North America, compared to only 8.5 percent growth worldwide.

Although neither Samsung nor TSMC placed equipment into their new U.S. fabs in 1996, capital spending on the shells began, with equipment orders being placed mostly in the first half of this year. In 1997, we see an increase in capital spending by American companies domestically over 1996. Intel leads the charge, with increases from LSI Logic Corporation, Advanced Micro Devices Inc., Analog Devices Inc., Lucent Technologies, and National Semiconductor Corporation, with relatively stable spending by IBM. Spending is significantly down for Micron Technology Inc., but the focus is on 0.25-micron technology, as witnessed by the recent announcement of a $150 million order by Micron for mostly deep-UV and some advanced i-line steppers. Also, capital spending from Asia/Pacific companies is expected to increase by about 40 percent in 1997 in America. As noted, equipment orders were placed for the first fabs in the United States for Samsung and TSMC (Tech Semiconductor), but orders are expected in the second half for Hyundai, White Oak Semiconductor (a Motorola/Siemens joint venture), and Dominion Semiconductor (an IBM/Toshiba joint venture). It is clearly evident that logic-oriented companies with a primary capacity base in the United States will also come back into the investment picture, finishing up projects started but left incomplete. We would be cautious about new projects being announced, however, as these companies will likely take advantage of the favorable foundry pricing environment before acting on rather risky capital investment plans.

Japan: DRAM Capacity Additions Stop, Investment in Technology Is Under Way

Japan's 7 percent decrease in capital spending in 1996 was really an 8 percent increase on a yen basis, because Japanese companies were among the first to cut capital investment and retrench. Despite the early cutback in spending, Dataquest forecasts the Japanese region's 1997 capital spending decline to be stronger than the worldwide average, based on the strong dependence on memory products, with growth returning in 1998. Lagging investment patterns in Japan are expected to continue throughout the decade.

Some of the Japanese electronics giants that experienced good profit growth in 1995, driven by semiconductor operations, have seen those profits evaporate with the precipitous fall of DRAM prices. Although spending on capacity has essentially stopped, two other types of investments are likely to be important in Japan now through 1998.

First, Japanese companies will invest in any new technology and equipment targeted at 0.25-micron production. This technology will not likely be in volume production until 1999, but the Japanese companies are expected to take advantage of this slowdown to understand and progress down the learning curve on these new process technologies. Second, the

Japanese companies found that the shells built in 1990 and 1991 became an asset during the ramp in 1993 and 1994. After building a fab shell, equipped with a skeleton equipment set, they were positioned to more quickly ramp up production when the market turned up. We see that pattern repeating, so we would expect several new fabs to be started in 1997, at very low run rates, however. Once these fabs are in place, Japanese companies can review the market every six months, making course corrections in April and October, as they have been doing through the last cycle ramp.

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, although diversification has come to the forefront again there. Japanese companies are in the process of refurbishing their fabs to support what they call "portfolio" production (mixed product manufacturing)—there will be fewer dedicated DRAM or logic fabs. Most fabs will be ready to produce any product, following closely the trends in the market. Japanese companies will continue to invest within Japan, particularly in the near term with the weaker yen, but will grow to depend on production outside of Japan as well. Dataquest is therefore forecasting a below-average CAGR of 9.5 percent in Japan for 1996 through 2002.

Europe Sustains Its Presence as a Growth Market, Even in 1997

As did the United States, Europe experienced a slowdown during 1996, with capital spending growing 12.9 percent. While SGS-Thomson Microelectronics B.V. and Siemens AG remained strong, Philips Semiconductors Inc. and the Japanese companies significantly pulled back investment in capacity. For 1997, Dataquest expects a surprising increase in spending—about 9 percent, compared to the 11 percent decline forecast six months ago. The strength comes from strong investments by Siemens and SGS-Thomson, with increases of almost 31 percent and 17 percent, respectively, over last year. Both companies rose this year into the top 10 worldwide spenders. For 1998, spending is expected to be flat to down because we expect multinationals will ramp their domestic memory fabs before Europe's. All three big Korean companies have now announced plans for fabs in Europe to come on line during 1999, with only Samsung undecided about the exact location.

