Semiconductor Procurement

Source: Dataquest

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Welcome to Dataquest Semiconductor Procurement

You are in the *Source: Dataquest* binder

An annually updated collection of reference documents for the Semiconductor Procurement service. Worldwide and regional market statistics; *Company Backgrounders;* and several guides such as *How to Use Dataquest, Dataquest Research Methodology, Dataquest High-Technology Guide—Segmentation and Glossary* are contained in this binder.

Other Semiconductor Procurement service binders:

Dataquest Perspective

A series of multitopic publications that provide analysis on worldwide semiconductor procurement issues, regional pricing updates, and semiconductor news and views.

Semiconductor Procurement

Source: Dataquest

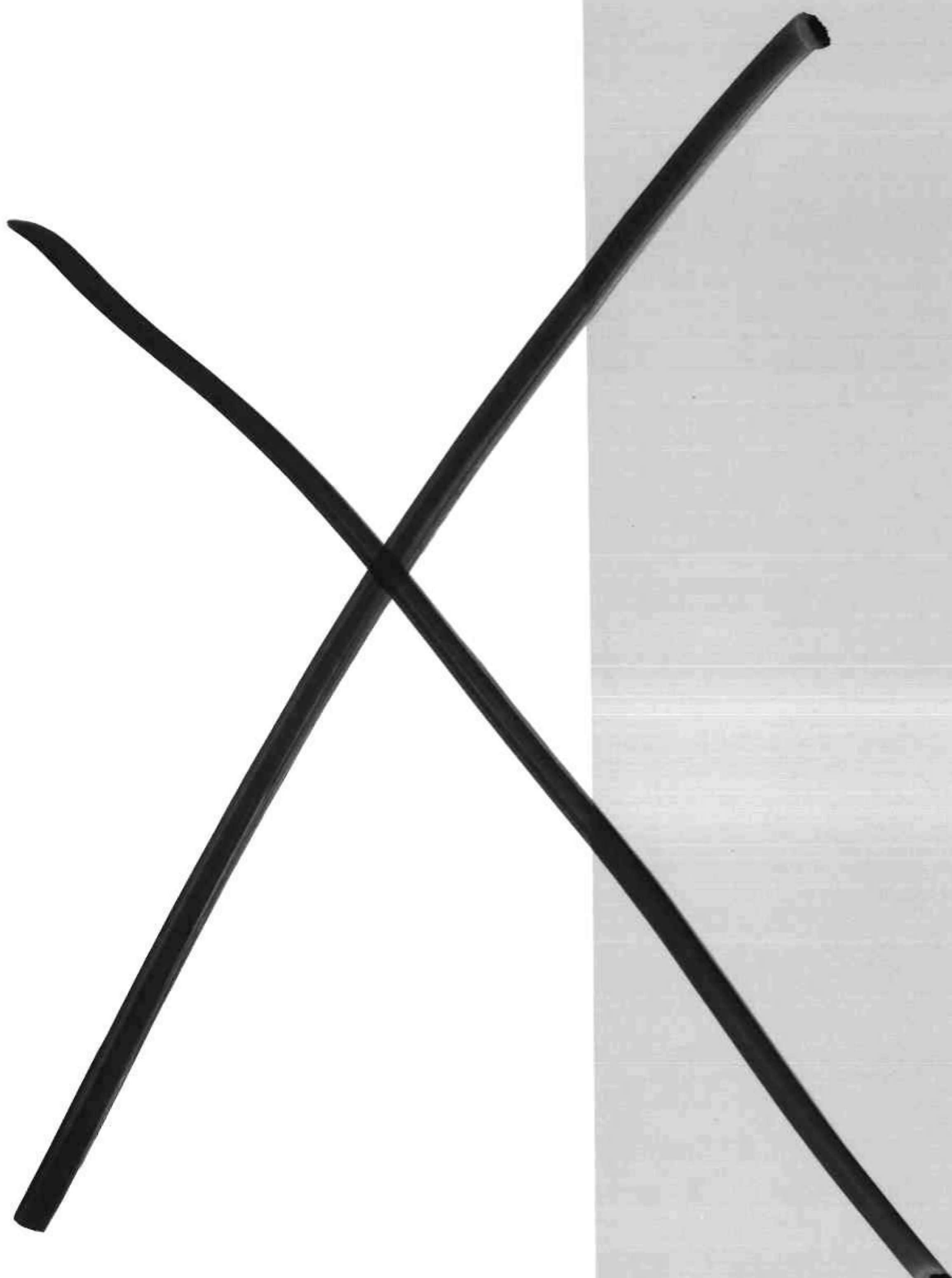
Table of Contents

Guides

Market Statistics

Company Backgrounders

*This document will be shipped in the fourth quarter of 1991.



Dataquest

How to Use Dataquest

Source: Dataquest

Dataquest

How to Use Dataquest

Dataquest

A worldwide network of information-gathering resources

Source: Dataquest

Published by Dataquest Incorporated

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Chapter 1

A Guide to Help You Get the Most Out of Your Dataquest Information Resources

Introduction

As a Dataquest client, we want you to obtain the greatest possible value from your subscription. This guide will acquaint you with the available information resources and will help you establish a "user strategy" that ensures that Dataquest's products and services contribute to your success.

This guide is divided into the following sections:

- Your Industry Service: What's in It for You?
- How to Use Your Industry Service
- Customizing Your Industry Service
- Whom Do You Call at Dataquest?
- About Dataquest
- Subscription Terms
- Appendixes
  - Appendix A: Dataquest Information Resource Center CD-ROMS and Computer Databases
  - Appendix B: Dataquest 1991 Conference Schedule
  - Appendix C: Technology Products

Chapter 2

Your Industry Service: What's in It for You?

Clients can tap into Dataquest's extensive knowledge base to support their decision-making process in the industries and markets that we track. The information and analysis that you receive from Dataquest can help you to better:

- Evaluate markets
- Position new products
- Develop marketing strategies
- Perform competitive analysis
- Understand end-user trends
- Verify critical market assumptions
- Assess emerging technologies
- Implement and execute tactical plans
- Support your ongoing research activities

As a Dataquest client you will receive much of this information automatically through the regular publication of database documents and industry analysis. Your industry service also provides information, available at your initiation, that is specific to your company's needs. You will receive Dataquest information through a variety of forms, including:

- *Source: Dataquest*
- *Dataquest Perspectives*
- Inquiry support
  - Industry Analysts
  - Client Inquiry Centers
- Dataquest Information Resource Center

Source: Dataquest

The *Source: Dataquest* binder is an annually updated collection of reference documents. The binder contains worldwide and regional market statistics, *Company Backgrounders*, and several guides.

Guides

- *How to Use Dataquest*: Describes your industry service subscription, publications, inquiry privileges, phone contacts, library use, and other services.
- *High-Technology Guide—Segmentation and Glossary*: Lists key terms and defines the market segments, products, applications, regions, distribution channels, and environments tracked by Dataquest.
- *Dataquest Research Methodology*: Details the research methodology used by Dataquest to gather data and information and provides the general assumptions used to generate industry forecasts.

Market Statistics

Market Statistics documents provide clients with detailed tables consisting of product shipments, average selling prices, industry revenue, forecasts, and market share data.

Company Backgrounders

Each service provides its clients with a set of *Company Backgrounders by Dataquest*, made up of companies that represent 80 percent of the revenue of that industry. *Company Backgrounders* are produced by the Strategic Company Analysis group in Research Operations. The documents contain useful information on a company's finances, product lines, sales and manufacturing locations, and joint ventures, mergers, and acquisitions.

Dataquest Perspective

This multitopic publication, delivered on average twice a month, contains timely analysis of markets, products, technologies, companies, and industry events, and provides detailed discussions of our market projections and market share statistics. These publications are filed chronologically, and include a quarterly index that cross-references articles by company name and major topic. They may be supplemented as needed by the timely delivery of faxes that provide information and analysis of current significant events.

Please note that all of Dataquest's written material is copyrighted and therefore may not be copied without our permission.

Inquiry Support

Inquiry—via phone, fax or letter—is an integral part of the service Dataquest provides. Through inquiry you can:

- Clarify or interpret information.
- Explore Dataquest information in more depth.
- Discuss the application of this information to a particular situation.
- Access information that is not available in Dataquest publications, but is available in Dataquest's extensive files.

Each Dataquest client has a designated binderholder. In addition to receiving all the Dataquest published materials, the binderholder serves as the liaison between Dataquest and your company.

The binderholder has access to Dataquest's inquiry privilege and may designate up to two people to serve as alternates for inquiry privileges. Dataquest account managers need to be aware of any designated alternates.

If someone calls who is not a binderholder or alternate, Dataquest will refer that person to the account manager for your company. We have a commitment to our clients to provide them with timely, high-value information. In order to do that, services must be restricted to authorized contacts.

Call Your Industry Analyst

Industry analysts have significant industry expertise. Directly or through the assistance of Client Inquiry Center (CIC) personnel, you have access to the industry analysts associated with your service. This access is on an as-required basis relative to those markets, products, and technologies within the scope of your service. Analysts may be called directly when you know exactly what you need and who at Dataquest can provide the information.

Call the Client Inquiry Center

Many of Dataquest's services provide a Client Inquiry Center (Enquiry Desks for European customers). These centers are responsible solely for the quick turnaround of your fact-based questions. CIC personnel have access to industry service publications and database information, and they are trained to help you locate information within your Dataquest service. CIC personnel will also put you in touch with appropriate industry analysts when you require in-depth analysis of issues and trends, or opinion about the implications of recent industry events. The CIC may be called when you need an answer to a fact- or data-related question, when you need a backup to your regular analysts should they not be available, or when you need direction to new areas as your questions develop.

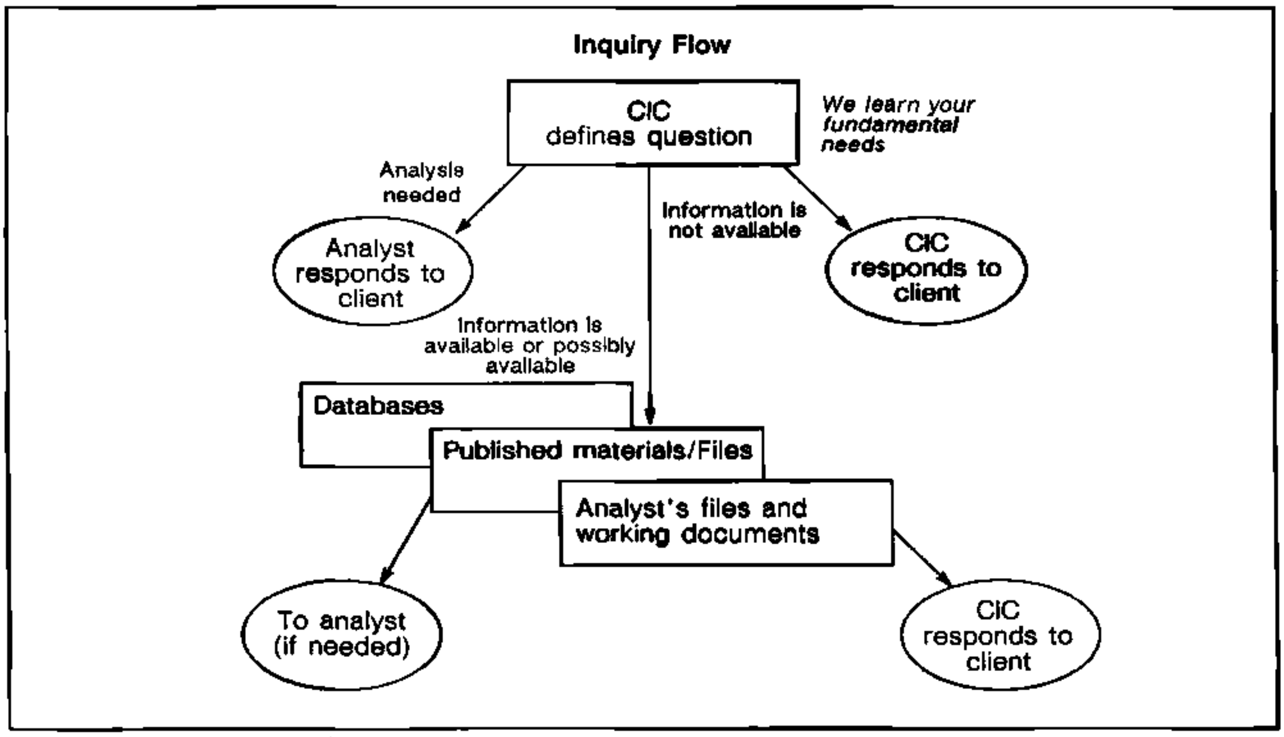
Dataquest is committed to personally handling each of your calls. Figure 2-1 illustrates how inquiries in the CIC are handled. We will ensure that you are put in touch with the right individual, or if you wish, you may choose to leave a voice-mail message when a particular analyst is not immediately available.