Dataquest is expecting Europe to be a reflection of the overall worldwide market because there is now a good mix of multinational investment in the region. Europe is at equilibrium with the world, with a stable percentage of the demand and production mix. This stability is what has attracted more companies to produce in the region. Europe is viewed as a strategic location for production longer term to take better advantage of European import tariff laws and memory growth in the future driven by PC production. We therefore expect Europe to be a near-average investment region in the long term, with a six-year CAGR of 13.5 percent.

Asia/Pacific Investing Focuses on Foundry Near Term as DRAM Falls

The often-erratic but long-term semiconductor capital spending growth in the Asia/Pacific region continued at a market-leading pace of 37 percent growth in 1996. However, the tide has turned in the DRAM area, and we are forecasting the Asia/Pacific region to be hit the hardest in 1997, with a 23 percent decline in capital spending and a flat-to-down 1998 as the foundry industry deals with oversupply and the DRAM market remains under pressure. Longer term, we expect Asia/Pacific to exhibit among the most aggressive growth in capital spending of any region, but much closer to overall market growth rates than in the recent past.

Spending in the Asia/Pacific region comes from primarily two areas, DRAMs and foundry capacity. The Korean conglomerates have fully succumbed to the inevitable reality of overcapacity, with significant cutbacks for 1997 and a fair percentage of the remaining investment being placed strategically in overseas fabs. Spending within Korea at present is truly abysmal when compared with recent history.

The real story of interest is in Taiwan. A mostly new crowd of Taiwanese companies that entered the DRAM manufacturing business, spending over $1 billion collectively in 1995, increased spending feverishly in 1996 to spend over $2 billion in DRAM capacity. Yet many companies in Taiwan are tied strategically to companies outside the region, lending some investment stability there in the near term. Winbond, Powerchip, Nan Ya Technology, and Macronix have activities tied to Japanese companies, with Mosel Vitelic tied to Siemens.

The foundry industry is now a *strategic* industry rather than simply a tactical one, but it has now also become susceptible to the general industry overcapacity, with dramatically falling prices for processed wafers in the second half of 1996. Despite this price action, companies like TSMC, Chartered Semiconductor, and UMC are continuing to spend more in 1997 and plan to continue spending heavily in 1998.

The reason for the continued interest in spending capital in this area comes from the fact that the core business is dependent on logic and PC unit demand rather than DRAM. Further, Dataquest estimates that only about 28 percent of the contracted manufacturing of semiconductors originated from fabless companies in 1996, but the trend of this share is increasing. The remainder is from IDMs that wish to manufacture lower-value-added products away from their own facilities 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 foundries (in some cases) as a growth strategy.

There have been several noticeable casualties, two foundries and a DRAM venture. This is indicative of the overcapacity and the fact there is little room for new entrants.

Who's Investing Where?

In the capital spending survey recently completed, Dataquest gathered a picture of how money is being spent. Table 2-5 summarizes how companies based in different regions are spending their money abroad for 1996, and Table 2-6 summarizes the same for 1997. About 77 percent of money spent went into domestic economies worldwide in 1996, and that ratio is expected to increase slightly to 79 percent in 1997, because companies tend to cut back externally first.

Asia/Pacific companies have historically placed all of their investments domestically, but 1994 was the first year of diversification, which continued in 1995. Asia/Pacific companies spent about 14.3 percent of their money abroad in 1996, and this is likely to increase to about 16.4 percent in 1997. We would expect this ratio to increase further over the next two to three years. European companies have been the most aggressive capital exporters, historically, placing only 59 percent of their investment inside of Europe in 1995. This figure grew slightly to 68 percent in 1996, but has declined slightly in 1997 to 66 percent, to a large extent as a result of Siemens' investment in the White Oak facility in the United States.

Japanese companies are very close to the worldwide average with about 77 percent domestic investment in 1995, rising to 80 percent in 1996 and 81 percent in 1997. North American companies are also high domestic spenders, with about 73 percent staying at home for 1995, declining to just below 70 percent in 1996, but likely to increase to 78 percent in 1997. Dataquest would expect both of these groups to fluctuate between 70 and 80 percent long term, depending on market conditions.

The North American and Japanese regions are net investors, while European and Asia/Pacific regions are net beneficiaries of that investment. This parallels those regions being net exporters and net importers of semiconductors, respectively. However, the net balance in 1997 for each regional market is smaller than that of prior years as a result of the general contraction in spending.

Table 2-5
Regional Investment Patterns of Semiconductor Manufacturers in 1996
(Millions of U.S. Dollars)

	Worldwide	North America	Japan	Europe	Asia/ Pacific	Percentage of Worldwide Spending
American Companies	15,413.1	10,457.5	362.2	1,266.8	3,326.6	34.6
Japanese Companies	11,159.9	907.8	8,912.9	675.5	663.8	25.1
European Companies	3,672.2	385.7	18.0	2,501.0	767.4	8.2
Asia/Pacific Companies	14,268.9	916.5	944.5	184.0	12,223.9	32.1
All Companies	**44,514.2**	**12,667.6**	**10,237.6**	**4,627.3**	**16,981.7**	-
Percentage of Worldwide Spending	-	**28.5**	**23.0**	**10.4**	**38.1**	**100.0**

Source: Dataquest (July 1997)

Table 2-6
Regional Investment Patterns of Semiconductor Manufacturers in 1997
(Millions of U.S. Dollars)

	Worldwide	North America	Japan	Europe	Asia/ Pacific	Percentage of Worldwide Spending
American Companies	14,488.8	11,229.0	337.8	1,632.9	1,289.1	35.6
Japanese Companies	9,926.3	802.6	8,037.8	556.1	529.9	24.4
European Companies	3,779.9	673.5	0.0	2,488.2	618.2	9.3
Asia/Pacific Companies	12,548.4	1,278.9	399.2	380.7	10,489.7	30.8
All Companies	**40,743.4**	**13,984.0**	**8,774.8**	**5,057.8**	**12,926.9**	-
Percentage of Worldwide Spending	-	**34.3**	**21.5**	**12.4**	**31.7**	**100.0**

Source: Dataquest (July 1997)

Dataquest Perspective: Sluggish Growth and Technology Focus Continues

The capital spending boom that began in 1993 ended in 1996. The industry is now in what we would characterize as a two-year "pause," with investment in capacity. Dataquest believes that capital investment will be in for sluggish business conditions through at least the middle of 1998 before a sustainable recovery can start. Fundamentals of capacity supply and demand balance simply do not support a major recovery occurring in 1997 or early 1998 for either memory or mainstream logic. Companies will continue to invest in technology, with shifting emphasis from 0.25-micron technology toward 300mm.

Dataquest's quarterly forecast profile shows weakness in the market from 1997 well into 1998 before a recovery starts much later in 1998. Here are specific points for which to watch:

- We expected the third quarter to be strong in the United States and Taiwan during 1997 but relatively weak in Korea and Japan. Coupled with a seasonally weak pattern from Europe, this meant basically a flat quarter. However, because U.S. and European equipment companies were better positioned in Taiwan and the United States, the market "felt" stronger than it really was when looking at the Semiconductor Equipment and Materials International (SEMI) North American book-to-bill ratios and reports on the stock market.
- In a recent survey of purchasing managers published by SEMI outlining the plans for 1997 spending, fourth quarter 1997 looked extremely weak. This survey, which excludes the Japanese companies but does survey over 80 percent of the remaining market, indicates that orders were expected to be down across all regions and collectively down over 15 percent. Dataquest believed that the Japanese companies would temper this and that some weakness actually appeared sooner.
- During 1998, the industry will shift its focus strongly to 300mm shipments. The bulk of the growth will come in the late second half. The vast majority of the growth in Dataquest's 1998 capital spending forecast comes from the investment in 300mm pilot lines. We expect that capacity purchases will be relatively flat with 1997 levels but will accelerate with the Japanese companies, probably starting in the fourth quarter of 1998.