The more Dataquest knows about your inquiry, the better we will be able to help you. When you call with a question, the CIC will want to know:

- What information you already have on the subject
- What related information you are gathering
- How you plan to use the information
- What you are trying to demonstrate

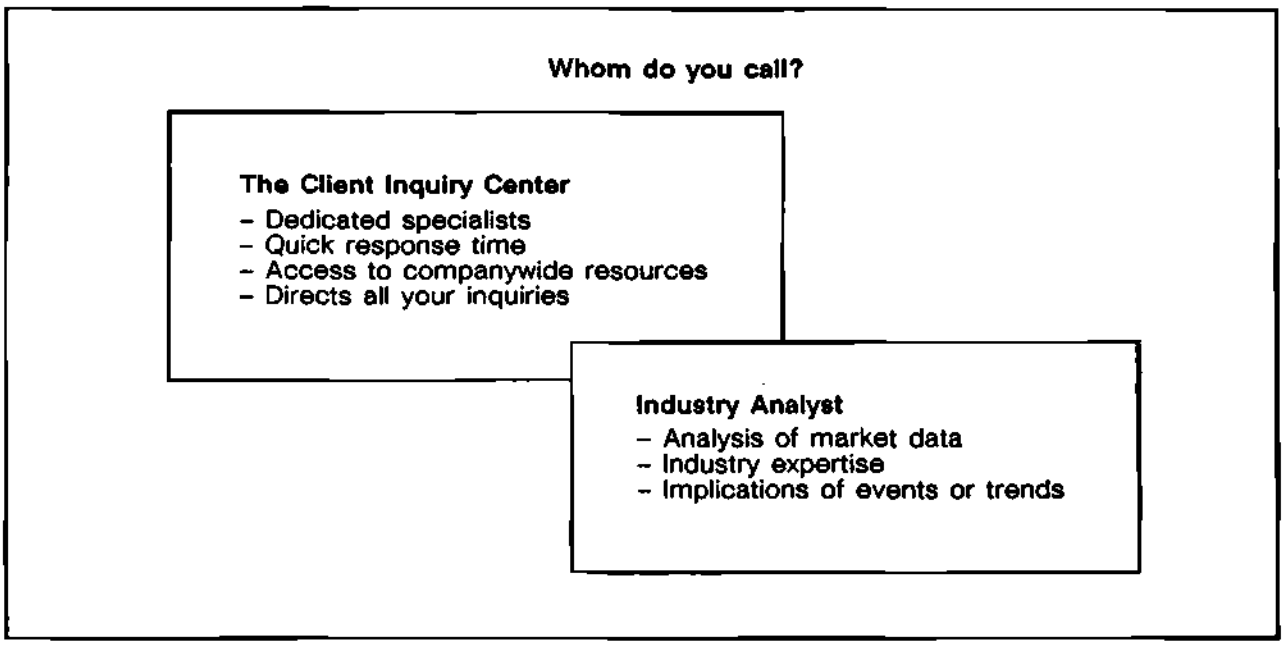
It will also help us to know what stage of the market research process you are in, as well as the depth of information you require. The more we know, the better we will be able to offer additional or related information, or offer insights into different ways to approach the question. Of course, tell us only what you are comfortable with—we don't need or want to know proprietary information. Figure 2-2 shows the mix of people available to respond to your inquiries.

Figure 2-1
Client Inquiry Center Flow



Source: Dataquest (April 1991)

Figure 2-2
Whom to Call for Your Inquiry



Source: Dataquest (April 1991)

Information Resource Center

Dataquest's Information Resource Center (IRC) is a valuable supplement to the information delivered through your industry service. It consists of a 1,200-square-foot corporate library in San Jose, plus two major satellite libraries located in Boston and the United Kingdom. The IRC maintains a wide selection of industry directories, trade press periodicals, financial reports from most of the publicly held companies followed by Dataquest industry services, government reports, and CD-ROM-based and on-line information services.

The European Corporate Library maintains more than 300 titles and reference works concerning the European Community, including approximately 30 files and 100 reference works on the 1992 single European market objective. The U.K. library collection includes basic reference works produced by Her Majesty's Government, the Department of Trade and Industry, and other governmental agencies. Special reports have also been collected from a variety of sources, including the U.K. government, trade associations, the Financial Times, and other research organizations.

Appendix A lists the CD-ROMs and computer databases available to clients at the San Jose IRC. The San Jose IRC is staffed by three degreed professionals (Master of Library Science), as well as assistants who specialize in managing the corporation's secondary research resources.

Clients typically use the IRC in the following ways:

- To obtain financial information on the leading companies within their industry
- To collect recent publications on new areas of the market
- To research a market or topic not covered by a Dataquest industry service

You are encouraged to use the IRC. If it is not convenient to visit an IRC, your Client Inquiry Center staff can often make many of the center's resources available to you through your inquiry privilege.

Policies and Procedures

Because the IRC is a private company library, our collections are limited to the following individuals:

- All permanent Dataquest employees
- Current clients—Binderholders and designated alternates from within the client company
- Consultants/contractors working on specific Dataquest projects (only for duration of contract)
- Prospective clients escorted by a Dataquest salesperson

Non-Dataquest Consultants

It is Dataquest policy to deal directly with Dataquest clients in answering their information needs. The Information Resource Center does not authorize the use of library facilities by consultants working for clients.

Chapter 3

How to Use Your Industry Service

Receiving value from your industry service requires knowing where to find the information you need and how to use that information. The following guidelines will help you get the most out of the many elements of your service.

What Written Materials Will You Receive?

You will receive written material at least twice a month. Some industry services are segmented into key market areas (product or geographic) to allow you to choose the coverage that is most relevant to the markets in which you participate. You will receive written material covering both the broad-based issues of the industry as a whole, as well as the more focused issues of the particular market segment. All written material will be labeled as belonging to one of the following:

- The *Source: Dataquest* binder
- The *Dataquest Perspective* binder
- The segment binder

Source: Dataquest

Source: Dataquest is a regularly updated reference binder in which you'll find the following:

- *How to Use Dataquest:* You are currently in this document.
- *Dataquest High-Technology Guide—Segmentation and Glossary:* This document describes in detail the segmentation and terms used by all Dataquest services to define the markets they track. This guide should be used whenever you are looking for definitions of products, applications, regions, technologies, and environments referred to by your industry service. This document also provides you with standard definitions of research terms that appear in your industry service publications, such as retirements, average selling price, and compound annual growth rate.
- *Dataquest Methodology:* This document will help you understand the research methodology Dataquest uses to gather information on the industries covered by our industry services. It also describes the general assumptions used to generate industry forecasts.
- *Market Statistics:* Each Dataquest industry service provides its clients with documents that contain detailed tables consisting of history, market forecasts, and market share data. We encourage you to use these tables as an opportunity to review your business outlook with Dataquest analysts. Updates and detailed discussions of these data are provided in the *Dataquest Perspective* on an ongoing basis. For segmented services, top-level market statistics are provided in the *Source: Dataquest* binder, and the more detailed statistics for each segment can be found in each segment binder.
- *Company Backgrounders:* You will receive a set of *Company Backgrounders*—profiles on the top players in your industry. These documents are published annually. You should refer to them for corporate overview information, such as financial reports, product line descriptions and analysis, sales and manufacturing locations, and joint ventures, mergers, and acquisitions.

With the exception of the *Company Backgrounders,* these documents will be individually bound and delivered annually or twice yearly, as required. Each *Company Backgrounder* will be updated once a year and will be shipped shortly after the close of the fiscal year for that company. At the time of arrival, the earlier version of the document should be removed from the binder and archived as desired so that the most recent information will be easily accessible to you.

Dataquest Perspectives

Dataquest Perspectives are designed to deliver analysis and Dataquest's view of important issues in your industry. This is a multitopic publication delivered twice a month that contains articles under the following major topic headings:

- Market Analysis: These articles may cover either a product market, regional market, application market, or a distribution channel. Industry service forecast updates are presented and discussed in this section of the *Dataquest Perspective.*
- Product Analysis: These articles analyze the impact of new products on the industry.
- Company Analysis: This section highlights new activities or organizational changes within companies. The articles provide more in-depth analysis of a company's product strategy, financial performance, or marketing performance and strategy than is contained in the *Company Backgrounders.* Articles may also be written about companies for which there is no *Company Backgrounder.*
- Technology Analysis: This section analyzes the impact of key or emerging technologies on your industry. These articles are designed to assist you in strategic and competitive evaluations.
- Conferences and Exhibitions: These articles will identify important industry trends and analyze key events at the conferences and exhibitions attended by Dataquest analysts.
- News and Views: These shorter articles provide Dataquest's perspectives on major industry events.

Dataquest Perspective offers a twice-monthly opportunity to engage your industry service analysts in discussion of the issues and events contained in each publication. For this reason, we provide the name of the author of each article along with a brief synopsis. Clients are encouraged to call the appropriate analyst with questions or a request for more information.

How Do You File Your Written Materials?

Your *Source: Dataquest* binder holds a collection of reference and statistical material. Each document that belongs in this binder will be clearly marked as such and should be filed behind the appropriate tab as indicated in the Table of Contents. Outdated sections should be either discarded or filed separately for archival purposes.

Clients will receive at least 24 *Dataquest Perspectives* each year. These should be filed in the *Dataquest Perspective* binder in chronological order. If you subscribe to a segmented service, at least 4 of your 24 annual *Dataquest Perspectives* will focus on issues specifically related to the markets covered under that industry segment. The industrywide *Dataquest Perspectives* are filed in the core *Dataquest Perspective* binder, and the segment-specific editions are filed in the segment binder.

Each *Dataquest Perspective* will be identified by the name of the service and the name of the segment, if appropriate. It will also have the date, volume, and number on the first page. For example, a subscriber to the Telecommunications—North America service may receive the following two *Dataquest Perspectives:*

- Telecommunications—North America
  Vol. 1, No. 1
- Telecommunications—North America
  Image Communications
  Vol. 1, No. 1

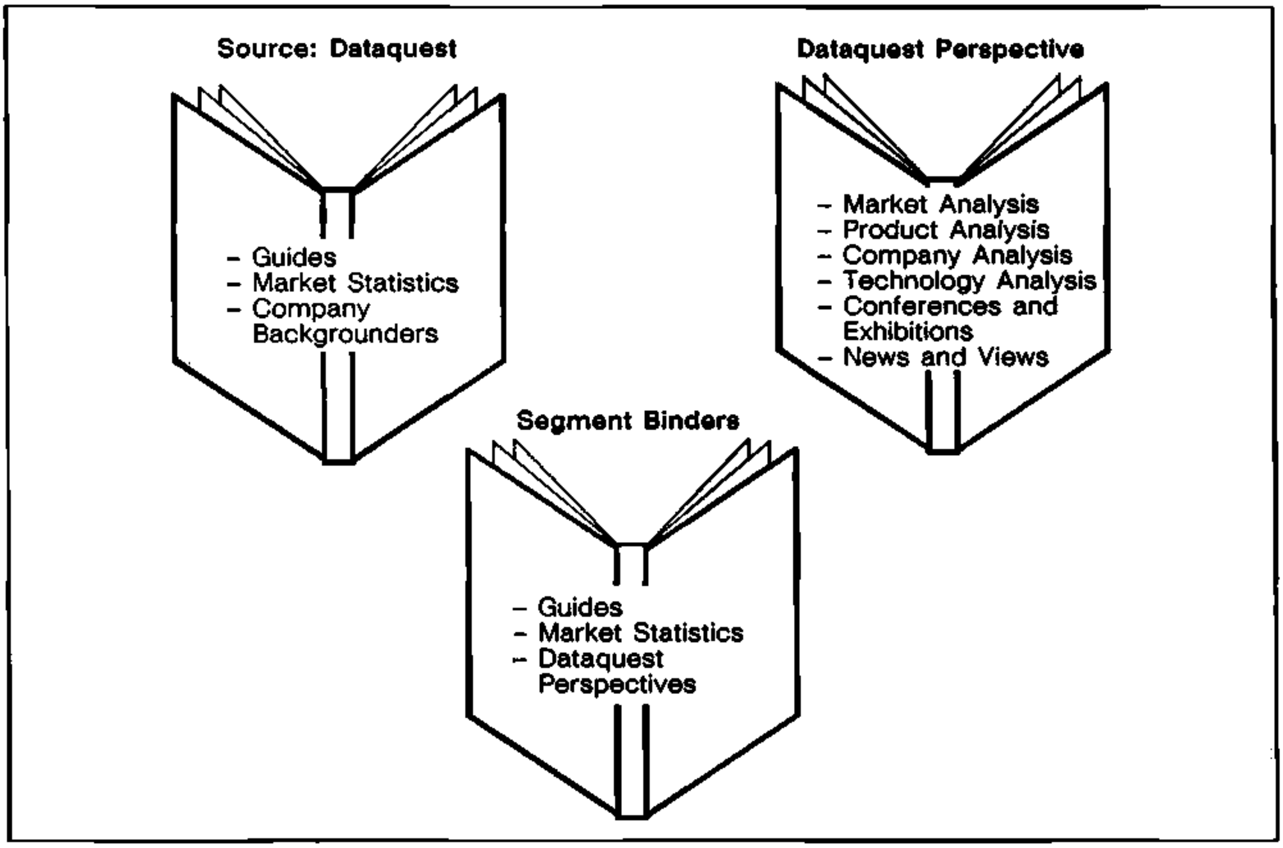
The first document would be filed in the core Telecommunications—North America *Dataquest Perspective* binder. The second would be filed in the Image Communications segment binder.