Longer term, the pervasive strength of the semiconductor industry will drive capital spending to more than double 1997 levels by 2001.

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 issues. The current slowdown in capital spending correlates directly with the pricing debacle of the past two years—from a supplier's perspective. Although supplies of semiconductors are expected to remain good for the next four to six quarters, strategic technology investments are still needed for many companies. Long-term decisions about semiconductor sourcing require suppliers with a solid technology foundation and 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 comparison with total expenses, give a good picture of where a supplier plans to go. Doing a similar analysis of R&D spending versus sales and total expenses is also helpful as an early indicator of potential problems. 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.

For More Information...

Mark Giudici, Director and Principal Analyst .... (408) 468-8258
Internet address .... mark.giudici@dataquest.com
Via fax .... (408) 954-1780
Dataquest Interactive .... http://www.dataquest.com

Dataquest
A Gartner Group Company

DATAQUEST WORLDWIDE OFFICES

NORTH AMERICA
Worldwide Headquarters
251 River Oaks Parkway
San Jose, California 95134-1913
United States
Phone: 1-408-468-8000
Facsimile: 1-408-954-1780

East Coast Research Center
Nine Technology Drive
P.O. Box 5093
Westborough, Massachusetts 01581-5093
United States
Phone: 1-508-871-5555
Facsimile: 1-508-871-6262

Dataquest Global Events
3990 Westerly Place, Suite 100
Newport Beach, California 92660
United States
Phone: 1-714-476-9117
Facsimile: 1-714-476-9969

EUROPE
European Headquarters
Tamesis, The Glanty
Egham, Surrey TW20 9AW
United Kingdom
Phone: +44 1784 431 611
Facsimile: +44 1784 488 980

Dataquest France
Immeuble Défense Bergères
345, avenue Georges Clémenceau
TSA 40002
92882 - Nanterre CTC Cedex 9
France
Phone: +33 1 41 35 13 00
Facsimile: +33 1 41 35 13 13

Dataquest Germany
Martin-Kollar-Strasse 15
D-81829 München
Germany
Phone: +49 89 42 70 4-0
Facsimile: +49 89 42 70 4-270

JAPAN
Japan Headquarters
Aobadai Hills 4-7-7
Aobadai
Meguro-ku, Tokyo 153
Japan
Phone: 81-3-3481-3670
Facsimile: 81-3-3481-3644

ASIA/PACIFIC
Asia/Pacific Headquarters
Suite 5904-7, Central Plaza
18 Harbour Road, Wanchai
Hong Kong
Phone: 852-2824-6168
Facsimile: 852-2824-6138

Dataquest Korea
Suite 2407, Trade Tower
159 Samsung-dong, Kangnam-gu
Seoul 135-729
Korea
Phone: 822-551-1331
Facsimile: 822-551-1330

Dataquest Taiwan
11F-2, No. 188, Section 5
Nan King East Road
Taipei
Taiwan, R.O.C.
Phone: 8862-2756-0389
Facsimile: 8862-2756-0663

Dataquest Singapore
6 Temasek Boulevard, #26-02/03
Suntec City Tower 4
Singapore 038986
Phone: 65-333-6773
Facsimile: 65-333-6768

Dataquest Thailand
12/F, Vanissa Building
29 Soi Chidlom
Ploenchit Road
Patumwan, Bangkok 10330
Thailand
Phone: 662-655-0577
Facsimile: 662-655-0576

Dataquest Australia
80 Alfred Street
Milsons Point NSW 2061
Australia
Phone: 61-2-9941-4860
Facsimile: 61-2-9941-4868

Dataquest
A Gartner Group Company