The contents of your binders are illustrated in Figure 3-1. Subscribers to a standalone European country segment will receive detailed market statistics for that particular country, top-level European statistics, and the pan-European Perspectives. The binder contents are illustrated in Figure 3-2.

How Do You Find the Written Material?

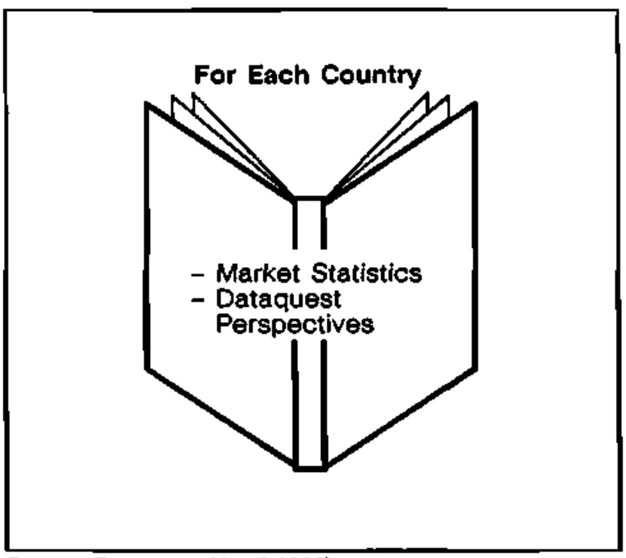
Dataquest is committed to not only providing you with the highest quality research, but also

Figure 3-1
Contents of Your Binder



Source: Dataquest (April 1991)

Figure 3-2
Standalone European Country Binder Contents



Source: Dataquest (April 1991)

making it easy for you to access the information. Clients are provided with the following tools:

- The spines of all binders list the types of information you will find in that binder.
- "What's in This Binder?", appearing immediately following the title page, summarizes the documents in that binder and highlights what can be found in other binders of that service.
- A detailed Table of Contents is contained in the *Source: Dataquest* and segment binders.
- Each bound document in the *Source: Dataquest* and segment binders has its own Table of Contents, including a list of tables where appropriate.
- To help you access the articles you need in a timely manner, Dataquest provides you with a comprehensive index which is delivered quarterly and provides a year-to-date

cross-reference by company name and major topic. The index lists the titles of all articles and of all tables and figures that appear in issues of the publication. Listings include the title, date, and page number for each entry. The first page of each quarterly index provides an explanation of how the index can best be used, along with an example. Segment Perspectives are indexed separately and incorporated into the year-end index provided for the entire service.

Chapter 4

Customizing Your Industry Service

As a subscriber to a Dataquest syndicated market research service, clients receive significant tactical and strategic information. Dataquest also offers a variety of individualized and proprietary programs to clients to help them solve their specialized information and analysis needs. Each project is treated with the strictest confidence.

We carefully review each project with the client prior to beginning the actual research. Dataquest's consulting staff designs a research plan that most effectively meets each client's unique requirements. This includes determining the appropriate information to be gathered, the proper sample size, appropriate collection techniques, and the best analytic methods to be used.

Custom Consulting

Dataquest's custom consulting helps clients in any of the following ways:

- Analyzing specific markets and competitive environments
- Developing strategies for increased market penetration
- Evaluating new business, product, and distribution plans
- Verifying critical market assumptions
- Assessing the impact of emerging technologies on existing products and markets
- Assisting in developing international business strategies, including:
  - Identifying strategic partners, both domestic and international
  - Defining technology "fits"

Custom consulting is structured to provide assistance across all TID services beyond the scope of each service. In areas where new, original work is needed, consulting provides value not only through its own individualized proprietary efforts, but also through its integration of TID information and analysis resources.

Among the elements that consulting can bring to a project are specialized planning assistance, proprietary analyses, in-person interviews, mail surveys, telephone surveys, focus groups, and custom database cuts.

Multiclient Studies

Custom Consulting engages not only in full-custom research projects, but also in the generation of multiclient studies. These studies allow Dataquest to offer clients in-depth information on emerging and/or niche markets at an amortized cost for consulting.

Retainer Consulting

Dataquest also offers its clients retainer consulting. Dataquest analysts and consultants provide consulting advice on an ongoing basis and with quick turnaround to address a variety of client management and marketing needs.

Primary Research

Dataquest's Primary Research services offer a comprehensive range of survey research capabilities that can provide vital information tailored to each client's specific needs. This is important when survey work, but not analysis, is needed. Studies of any type, size, or aspect can be performed as a supplement to existing market research efforts, when nonbiased third-party research is required, or to provide complete primary research capabilities when company resources are not available. Primary Research assumes total responsibility for a project at any stage, from questionnaire development through sample selection, data collection, and final tabulation. The following are examples of the broad range of business applications addressed by Primary Research:

- Market penetration surveys
- Customer needs and satisfaction surveys
- New product research
- Product pricing and positioning surveys
- Annual trend surveys
- Installed base surveys
- Sales trend identification

End-User-Based Services

Score Reports

Customer satisfaction surveys track the level of satisfaction by users of PCs, copiers, electronic printers, PBXs, and public key systems. Key indicators measured include value for price, quality, commitment to customer, features, product delivery, technical documentation, and service. The Score Report is conducted four times a year so that manufacturers can monitor trends in end-user satisfaction levels over an extended period of time.

Score Reports are based on telephone interviews with an annual sample of over 5,000 respondents. A stratified sampling plan is used, with users selected randomly by vendor from a database of U.S. business establishments. No manufacturers' lists are used.

The Score Report survey meets the requirements for measuring customer satisfaction as defined by the Malcolm Baldrige National Quality Award. The Baldrige Award is granted annually by the U.S. Department of Commerce in recognition of U.S. companies that excel in quality achievements and management.

CPE Market Dynamics

This end-user information service provides quarterly data on PBX, Centrex services, and key systems users' purchases by manufacturer, system model, RHC region, state, and vertical market. There are two proprietary custom options, as follows:

- Product-Presence-Hit Rate (PPH) Analysis: Assesses a company's position in the marketplace as a function of product acceptance, distribution, or sales effectiveness.
- Win-Loss Analysis: This option takes PPH analysis one step further, delving into why systems sales are being won or lost by you and your competitors. A customized direct mail, telephone, or personal interview program is established to contact the appropriate end users.

Chapter 5

Whom Do You Call at Dataquest?

Clients who have questions or need assistance in any way are encouraged to call Dataquest at their earliest convenience. Table 5-1 is an overview of who to contact at Dataquest.

Table 5-1

Who to Contact at Dataquest

Question/Concern	Who to Contact
My subscription (e.g., billing, renewal)	My customer service representative
Subscribing to another service	My sales account manager
Data or facts about my industry	Client Inquiry Center
Opinion or analysis about my industry	Analyst in the service
Other services/products offered by Dataquest	My sales account manager
New services/products I would like Dataquest to offer or feedback on current offerings	Product Marketing
	Components: (408) 437-8624
	Systems: (408) 437-8517
	Telecommunications: (408) 437-8602
	Peripherals: (408) 437-8308
	Ledgeway: (617) 862-8500
An upcoming conference	Conference Department
	U.S.—(408) 437-8245
	Europe—(44) 895-835050
	Japan/Asia—(81) 3-5566-0416
A possible proprietary consulting project	Consulting Department, sales account manager, or service analyst
Library visits	Client Inquiry Center, service analyst, or corporate librarian in the U.K.
The new Dataquest format for research delivery	(408) 437-8215, or dedicated Voice Mail Hot Line: (408) 437-7878
Reprints of selected articles	Sales Department—Technology Products: (800) 624-3282

Source: Dataquest (April 1991)

Chapter 6

About Dataquest...

Dataquest was formed in 1971 with the sole purpose of delivering timely and accurate information on critical issues in the high-technology arena. Quoting from the Dataquest mission statement:

> "Our goal is to be the acknowledged worldwide leader in market intelligence for the industries we serve by providing indispensable information and analysis to our clients."

As a member of The Dun & Bradstreet family of companies, Dataquest has access to supplemental information from Dun & Bradstreet and its subsidiaries. Together with our own primary and secondary research capabilities and analyst expertise, this relationship offers the most comprehensive information available on topics pertinent to your industry.

Dataquest comprises two basic business units. Dataquest's Technology Information Division (TID) provides data and analysis on the high-technology electronics industry, encompassing semiconductors, systems, peripherals, application markets, software, and service and support. A cross-industry financial program supported by TID analysts and assigned account managers is tailored to the needs of the financial community. The Machinery Information Division (MID) offers a full range of marketing research and consulting services for professionals in all areas of the heavy equipment and material-handling industries.

The Technology Information Division

The information service you have purchased from Dataquest is part of our Technology Information Division (TID) family of products. TID provides information services that are both tactical and strategic in nature, and include syndicated industry services, custom consulting, multiclient studies, primary research, specialized information services for the financial community, product specification directories, and standalone reports on technology markets. These services are described in more detail in the following paragraphs.

There are five research groups within TID. Each provides data and analysis covering the global electronics industry from semiconductors to systems, from hardware to software, and from applications to service.

Semiconductor Group

This group covers the entire semiconductor "food chain," including manufacturing equipment and materials, device technologies and markets, and end-use applications and procurement issues. Its information services are worldwide in scope and include targeted North American, European, Japanese, and Asian services. The Semiconductor Group is divided into the following 9 services:

- Semiconductors—Worldwide
  - Segments:
    - Semiconductor Memories
    - ASICs
    - Analog and Mixed Signal ICs
    - Microcomponents
    - Gallium Arsenide Semiconductors
- Semiconductors—Europe
- Semiconductors—Japan
- Semiconductors—Asia
- Semiconductor Application Markets—Worldwide
- Semiconductor Application Markets—Europe
- Semiconductor Application Markets—Japan
- Semiconductor Procurement
- Semiconductor Equipment, Manufacturing, and Materials

Systems Group

This group covers business and technical computer systems and applications, both hardware and software, ranging from palmtops to PCs to supercomputers.

Computer Systems Services

The computer systems services cover the following six segments:

- Business Computers
- Servers
- Supercomputers
- Technical Computers
- Unix Systems
- Workstations

European Computer Systems

This service covers the same product areas for 14 European regions.

Microcomputer Systems Group

This worldwide service tracks and analyzes PCs by packaging type, microprocessor, operating system, price point, environment, and region of the world. It includes the following segments:

- Personal Computers—North America
- Personal Computers—Europe
- Personal Computers—Asia
- Personal Computers—European Quarterly Statistics
- Personal Computers—European Price Tracking

Business Applications

This service covers electronic equipment environments in the office that are primarily software driven and looks at the ways in which these environments drive their associated hardware markets. Business Applications is divided into two services:

- Office Software
- Personal Computer Software

Technical Applications

The CAD/CAM/CAE service provides information on four key applications: Mechanical, AEC, GIS/Mapping, and Electronic Design Automation. Its geographic coverage extends to North America, Europe, and Asia. The service is segmented as follows:

- Electronic Design Automation
- Mechanical Applications
- Architecture, Engineering, and Construction, and Geographic Information Systems
- Personal CAD
- CAD/CAM—Europe
- CAD/CAM—Asia

In addition, CASE is covered through consulting.

Telecommunications Group

The Telecommunications Group is divided into two services, the Telecommunications North America service and the Telecommunications Europe service.

These worldwide services divide their coverage of the industry into five major product segments, as follows:

- Image Communications
- Networking
- Personal Communications
- Public Network Equipment and Services
- Voice Communications

Regional market options include country-specific coverage of any of the following European countries: France, Germany, Italy, Netherlands, Spain, Sweden, and the United Kingdom.

Peripherals Group

This group covers markets for devices that are typically attached to multiuser host systems or serve an output function.

Computer Storage Service

The Computer Storage service covers the following four segments:

- Rigid Disk Drives
- Tape Drives
- Optical Disk Drives
- Flexible Disk Drives

Graphics and Displays Service

The Graphics and Displays service covers the following four segments:

- Graphics Processors
- Monitors
- Display Terminals
- Network Stations

Document Management Group

The Document Management group is made up of the following four services:

- Copying and Duplicating (including fax coverage)
- Electronic Printers—North America
- Electronic Printers—Europe
- Electronic Publishing

Ledgeway/Dataquest

Ledgeway/Dataquest is the group that provides strategic and tactical information on the fast-growing services industry. Computer systems vendors typically obtain 25 to 30 percent of their revenue from pre- and postsale services. In addition to services provided by manufacturers, there is a very large and fast-growing industry for professional and systems integration services. Ledgeway/Dataquest covers both of these market sectors.

Ledgeway/Dataquest offers 10 different subscription programs. All programs include access to Ledgeway/Dataquest analysts for inquiry support, periodic bulletins on key events in the service industry, and attendance at Ledgeway/Dataquest's annual ServiceTrends conference.

The ServiceTrends Program

The most widely subscribed service, now in its eighth year, is Ledgeway/Dataquest's ServiceTrends program. In addition to the cornerstone of the program, Ledgeway/Dataquest's annual two-volume *Trends and Forecast* report, which provides in-depth market size and forecast information and analysis of market trends, four topical reports are provided. In 1991, these topical reports are:

- *Global Support Strategies*
- *Measuring and Managing Customer Satisfaction*
- *Japan and the Pacific Rim: Customers or Competitors*
- *Self-Service: Opportunity or Threat*

The Professional ServiceTrends program features analysis of customer wants and needs for systems integration and professional services, in addition to a market trends report, which forecasts market size, growth rates, and analyzes trends. In addition, there are six profiles provided on leading participants in the industry.

Sector Market Programs

Sector market programs are focused on narrow segments of the service market and feature an annual market trends and forecast report, user wants and needs analysis, a pricing trends and data study (for all but the European ServiceTrends program), and six profiles of leading service vendors in each sector. Ledgeway/Dataquest's sector market programs are as follows:

- European ServiceTrends
- Independent/Multivendor Services

- Network/Communications Support
- Mini/Mainframe Software Support
- PC/Workstation Software Support
- Technical Workstation Service and Support
- PC/End-User Computing Services
- Channel Support Strategies

In addition to its subscription services, Ledgeway/Dataquest has a very professional and active custom consulting group that conducts custom projects focused on the following areas:

- Customer satisfaction and service quality audits
- Key competitor analysis and positioning
- New service product market analysis and strategy formation

Subscription services and custom consulting are provided covering worldwide markets.

The Executive and Financial Group

Dataquest's Executive and Financial Group (EFG) offers a number of cross-industry services that are designed primarily for clients in the financial and executive communities. These services offer clients the following benefits:

- Access to all Dataquest research professionals
- Access to TID *Dataquest Perspectives*
- Access to TID conferences
- A personal account manager

EFG includes the following services, which are differentiated largely in terms of the type of clients they serve.

Financial Services Program

The Financial Services Program (FSP) is designed to serve the needs of clients who evaluate loans and investments, monitor portfolios, identify markets and prospects, and develop strategies for penetration of new markets. FSP clients include banks, venture capital firms, CPAs, leasing companies, and development agencies. The program benefits these clients by helping them develop financial strategies in high-technology areas, identify financial opportunities, evaluate proposed client investments and relationships, and monitor companies and markets.

Strategic Executive Service

The Strategic Executive Service (SES) is a networking and technology advisory program specifically designed for CEOs or senior executives. The service is open by invitation only to the presidents of technology companies. Dataquest senior staff from all high-technology industry service groups provide decision support to each president. SES also hosts an annual Presidents' Summit Conference, bringing together subscribers to focus on future trends in high technology products and markets. It is a highly customized service for executive decision makers.

Equipment Leasing Service

At the core of Equipment Leasing Service (ELS) is a portfolio of more than 300 individual future value projections for specific products from more than 45 leading computer, peripherals, and telecommunications vendors. These projections are calculated through a proprietary model and are delivered to clients along with relevant research newsletters. Clients also receive inquiry access to specialized leasing analysts. ELS is designed for companies that lease high-technology equipment. The service assists clients in the areas of lease origination sales, vendor sales, equity sales, asset management and remarketing, and new business development and marketing.

Technology Investment Program

The Technology Investment Program (TIP) is designed to serve the needs of clients in the securities industry, investment banking industry, equity research markets, and institutional investment fields. The service provides clients with company evaluations, product and technology assessments, and other forms of information that help identify target companies for merger/acquisition, joint venture, initial public offerings, and equity investment.

Other Dataquest Services

Conferences

Technology Information Division Conferences

Dataquest hosts a number of conferences each year to present industry forecasts and discuss critical issues and trends. Clients obtain a number of benefits from attending these conferences, including:

- Receiving Dataquest updates on key markets
- Meeting with industry leaders and users
- Discussing market events and their significance to your organization with Dataquest analysts

As an industry service client, you may purchase tickets to any Dataquest conference you wish to attend. Each ticket entitles you, or someone you designate, to attend one Dataquest conference. A complete list of conferences is included in Appendix B of this document. To purchase a conference ticket, or to obtain more information about Dataquest's conferences, contact Dataquest's conference department at any of the following locations:

- North America
  (408) 437-8245
- Europe
  (44) 895-835050
- Japan/Asia
  (81) 3-5566-0416

Invitational Computer Conferences

Dataquest's Invitational Computer Conferences (ICCs) bring major computer manufacturers together with buyers in 41 regional markets around the world. The one-day ICC format combines hands-on product displays with technology seminars designed to educate prequalified regional buyers throughout the United States, Europe, and Asia/Pacific. Each SalesEvent ensures a focused conference, whereby the manufacturers have a selectively targeted audience of buyers and the buyers can learn about new technology, receive a hands-on view of products and solutions, and discuss their application needs with exhibiting regional sales and technical managers. Three ICC series are held as follows:

- *OEM Peripherals* (in various U.S. and European locations), serving OEMs, systems integrators, volume end users, and government buyers/integrators who are all looking to buy computer peripherals.
- *Computer Connectivity* (in various U.S. and European locations), serving MIS/DP managers, systems integrators, network managers, and value-added resellers/ dealers who are all looking to buy connectivity/networking solutions.
- *Asia Pacific* (in various Asian locations), serving OEMs, systems integrators, volume end users, and government purchasers who are all looking to buy computer peripherals.

Technology Products

Dataquest also provides standalone products, including specification guides in both hard copy and electronic format (disk), reports, and monthly newsletters that are marketed and sold individually to broad customer audiences. These products are designed to be complementary to the TID syndicated market research services and include highly tactical information on product specifications and pricing, as well as in-depth analyses of specific markets and technology trends. See Appendix C for a current list of products.

Chapter 7

Subscription Terms

Basic Terms of Syndicated Industry Services

The service begins on the date of the first billing. At that time, the subscriber receives the *Source: Dataquest* binder with the current documents and a *Dataquest Perspectives* binder complete with documents covering the last six months. Clients also receive the current year-to-date index as well as the previous year's annual index.

Subscribers to a segment of a service receive a segment binder containing recent segment-specific *Dataquest Perspectives* and the current version of the detailed, segment-specific market statistics. For the duration of the subscription, subscribers receive a copy of each *Dataquest Perspective* published and any annual updates to *Source: Dataquest* documents as they are produced. The inquiry privilege may be used to supplement the material in the binders.

Add-On Subscriptions

Subsidiaries, divisions, regional offices, majority-owned affiliates, and parent companies of a subscribing organization within the same region are eligible for add-on subscriptions at a percentage of the base subscription price. Add-on subscriptions include complete copies of all published material, inquiry privileges specific to the markets subscribed to, and conference attendance at discounted prices. Regions are defined as North America, Europe, and Japan.

Payment Terms

Dataquest's terms, including the applicable sales or value-added tax, are net 30 days.

Base Price

Dataquest reserves the right to change its subscription prices to reflect broadened scope or increased costs. Subscribers will be notified in advance of any such price increase.

A Reminder

Your agreement specifies the individuals in your company who have access to Dataquest information. You will need to obtain written consent from Dataquest to disclose data, analysis, and written materials to any other person or entity beyond those specified by the terms of the agreement.

Dataquest also asks that you not use any data obtained through your industry service in any legal proceedings, or as the basis for advertising copy, press releases, collateral material, or any other promotional material. For further information on the conditions pertaining to your industry service, please refer to your industry service agreement, or contact your sales representative.

Your industry service agreement provides you with a license to use your industry service for the length of time designated in the agreement. If you decide not to renew your industry service at the end of this time, it is your obligation to return these materials to your nearest local Dataquest office.

We Thank You for Choosing Dataquest as Your Marketing Research Partner.

We hope this guide has helped you. Please take advantage of the services we have described. Dataquest's goal is total satisfaction. If you have any questions or comments about this guide or the services it describes, please let us know.

Appendix A

Dataquest Information Resource Center CD-ROMS and Computer Databases

PATENTS

Micropatent

This CD-ROM is a basic search and current awareness tool for U.S. patents, containing abstracts and selected front-page information from patents published by the U.S. Patent and Trademark Office. It covers 1975 to date, with limited information 1969 to 1974. Patent number, inventor, title, and assignee are just a few of the ways to search this CD. It is updated monthly. Book version not available.

FINANCIAL INFORMATION

Compact d Sec—USA

This CD-ROM contains financial and management information on 11,000 public companies filing with the SEC. The current and historical financial information is culled from annual reports and 10-Ks. It is updated monthly. Book version not available; however, the library files have annual reports, 10-Ks, quarterly reports, and 10-Qs. Please check the lateral files and the listing on top of the files.

Compact d Sec—Canada

This CD-ROM provides financial information on 6,000 Canadian companies and is updated quarterly. Book version not available; however, the library files have annual reports. Please check the lateral files and the listing on top of the files.

Compact d Sec—Europe

This CD-ROM provides financial and factual information on 2,000 publicly held European companies and is updated quarterly. Book version not available; however, the library files have annual reports. Please check the lateral files and the listing on top of the files.

COMPANY DIRECTORIES

Corptech

This database contains information on developers and manufacturers of high-technology products in the United States. It is searchable by product, location, size, status, and name and is updated quarterly. Book version available.

Thomas Register

This CD-ROM provides product and directory information for manufacturing companies in the United States and Canada. It is updated monthly. Book version available.

ARTICLE SEARCH

Computer Select (formerly Computer Library)

This CD-ROM is a major upgrade to Computer Library. In addition to the ever-growing list of periodicals included in Computer Select, the full contents of Data Sources, the most comprehensive computer industry directory available, have been added. You'll be able to retrieve specifications on over 67,000 hardware, software, and data communications products, as well as profiles of the over 1,000 companies that make them. New searching capabilities include locating articles by choosing lists of publications, article types, date ranges, topics, and other fields. It is updated monthly. Book version of Data Sources available.

COMPUTER DIRECTORIES

ICP Software Information Database

This CD-ROM provides information on micro, mini, and mainframe software products offered by over 4,000 vendors and is updated quarterly. Book version available.

Appendix B

Dataquest 1991 Conference Schedule

North America		
Forecast '91-Technology Briefing	March 5	San Jose
Ledgeway Service & Support	April 8-9	San Francisco
Semicon/West	May 22	Redwood City
Document Management	June 27-28	San Francisco
Personal & Wireless Communications	August 12-13	Monterey
Portable Computing	September 11-12	San Jose
Semiconductor	October 14-16	Monterey
Europe		
Computer Industry	February 14-15	London
	February 19-20	Milano
	February 25-26	Frankfurt
	March 6-7	Paris
Semicon/Europa '91	March 6	Zurich
Semiconductor	May 29-31	Marbella
Printer	June 11-12	Amsterdam
Colour Market	June 12-13	Amsterdam
Copying & Duplicating	June 13-14	Amsterdam
Telecommunications	November 7-8	London
Japan and Asia		
Semiconductor	April 22-23	Tokyo
Computer & Telecommunications	June 25-26	Tokyo
Strategic Industry	September 24-25	Taipei
Peripherals	October 1-3	Tokyo

For reservations or further information call: U.K. 895-835050 San Jose (408) 437-8245 Tokyo 3-5566-0411
January 1991—Subject to revision

Appendix C

Technology Products

SpecCheck Guides

Copier SpecCheck-On-Disk Disk version of the Copier SpecCheck Guide. Allows custom sorts on 500 models and 24 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

Copier SpecCheck Guide Detailed specifications and pricing information on 500 copier models. Two full books, two updates per year.

Fax SpecCheck-On-Disk Disk version of Fax SpecCheck Guide. Allows custom sorts on 600 models and 47 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

Fax SpecCheck Guide Detailed specifications and pricing information on 600 fax models. Two full books, two updates per year.

PC SpecCheck-On-Disk Disk version of PC SpecCheck Guide. Allows custom sorts on 400 models and 47 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

PC SpecCheck Guide Detailed specifications and pricing information on 400 PC models. Four full books per year.

Personal Page Printer SpecCheck-On-Disk Disk version of Personal Page Printer SpecCheck Guide. Allows custom sorts on 400 models and 100 vendors. Four annual updates on either 3.5-inch or 5.25-inch format.

Personal Page and Ink Jet Printers SpecCheck Guide Detailed specifications and pricing information on 275 personal page and ink jet printer models. Two full books per year.

Dot Matrix Printer SpecCheck Guide Detailed specifications and pricing information on 300 dot matrix printers. Two full books per year.

High-Speed Page and Line Printers SpecCheck Guide Detailed specifications and pricing on 300 high-speed page and line printers. Two full books per year.

Reports

Imaging Materials Series

Series of reports on key areas of the imaging materials industry. Reports currently available or planned are:

Toner in the '90s: The Shape of Things to Come Detailed analysis of the liquid and dry toner and developer industry. The report looks at market size, structure and growth, U.S. and foreign producers, and trends in materials manufacturing and distribution. Includes directory of suppliers. Available now.

Specialty Papers and Films: New Technology, Media, and Markets In-depth report on the hard-copy media field for paper and film products. The report looks at imaging processes, imaging hardware, end-use applications for hard-copy output, and market size and forecast. Includes directory of suppliers. Available June 1991.

The Photoreceptor Industry: A Marketing and Technical Analysis Detailed analysis of photoreceptor technology and the industry. Volume I chronicles the evolution of the industry in terms of equipment, manufacturing, and distribution, providing market size and forecasts. Volume II is a complete reproduction of U.S. patent abstracts from 1979-1990. Includes directory of manufacturers. Available Fall 1991.

Other Reports

Fax On Demand—Marketing Tool for the '90s A useful report to help end users evaluate and select voice/fax systems and implement fax-on-demand services for their business. Includes applications, technology, and economic considerations for fax-on-demand, as well as a directory of product vendors and service providers. Available June 1991.

Color Scanner User Survey for U.S. Publishing Markets Extensive survey of key end-user markets in publishing, advertising, printing services, graphic design, PostScript output services, and Fortune 1000 companies to ascertain purchase intentions and installed base of color and monochrome scanners. Available May 1991.

Semiconductor Industry Insights—from Silicon to Systems Analysis of the global semiconductor industry containing market forecasts, key drivers, product demand, semiconductor production, equipment, and materials.

Voice Processing Opportunities in the U.S.—A Market Assessment and End-User Survey Extensive end-user survey providing networking information, applications, satisfaction level, purchase decision making, and selection criteria by key vertical markets. Also includes market shares, technology, standardization, revenue, and pricing forecasts through 1994.

High-Speed Printing Applications in Banking A vertical market study comprising two reports and videotapes/transcripts of three focus sessions. Study focuses on high-speed printing applications in the banking industry and examines the applications that banks print internally and externally, as well as special printing capability needs of the banking industry.

Portable Computing in the 1990s Three-part series on the latest products, features, and options for transportables, laptops, notebooks, palmtops, and electronic daybooks.

PC LAN Markets in Europe 1990 Analysis of all the major PC LAN vendors in 13 European countries. Market shares, forecasts, distribution channels, and shipments segmented by end-user types.

Computer Usage in European Banks 1990 In-depth, two-volume study on the demand for hardware, applications, LANs, and operating systems in European banks, segmented by bank size. A widespread survey of banks in nine European countries was supplemented by personal interviews with key decision makers at the largest banks.

Monthly Newsletters

Copier FAXts A look at new products, distribution, organizational news, and trade show highlights for the copier and fax industries.

IC Europe All the latest local intelligence and analysis of new products, alliances, technology impacts, and forecasts for the European semiconductor industry.

European Monitor Monthly newsletter with all the latest news on vendor, product, and distribution developments in the European personal computer market.

Price Tracking Flash Monthly newsletter on PC product announcements and changes in price, configuration, and distribution for PC products by 16 manufacturers in 14 European countries.

Other Technology Products

Company Backgrounders by Dataquest Detailed vendor profiles on almost 300 leading worldwide high-technology companies highlighting company strategic direction, business direction, detailed product line summaries, information on joint ventures, mergers and acquisitions, and licensing agreements.

DQ Monday On-Line News, analysis, and current prices for 25 leading semiconductor product groups for all the major markets: United States, Europe, Japan, Hong Kong, Taiwan, and Korea.

DQ Test Target Package of ten 8.5 x 11-inch copier/fax test patterns: gray scale, black and white, and color.

International Test Target Package of ten standard European-size test targets.

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0009733

Dataquest Research Methodology

Source: Dataquest

Dataquest

Dataquest Research Methodology

Source: Dataquest

Published by Dataquest Incorporated

Dataquest's Research Philosophy—Methodology for Value

From semiconductors to systems, office to factory automation, Dataquest provides quality research on more than 25 separate high-technology industries and their markets.

Fundamental to the way Dataquest conducts its research is an underlying philosophy that says the best data and analysis come from a well-balanced program. Such a program includes a balance between primary and secondary data collection techniques; between supply-side and demand-side analysis; between focused, industry-specific research and coordinated, "big picture" analysis; and between the informed, insightful perspectives of experienced industry professionals and the rigorous, disciplined techniques of seasoned market researchers. Ultimately, this leads to a balance between data and analysis—the combination of which provides unique insight and ultimate value to our clients.

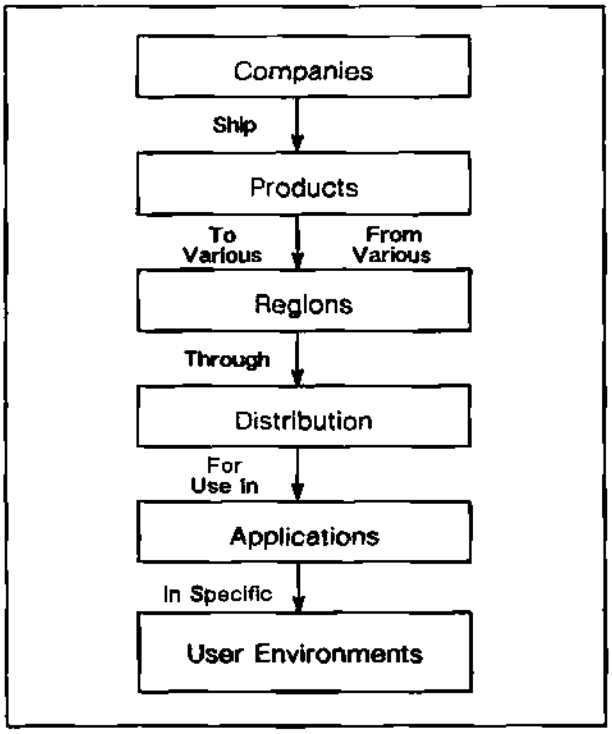
Market Segmentation—Setting the Standards

The design of market segmentation and data standards is a critical issue at Dataquest. Much effort is devoted to choosing and defining the way products, industries, and markets are segmented. Dataquest's objective is to provide data and analysis along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

Over the years, Dataquest has consistently established industry-accepted standard segmentations for the way we follow products and their movement. Figure 1 reflects the way we track products. Further, we spend a great deal of time and effort in defining *how* we track these products and determining what *our* definitions are for the market metrics we use—for example, shipments, installed base, retirements, factory revenue versus end-user revenue, market share, and so on.

We follow several dimensions. Sometimes there are one-to-one, or dedicated, relationships between dimensions—for example, between software products and their applications. We believe that all major high-technology industries mirror this scheme. Note that we do not use the term vertical markets. This term is often used to refer to either applications or environments because both terms describe the use of a product. Application describes what the product is used for, and environment describes where the product is used. The term vertical market often is used for either of these terms and thereby can cause confusion.

Figure 1
How Dataquest Tracks High Technology



Source: Dataquest (March 1991)

We have therefore standardized on the following terminology, which distinguishes between application and environment, for each dimension we follow:

- Major product categories:
  - Materials
  - Components
  - Boards and subsystems
  - Equipment
  - Software
  - Consumables
  - Services
  - Others
- Product—A good or service
- Product category—A group of similar products
- Region—Geographic areas of both shipments and consumption
- Distribution—The path by which a product moves from manufacturer to ultimate user
- Application—The use to which a product is put; the function it performs
- Environment—Where a product is ultimately used

The Dataquest Staff

Dataquest believes that in order for an analyst to understand and analyze an industry, the analyst must have competed in it. To that end, our staff is heavily populated with professionals who have extensive experience in the industries they analyze. These analysts have held high-level positions in engineering, marketing, product development, and other related areas.

These industry veterans are complemented by a staff of professional market researchers who understand the principles of market research and who direct Dataquest's programs in primary and secondary research, demographics, economics research, statistical analysis, forecasting, and modeling. Figure 2 illustrates our staffing philosophy. This blend of experience and training is unique in the research industry and allows Dataquest to provide its clients with market research of unequaled value.

To develop industry analysis and data, Dataquest collects a wide spectrum of information from a carefully selected portfolio of sources. Data are collected directly by our researchers in the United States, Europe, Japan, and Asia.

Primary Research

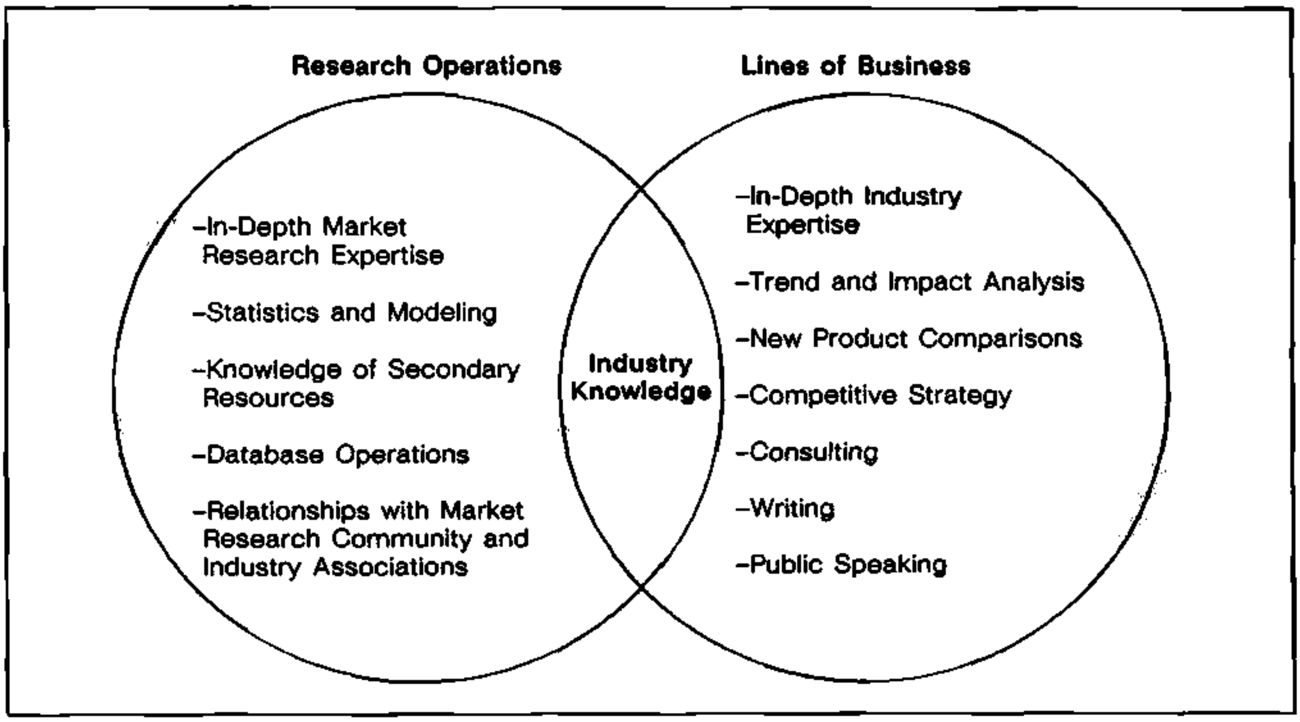
The principal data collection methodology at Dataquest is primary research—firsthand data collection by Dataquest researchers. Primary research is conducted with businesses, households, government, and schools; manufacturers, suppliers, and distributors; and product end users. Dataquest's in-house Primary Research Group (located in San Jose and Paris) processes more than 10,000 interviews each month, through both mail and telephone interviews, as well as using focus groups and personal interviews. Questionnaires are developed by the Primary Research Group in conjunction with Dataquest industry analysts.

All surveys have been designed and demographic samples selected to answer specific inquiries. These samples conform with Dataquest's standard demographic profiles so that results will comply with existing data structures.

The samples are drawn from a variety of sources, frequently from the databases of our parent company, The Dun & Bradstreet Corporation, including the Dun's Market Identifier File of 6 million U.S. businesses. We also draw samples from the databases of Computer Intelligence and Focus Research. The number of interviews conducted is usually specified to produce data with a reliability of ± 5 percent at a 95 percent confidence level.

Following questionnaire development and sample selection, each survey undergoes a rigorous pretesting to make sure the interview captures the desired information. Once adjustments have been made, the telephone surveys are conducted on-line by Dataquest's in-house team of professional interviewers. Call monitoring allows us to provide quality control throughout the process. All data entry and tabulation are done in-house.

Figure 2
Research Organization



Source: Dataquest (March 1991)

Firsthand Observation

On a daily basis, Dataquest watches and measures high technology around the world, using yet another technique of primary research: firsthand observation. Dataquest analysts regularly visit the laboratories, R&D facilities, and manufacturing plants of the companies they follow. They view the technologies and new products; study the manufacturing yields and levels of automation; and meet the people behind the products and companies, from start-up companies to industry leaders.

Secondary Sources

Primary research is supplemented with a review of secondary-source materials. Dataquest's Information Resource Centers throughout the world maintain an extensive collection of information including technical, trade, and general business periodicals; reports; economic data; technical papers; patents; government data; directories; financial literature; product literature; press releases; and many on-line databases. These sources provide specific data points and qualitative input to Dataquest analysis. They cover trends in technology, pricing, manufacturing capacity, competition, product features, demand, buyer behavior, and macroenvironmental forces such as demographics, the economy, and the regulatory arena. The following steps reflect the overall research process at Dataquest:

- Initiate and clarify research request
- Develop methodological approach
- Develop questionnaire
- Select sample
- Load questionnaire (on-line interviewing)
- Prepare estimates (if appropriate)
- Conduct interviewer briefing
- Pretest
- Interview

- Perform quality check and call monitoring
- Merge data
- Perform scrubbing, tabulation, and statistical analysis
- Approve data
- Report on and deliver results
- Maintain database (as required)

The following is a typical cadre of sources:

- Industry contacts
- Industry associations and user groups
- Trade shows and conferences
- Demographics
- D&B economic research
- D&B credit services
- Computer intelligence
- Document management systems
- Focus Research
- Government and regulatory agencies
- Industry and trade publications
- Public databases and libraries
- Annual reports and Forms 10-K
- Product specifications and press releases
- Patent activity

Market Sizing and Market Share

Dataquest conducts surveys of manufacturers and distributors in their respective industries monthly, quarterly, or annually. These surveys collect information on shipment and inventory levels, pricing, and short-term market expectations. Data are checked and cross-checked across data collection points at the supplier, manufacturer, distributor, and end-user levels.

This data collection effort resides at the core of our standard syndicated industry services. We use demand-based surveys for many of our newer products and custom consulting. However, the balance of this discussion focuses on our standard, syndicated industry service product line.

We first develop a company universe for each industry. The sources reflected in Figure 2 are checked to make sure that we have a full census of industry participants.

Next, Dataquest analysts and researchers derive estimates for each product or product category for which we collect shipment and revenue data. The estimates are then provided to vendor representatives for correction or substantiation.

The data collected in our vendor surveys are always considered public information. The data are used to allow bottom-up analysis defining market revenue, market size, and market share. The names of respondents are always kept confidential, and all data are published as Dataquest estimates. All respondents are notified of our policies when our market estimates are initially sent.

Following is a list of steps we go through to derive estimates and reconcile the responses for final approval and reporting:

- We establish product category or model-level detail.
- We establish estimates and check against the following:
  - Aggregate data
  - Industry forecast
  - Historical performance
  - Growth rate of competition
  - Growth rate of related products
- We use the following sources:
  - Vendor verification
  - Quarterly financials
  - Industry associations
  - Distribution channel data
  - Manufacturing capacity
  - Life-cycle analysis
  - Components and peripherals purchases
  - Consumables production
  - Ongoing dialog with industry sources

- Industry analysts' qualitative insight
- Government statistics
- Other secondary sources

- We reconcile responses against Dataquest segmentation standards.

Market Forecasts

We believe that complex interrelationships among the various products, markets, and high-technology industries that we follow should be understood and accounted for in the assumptions underlying each forecast. Forecasts must reconcile the complementary nature of systems, peripherals, and components.

Our forecast methodology begins with the completion of our vendor-based data acquisition, which is used to establish market size for the given year of data collection. These data are used to measure the accuracy of our previous year's projection for the current year. This infrastructure creates a critical foundation that is the starting point for our forecasts.

No single forecast model applies at Dataquest because of the large scope of products and industries that we follow. We have a basic forecasting framework in place that incorporates both quantitative and qualitative data to derive forecasts. Analysts take the following factors into consideration when deriving and cross-checking forecasts and their assumptions:

- Macroeconomics
- Emerging technologies
- Life-cycle analysis
- Retirements
- Environmental trends
- Demographic trends
- Product availability
- Buying intentions
- Captive production
- Historical growth
- Historical pricing
- Installed base
- Saturation
- Obsolescence
- Import and export
- Most likely constraints
- Total available market

Finally, we regularly hold research forums that provide an open exchange of opinions for our analysts.

Throughout Dataquest, each variable must be defined and measured in the same way. Analysts may vary the relationships between variables but not the values themselves. Not all variable relationships hold true for all industries; therefore, analysts may specify which sets of variables to use. Data must be reported according to Dataquest standard segmentation, and all final data must be approved before they are reported. *All* preliminary data are clearly stated as such. All final data are reported as Dataquest estimates. Our information is sourced appropriately with the phrase "Source: Dataquest," and the data are stamped with a date so that users have a clear understanding of what iteration they are using and the assumptions behind those data.

Dataquest Market Research—What's behind the Numbers?

When Dataquest clients receive forecast data with the familiar line "Source: Dataquest," they receive the end result of a rigorous process of primary and secondary data collection; supply-side, demand-side, and macroenvironmental analysis; and the cross-industry perspective afforded by Dataquest's uniquely broad and in-depth worldwide coverage of high technology.

Behind the numbers is a thorough discussion, involving industry professionals and research experts, and testing of the assumptions used to develop Dataquest's forecasts. In this way, clients get more than simply a single point of data for planning and decision making. Behind the numbers is a commitment to quality—a worldwide organization of people committed to supplying the highest-quality *information* and *analysis* to Dataquest's clients.

Dataquest

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Dataquest High-Technology Guide

Segmentation and Glossary

1991

Source:
Dataquest

Dataquest

Dataquest High-Technology Guide

Segmentation and Glossary

1991

Source: Dataquest

Dataquest

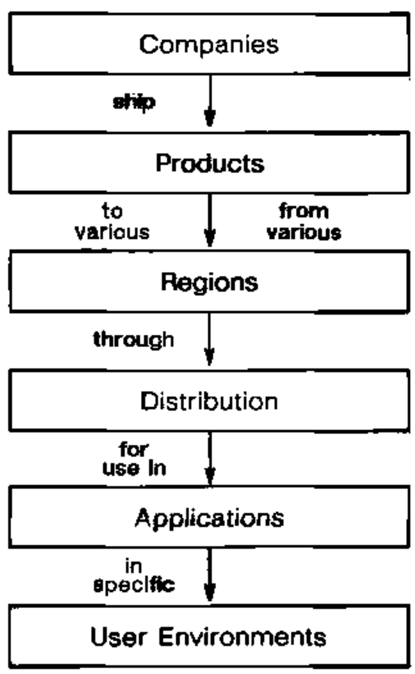
Published by Dataquest Incorporated

High–Technology Guide

The *High–Technology Guide* provides a reference for Dataquest research, analysis, and publications. The segments and terms found in this guide are used consistently in our research and methodology and throughout Dataquest products.

The *High–Technology Guide* is divided into two parts: segmentation and glossary. The segmentation section provides a comprehensive listing of the classifications used in our research. This segmentation is broken into different dimensions including companies, products, regions, distribution, applications, and user environments. These dimensions are illustrated below (see Figure 1). The glossary is an alphabetical list defining the terms found in the segmentation section.

Figure 1
Research Dimensions



Source: Dataquest (January 1991)

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Segmentation

Companies

The companies section contains more than 3,500 companies on which Dataquest conducts research. These companies are studied because of their concentration or emphasis in technology markets and industries. The company segmentation shows the breadth and depth of collective coverage that Dataquest maintains. Because of the extensive nature of the company list, it is not published in this guide but can be provided upon request.

Products

The products section lists high-technology products. This section presents the segmentation of the technology as defined by Dataquest.

The major categories of products are as follows:

- Materials
- Components
- Boards and Subsystems
- Equipment
- Software
- Consumables
- Services
- Other Products

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Products

MATERIALS

- Wafer
  - Silicon Wafer
  - Epitaxial Wafer
- Gas
  - Bulk Gas
    - Nitrogen
    - Oxygen
    - Hydrogen
    - Argon
  - Specialty Gas
    - Silicon Precursor
    - Dopant
    - Plasma Etchant
    - Reactant Gas
    - Atmospheric/Purge Cylinder Gas and Other
  - Plastics

COMPONENTS

- Semiconductor
  - Integrated Circuit
    - Bipolar Digital (by Technology)
      - TTL/Others
      - ECL
    - Bipolar Digital (by Function)
      - Bipolar Digital Memory
        - Bipolar RAM
        - Bipolar Nonvolatile Memory
        - Other Bipolar Memory
      - Bipolar Digital Microcomponents
      - Bipolar Digital Logic
        - Bipolar ASIC
          - Bipolar Gate Array
          - Bipolar PLD
            - Bipolar PLA
            - Bipolar PMD
            - Bipolar FPGA

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Bipolar ASIC (Continued)
  - Bipolar Cell-Based IC
- Bipolar Custom IC
- Bipolar Standard Logic
- Other Bipolar Logic

- MOS Digital (by Technology)
  - NMOS/PMOS
  - CMOS
  - BiCMOS

- MOS Digital (by Function)
  - MOS Memory
    - DRAM
      - 16K DRAM
      - 32K DRAM
      - 64K DRAM
      - 128K DRAM
      - 256K DRAM
      - 1Mb DRAM
      - 4Mb DRAM
      - 16Mb DRAM
    - SRAM
      - Slow SRAM
        - 1K SRAM
        - 4K SRAM
        - 8K SRAM
        - 16K SRAM
        - 64K SRAM
        - 256K SRAM
        - 1Mb SRAM
        - 4Mb SRAM
      - Fast SRAM
        - 1K SRAM
        - 4K SRAM
        - 8K SRAM
        - 16K SRAM
        - 64K SRAM
        - 256K SRAM
        - 1Mb SRAM
        - 4Mb SRAM

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Nonvolatile Memory IC
  - ROM
    - 4K ROM
    - 8K ROM
    - 16K ROM
    - 32K ROM
    - 64K ROM
    - 128K ROM
    - 256K ROM
    - 1Mb ROM
    - 2Mb ROM
    - 4Mb ROM
    - 8Mb ROM
    - 16Mb ROM
  - EPROM
    - 16K EPROM
    - 32K EPROM
    - 64K EPROM
    - 128K EPROM
    - 256K EPROM
    - 1Mb EPROM
    - 2Mb EPROM
    - 4Mb EPROM
    - 8Mb EPROM
  - EEPROM
    - 1K EEPROM
    - 2K EEPROM
    - 4K EEPROM
    - 8K EEPROM
    - 16K EEPROM
    - 32K EEPROM
    - 64K EEPROM
    - 128K EEPROM
    - 256K EEPROM
    - 512K EEPROM
    - 1Mb EEPROM
  - Other MOS Memory
- MOS Microcomponents
  - MOS Microprocessor (by Word Length)
    - 8-bit MOS MPU

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- MOS Microprocessor (by Word Length) (Continued)
  - 16-bit MOS MPU
  - 16/32-bit MOS MPU
  - 32-bit MOS MPU
  - 32/64-bit MOS MPU
  - 64-bit MOS MPU
- MOS Microprocessor (by Technology)
  - CISC MOS MPU
  - RISC MOS MPU
- MOS Microcontroller
  - 4-bit MOS MCU
  - 8-bit MOS MCU
  - 16-bit MOS MCU
  - 32-bit MOS MCU
  - Digital Signal Processor
    - DSP Microprocessor (DSMPU)
    - Microprogrammable DSP (MPDSP)
    - Special-Function DSP (SFDSP)
- MOS Microperipheral
  - System Support Peripheral
    - Traditional Peripheral
      - Counter/Timer
      - DMA
      - Interrupt Controller
      - Memory Management
      - Real-Time Clock
      - Others
    - General-Purpose I/O
    - DRAM Controller
    - Cache Controller
    - PC Logic Chip Set
  - Display Peripheral
    - Alphanumeric CRT Controller
    - Graphics Controller
    - Keyboard Controller
    - Printer Controller
    - Others
  - Mass Storage Peripheral
    - Floppy Disk Controller
    - Hard-Disk Controller
    - Optical Disk Controller
    - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Communications Peripheral
  - LAN
  - ISDN
  - Modem
  - Serial I/O
  - UART/USART
  - Others
- Floating-Point Coprocessor
  - 16-bit
  - 32-bit

MOS Logic
- MOS ASIC
  - MOS Gate Array
  - MOS PLD
    - MOS PLA
    - MOS PMD
    - MOS FPGA
  - MOS Cell-Based IC
- MOS Custom IC
- MOS Standard Logic
- Other MOS Logic

Analog Integrated Circuit
- Monolithic Analog IC
  - Linear IC
    - Amplifier IC
    - Voltage Regulator
    - Voltage Reference IC
    - Comparator IC
    - Special-Function IC
    - Special Consumer IC
    - Special Automotive IC
    - Linear Array/ASIC
  - Mixed Signal IC
    - Data Converter IC
    - Telecommunication IC
    - Interface IC
    - Switch/Multiplexer IC
    - Disk Drive IC
    - Mixed Signal ASIC
- Hybrid Analog IC

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Discrete Semiconductor
  - Transistor
    - Small Signal Transistor
    - Power Transistor
      - Bipolar Power Transistor
      - MOS Power Transistor
      - Insulated Gate Bipolar Transistor
  - Diode
    - Small Signal Diode
    - Power Diode/Rectifier
  - Thyristor
  - Other Discrete Semiconductor
- Optoelectronic Semiconductor
  - Light-Emitting Diode/Display
  - Optocoupler
  - CCD
  - Laser Diode
  - Photosensor
  - Solar Cell
- III-V Semiconductor
  - GaAs Digital IC
  - GaAs Analog IC
  - III-V Discrete Transistor
  - Optoelectronic IC

Passive Component
- Cable
- Capacitor
- Cathode Ray Tube (CRT)
- Connector
- Inductor
- Potentiometer
- Relay
- Resistor
- Socket
- Splice (Optical)
- Transducer
- Liquid Crystal Display
- Switch

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

BOARDS AND SUBSYSTEMS

- Graphic Board
  - Mac-Type Add-On Graphic Board
  - IBM-Type Add-On Graphic Board
- Imaging Subsystem
  - Add-On Memory Board
  - Controller Board
    - Storage Controller Board
    - Printer Controller Board
  - Magnetic Recording Head
  - Board-Level Computer
- Storage Subsystem

EQUIPMENT

- Data Processing Equipment
  - Computer Systems by Product Segment
    - General-Purpose Computer System
      - Supercomputer
        - Corporate Supercomputer
        - Departmental Supercomputer
        - Research Supercomputer
      - Mainframe Computer
      - Midrange Computer
        - Superminicomputer
        - Minicomputer
        - Microcomputer
      - Workstation Computer
        - Graphic/Project Supercomputer
        - Superworkstation
        - Traditional Workstation
        - Entry-Level Workstation
      - Personal Computer
        - Desktop Personal Computer
        - Desk-Side Personal Computer
        - Transportable Personal Computer
        - Laptop A/C Personal Computer
        - Laptop D/C Personal Computer
        - Notebook D/C Personal Computer
        - Pen-Based Personal Computer

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Hand-Held Personal Computer

Special-Purpose Computer System

Data Storage Device
- Flexible Disk Drive
  - Fixed Media
    - Sub-3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501+MB
    - 3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 5.25-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 8 to 10.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 14-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive (Continued)
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- Rigid Disk Drive
  - Fixed Media
    - Sub-3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501+MB
    - 3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 5.25-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 8 to 10.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

Removable Media

- Sub-3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501+MB
- 3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 5.25-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 8 to 10.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

Dual Media

- Sub-3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501+MB
- 3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 5.25-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 8 to 10.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- Optical Disk Drive
  - CD-ROM
  - WORM Optical Disk Drive
    - 5.25 Inch
    - 8 to 12 Inch
    - 14 Inch
  - Rewritable Optical Disk Drive
    - 2 to 5.25 Inch
    - 8 to 12 Inch
  - Optical Jukebox
- Tape Drive
  - 1/4-Inch Tape Drive
    - Start-Stop
    - Streamer
      - 8 Inch
      - 5.25 Inch
      - 3.5 Inch
  - 1/8-Inch Tape Drive
    - Cassette
    - Cartridge
  - 1/2-Inch Tape Drive
    - 1/2-Inch Vacuum Column
    - 1/2-Inch Tension Arm
    - 1/2-Inch Streaming
    - 1/2-Inch Cartridge
  - Reel-to-Reel Tape Drive Recap
  - Helical Scan Tape Drive
    - VHS
    - DAT
    - 8mm
    - Others
- Input/Output Device
  - Terminal
    - Alphanumeric (CRT) Terminal
      - Minicomputer-Based Terminal

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Alphanumeric (CRT) Terminal (Continued)
- Non-IBM, Protocol-Specific Terminal
- IBM 3270 Protocol Terminal
- Host/Vendor-Independent Terminal
- Processing Terminal

Graphics Terminal
Point-of-Sale Terminal
Funds Transfer Terminal (ATMs)
Smart Card
Other Specialized Terminal

Electronic Printer
- Serial Printer
  - Serial, Impact, Dot Matrix Printer
    - Dot Matrix Printer by Speed
      - 0 to 180 cps
      - 181 to 250 cps
      - 251 to 399 cps
      - 400+ cps
    - Dot Matrix Printer by Size
      - Total < 9 Wire (Pin)
      - Total 9 Wire (Pin)
      - Total 18 Wire (Pin)
      - Total 24 Wire (Pin)
  - Serial, Impact, Fully Formed Printer
    - 0 to 30 cps
    - 31+ cps
  - Serial, Nonimpact, Direct Thermal Printer
  - Serial, Nonimpact, Thermal Transfer Printer
    - Wax-Based
    - Sublimation
    - Dry Silver
  - Serial, Nonimpact, Ink Jet Printer
- Line Printer
  - Line, Impact, Dot Matrix Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651+ lpm
  - Line, Impact, Fully Formed Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651 to 1,050 lpm

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Line, Impact, Fully Formed Printer (Continued)
- 1,051 to 1,250 lpm
- 1,251+ lpm

Line, Nonimpact, Direct Thermal Printer
Line, Nonimpact, Thermal Transfer Printer

Page Printer
- 0 to 6 ppm
- 7 to 10 ppm
- 11 to 15 ppm
- 16 to 20 ppm
- 21 to 30 ppm
- 31 to 50 ppm
- 51 to 80 ppm
- 81 to 150 ppm
- 151+ ppm

Other Input/Output Devices
- Monitor
- Remote Batch, Job-Entry, and Output
- Key Entry Equipment
- Media-to-Media Data Conversion
- Magnetic Ink Character Recognition (MICR)
- Optical Scanning Equipment
- Computer Plotters
  - Small Format Pen Plotter
  - Large Format Pen Plotter
  - Small Format Electrostatic Plotter
  - Large Format Electrostatic Plotter
  - Ink Jet Plotter
  - Thermal Plotter
  - Photosensitive Plotter
  - Laser Plotter
- Voice Recognition Computer Device
- Voice Synthesizer
- Mouse
- Keyboard
- Digitizer

Office Equipment
- Copier and Duplicator
  - Personal Copier (Up to 12 cpm)
  - Segment 1 (Up to 20 cpm)

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Copier and Duplicator (Continued)
  - Segment 2 (21 to 30 cpm)
  - Segment 3 (31 to 44 cpm)
  - Segment 4 (45 to 69 cpm)
  - Segment 5 (70 to 90 cpm)
  - Segment 6 (91+ cpm)
- Full-Color Copiers
- Electronic Calculator (without Alpha Keyboard)
- Dictating, Transcribing Machine
- Electronic Typewriter
- Word Processor
- Banking System
  - Check-Handling System
- Cash Register
- Mailing, Letter-Handling, Addressing Equipment
- Other Office Equipment

- Communications
  - Telecommunicatons
    - Image Communications
      - Facsimile
        - Classification by Type
          - Standalone Systems
          - PC Facsimile Cards
          - LAN to Fax Gateways
        - Classification by Technology
          - Group I
          - Group II
          - Group III
          - Group III Bis
          - Group IV
        - Classification by Feature
          - Ultra Low End
          - Low End
          - Midrange
          - High End
        - Classification by Price
          - <$1,000
          - $1,000 to $1,499
          - $1,500 to $1,999
          - $2,000 to $2,499
          - $2,500 to $2,999
          - $3,000 or More

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Classification by Printing Technology
  - Thermal
  - Thermal Transfer
  - Plain Paper (Laser, LED, etc.)
- ISDN Terminals
- Servers
- Teleconferencing
  - Audio
  - Video
    - Captured Image
    - Near-Full Motion
    - Codecs
    - PX64
  - Telex
    - Machines
    - Black Boxes
    - Gateways
    - Message Switches
  - Videotex
    - Terminals

Personal Communications

- Mobile Radio
  - Cellular Handsets
    - Classification by Type
      - Car-Mounted
      - Transportable
      - Portable
    - Classification by Technology
      - Analog
        - C450
        - NMT450
        - NMT900
        - TACS
        - ETACS
        - Radiocom 2000
        - AMPS
        - RTMS-Italy
      - Digital
        - GSM
        - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Cordless Handsets
  - CT0
  - CT1
  - CT2
  - CT3
  - DECT
  - GSM
  - Base Stations
- Global Positioning Systems
- Mobile Infrastructure
  - Base Stations
- Personal Communications Networks (PCN)
  - Mininetworks
- Public Mobile Radio (PMR)
- Paging Systems

Networking

- Cable (Private)
- Data PBX
- Encryption Units
- Front-End Processors
  - IBM and IBM-Compatible
  - Proprietary
- ISDN
- Local Area Networks (LANs)
  - Terminal Servers
    - Ethernet
    - Token Ring
    - Others
  - PC Network Operating Software
  - PC LANs
  - Classification by Type
    - IBM PC/Compatible
    - Apple Macintosh
  - Classification by Technology
    - 802.3
    - 802.5
    - Arcnet
    - FDDI
    - Others
  - Classification by Media
    - Coaxial
    - Unshielded Twisted Pair (UTP)
    - Fiber-Optic
    - Datagrade

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Local Operating Network Systems (LONs)
Modems
  Classification by Standards
    U.S. Standards
      212 A
      V.22 Bis
      201 B/C
      208 A/B
      V.29
      V.32
      V.33
      16.8 Kbps
      19.2 Kbps
      V.35
      V.36
        Proprietary Dial-Up 9.6 Kbps
    European Standards
      V.21/23
      V.21/23 PC
      V.22
      V.22 PC
      V.22 Bis
      V.22 Bis PC
      V.26
      V.27
      V.29 Basic
      V.29 Premium
      V.32
      V.32 PC
      Proprietary Dial-Up 9.6 Kbps
      V.33
      16.8 Kbps
      19.2 Kbps
      Proprietary Baseband
      Proprietary DOVE
Multiplexers
  Classification by Technology
    Time Division (TDM)
      Low-End Point-to-Point/Dual Trunk
      Low-End Networking
      Channels Banks/Primary MUX
      T1/E1 Point-to-Point/Dual Trunk

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Time Division (TDM) (Continued)
  - T1/E1 Network Access
  - High-End Networking
  - Greater than T1/E1
- Statistical Time Division (STDM)
  - Classification by Size
    - Low End (Up to 16 Channels)
    - Midrange (Up to 48 Channels)
    - High End (More than 48 Channels)

Network Management Systems
- Public
  - Carrier
  - Local
  - Long Distance
- Private
  - LANs
  - T1/E1
  - X.25
  - Modems
  - Voice (Call Accounting)
  - Switch and Patch
  - Matrix
  - Mini/Mainframe-Based
  - Test Equipment
    - Analyzers
  - Operator Support Systems

Network-Terminating Devices

Operator Support Systems

Other Datacom Equipment
- Fiber-Optic Multiplexers

Public Data Network Systems (Equipment)
- X.21 Switches

Servers

Value-Added Networks (Equipment)

X.25
- Classification by Type
  - Packet Assemblers/Disassemblers (PADs)
    - Asynchronous Only
    - Synchronous Only
    - Multiprotocol
  - Packet Switches (Nodes)

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Classification by Capacity
Low End (Up to 100 Packets per Second)
Midrange (Up to 1,000 pps)
High End (More than 1,000 pps)

Public Network Equipment

Cable
Coaxial
Fiber-Optics
Monomode
Multimode
Multipair

Cable TV
Carrier Equipment
Central Office
Classification by Type
Local
Trunk
Gateway
Classification by Technology
Analog
Digital
ISDN
Basic Rate Interface (BRI)
Primary Rate Interface (PRI)
Others
Classification By Size
Less than 2K Lines
2K to 10K Lines
More than 10K Lines

Digital Access Crossconnect Systems (DACS)
Classification by Type
1/0 DCS
1/1 DCS
3/1 DCS
3/1/0 DCS
3/3 DCS
4/1 DCS
4/3 DCS
4/4 DCS
OCN/OCN

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Classification by Capacity
  - Low End
  - Midrange
  - High End
- Fiber-Optic Terminal (FOTs)
- Line Conditioners
- Main Distribution Frame (MDF)
- Connectors
- Microwave
  - Classification by Type
    - Systems
    - Antenna
    - Accessories
    - Electronics
  - Classification by Usage
    - Short Haul
    - Long Haul
  - Classification by Technology
    - Analog
    - Digital
- Multiplexers
  - Classification by Type
    - Multiplexers
    - Fiber-Optic Terminals
  - Classification by Technology
    - Analog
    - Digital
  - Classification by Standards
    - European/CEPT Standard
      - 2 Mbps
      - 8 Mbps
      - 34 Mbps
      - 140 Mbps
      - 565 Mbps
      - 2.4 Gbps
    - U.S. Standard
      - 1.5 Mbps
      - 6 Mbps
      - 45 Mbps
      - 90 Mbps
      - 135 Mbps
      - 1.2 Gbps

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EQUIPMENT

- SONET
- Synchronous Digital Hierarchy (SDH)
- Asynchronous Transfer Mode (ATM)
- Fast Packet Switching
- Frame Relay

Network Termination Units
- ISDN
- DSU/CSU
- NTU

Operating Support Systems
Pay Phones
Public Paging Systems
Local Loop Equipment
- Analog
  - PCM Repeaters
  - Digital
- Twisted Pair
- SLC-96 and Compatibles
- Others
- Fiber Optics
  - Universal Digital Line Carrier (UDLC)
  - Integrated Digital Line Carrier (IDLC)
  - Flexible Access System (FAS)
  - SONET
  - 802.6 Metropolitan Area Network (MAN)
  - Others
- Wireless
  - Basic Exchange Telephone Radio Service (BETRS)
  - Cordless

Satellite Communications
- Space Stations
- Earth Stations
  - VSAT
  - Master—Hub
  - Remote
    - Receive Only—Data Broadcast
    - Interactive
- Direct Broadcast
- Teleport
- Television Receive Only
- Video Distribution

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Satellite Communications (Continued)
  - Home
  - Intelsat
  - Eutelsat
  - Others
- Signaling
- Telex
  - Low End (Less than 20 Ports)
  - Midrange(20 to 80 Ports)
  - High End (More than 80 Ports)
- X.25
  - Classification by Size
    - Low End
    - Midrange
    - High End

Voice Communication
- Answering Machines
- Attendant Consoles
- Automatic Call Distributors (ACDs)
  - Classification by Type
    - Standalone
    - Integrated
    - Analog
    - Digital
  - Classification by Capacity
    - 1 to 8 Agent Positions
    - 9 to 24 Agent Positions
    - 25 to 48 Agent Positions
    - 49 to 100 Agent Positions
    - More than 100 Agent Positions
- Business Communications Systems
  - Classification by Type
    - Private Branch Exchange (PBX)
    - Key Telephone System (KTS)
  - Classification by Technology
    - Analog
    - Digital
    - ISDN
      - Terminals
      - ISDN
      - Proprietary
      - Servers
    - Network
      - BRI

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Network (Continued)
  - PRI
  - Proprietary
  - Gateways
- Basic

Classification by Capacity
- 1 to 8 Lines
- 9 to 24 Lines
- 25 to 48 Lines
- 49 to 100 Lines
- 101 to 400 Lines
- 401 to 1,000 Lines
- More than 1,000 Lines

Cable (Private)

Call Management Systems
- Centrex
- KTS
- PBX

Integrated Voice/Data Workstations (IVDT)

Intercom Systems

ISDN Terminals
- Voice
- Data
- Video
- Integrated

Private Paging Systems

Trading Turrets/Dealer Boards

Voice-Messaging Systems
- Classification by Capacity
  - 1 to 4 Ports
  - 5 to 8 Ports
  - 9 to 16 Ports
  - 17 to 32 Ports
  - 33 to 64 Ports
  - 65 to 128 Ports
  - More than 128 Ports

Voice Response Units (VRUs)
- Classification by Capacity
  - 1 to 4 Ports
  - 5 to 8 Ports
  - 9 to 16 Ports
  - 17 to 32 Ports
  - 33 to 64 Ports
  - 65 to 128 Ports
  - More than 128 Ports

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EQUIPMENT

- Voice Terminals
  - Classification by Type
    - Corded
    - Cordless
  - Classification by Technology
    - Analog
    - Digital
      - Pulse Dial
      - Tone Dial (DTMF)

Industrial Electronic Equipment

- Security/Energy Management
  - Alarm System
    - Intrusion Detection Alarm System
    - Fire Detection Alarm System
      - Discrete Device, Security/Energy Management
- MPU Load Programmer
- Computerized Energy Control System
- Manufacturing System
  - Wafer Fabrication Equipment
    - Lithography Equipment
      - Proximity/Contact Aligners
      - Projection Aligner
      - Steppers
      - Direct-Write E-Beam
      - Maskmaking E-Beam
      - X Ray
    - Automatic Photoresist Processing Equipment
    - Etch-and-Clean Equipment
      - Wet Process
      - Dry Strip
      - Dry Etch
      - Ion Milling
    - Deposition Equipment
      - Chemical Vapor Deposition
      - Physical Vapor Deposition
      - Silicon Epitaxy Deposition
      - Metalorganic CVD Deposition
      - Molecular Beam Epitaxy Deposition
      - Diffusion
      - Rapid Thermal Processing

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EQUIPMENT

Ion Implantation
Medium Current Ion Implantation
High-Current Ion Implantation
High-Voltage Ion Implantation
Optical CD/Wafer Inspection
Other Process Control Equipment
Factory Automation Equipment
Other Water Fabrication Equipment

Test Equipment
ATE (Automatic Test Equipment)
Discrete Component Tester
Semiconductor Tester
Interconnect/Bare PCB Tester
In-Circuit PCB Tester
Functional PCB Tester
Combined PCB Tester
Manufacturing EATE N/A
General Test Equipment

Process Control System
Process Control System, Controller
Process Control System, Recorder
Process Control System, Indicator
Process Control System, Auxiliary Station
Process Control System, Nonunified System
Process Control System, Industrial Process

Programmable Machine Tool
Boring Programmable Machine Tool
Drilling Programmable Machine Tool
Grinding Programmable Machine Tool
Horizontal Turning Programmable Machine Tool
Vertical Turning Programmable Machine Tool
Milling Programmable Machine Tool
Machining Center Programmable Machine Tool
Other Cutting Programmable Machine Tool
Punch/Shear/Bend Programmable Machine Tool
Flexible Manufacturing System Programmable Machine Tool

Mechanical Assembly Equipment
Plastic Processing Machinery

Robot System
Robotic Electronic Assembly
Robotic Nonelectronic Assembly

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Robot System (Continued)
- Material-Handling/Loading Robot System
- Painting Robot System
- Spot-Welding Robot System
- Arc-Welding Robot System
- Machining Robot System
- Other Robot System

Automated Material Handling
- Guided Vehicle
- Programmable Conveyor
- Storage/Retrieval Automatic Material-Handling System
- Programmable Monorail
- Warehousing
- Programmable Overhead Crane
- Other Automated Material-Handling Equipment

Instrumentation
- Integrating and Totalizing Meter for Gas
- Counting Device
- Digital Panel Meter
- Analog Panel Meter
- Panel Type Instrument
- Elapsed-Time Meter
- Portable Electronic Measuring Instrument
- Electronic Recording Instrument
- Physical Property Test, Inspection, and Measurement
- Commercial Meteorological and General-Purpose Instrument
- Nuclear Radiation Detection and Monitoring
- Surveying and Drafting Instrument
- Ultrasonic Cleaners, Drill
- Meteorological Instrument
- Geophysical Instrument
- Analytical and Scientific Instrument

Medical Equipment
- Diagnostic Medical Equipment
  - Automatic Blood Analyzer
  - CAT Scanner
  - Digital Radiography
  - Electrocardiograph
  - Electroencephalograph
  - Magnetic Resonance Imaging

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Medical Equipment (Continued)
  - Respiratory Analysis
  - Ultrasonic Scanner, Medical
  - X Ray, Medical
  - Other Diagnostic Medical Equipment
- Patient-Monitoring
- Prosthetic Medical Equipment
  - Hearing Aid
- Surgical Support
- Therapeutic
  - Defibrillator
  - Dialysis, Diathermy
  - Electrosurgical
  - Pacemaker
  - Ultrasonic Generator
  - Other Therapeutic Medical Equipment

Other Industrial Electronic Equipment
- Vending Machine
- Laser System (Excluding Communication)
- Power Supply
- Traffic Control
- Particle Accelerator
- Industrial and Scientific X Ray
- Laboratory and Scientific Apparatus
- Teaching Machine and Aid
- Scientific Not Elsewhere Classified

Consumer Electronic Equipment
- Audio Consumer
  - Audio Amplifier
  - Compact (Disc) Player, Music
  - Consumer Radio
  - Stereo (Hi-Fi) Component
  - Stereo Headphone
  - Electronic Musical Instrument
  - Tape Recorder, Consumer
- Video, Consumer
  - Video Camera, Consumer
  - VTRs (VCRs)
  - Videodisc Player

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Video, Consumer (Continued)
  - Color Television
  - Black-and-White Television
  - HDTV
  - Remote Control
  - LCD Television
- Personal Electronic
  - Game
  - Camera
  - Watch
  - Clock
  - Toy
  - Sewing Machine
  - Other Personal Electronic
- Appliance
  - Air Conditioner
  - Microwave Oven
  - Washer and Dryer
  - Refrigerator
  - Dishwasher, Disposal
  - Range and Oven, Consumer
  - Rice Cookers
  - Fans
  - Heaters
  - Vacuum Cleaners
  - Food Processors
  - Other Consumer Appliance
- Other Consumer Electronic
  - Automatic Garage Door Opener
  - Residential Smoke Alarm
  - Consumer Electronic Equipment Not Elsewhere Classified

Military/Aerospace Electronic Equipment
- Military Electronic Equipment
  - Radar, Military
  - Sonar, Military
  - Missile-Weapon
  - Space Military Equipment
  - Navigation, Military
  - Communication, Military
  - Electronic Warfare

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Military Electronic Equipment (Continued)
    - Reconnaissance
    - Aircraft System
    - Military Computer System
    - Simulation and Training, Military
    - Miscellaneous Military Equipment
- Civil Aerospace
    - Radar, Civilian
    - Civilian Space
    - Civil Navigation/Communication
    - Civil Aircraft Flight System
    - Civil Simulation and Training

Transportation Electronic Equipment

- Entertainment, Transportation
- Body Controls
- Driver Information
- Powertrain
- Safety and Convenience

Other Electronic Equipment

SOFTWARE

- Application Software (See Applications Segmentation)
- System Software
    - Operating System Software
        - Database
            - Document Management
            - Data Acquisition and Control
            - Storage Management
            - Database Administration
            - On-Line Transaction Processing
        - Development Tools
        - Editors
        - Language
            - Compilers
            - Assemblers
            - Translators
            - Data Translator
            - Query Languages

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SOFTWARE

- Interactive Languages
  - Fourth-Generation Languages
  - Visual Programming Languages
- Graphic
- Communication Management
  - User Interface
  - Device Interface
- Protocol
- Security

Operating Environment

Operating System

- Proprietary
  - IBM/VM/MVS
  - DEC VMS
  - Others
- Open
  - UNIX
    - OSF1
    - Sun OS
    - System V/BSD
    - Mach
    - XENIX
    - Others
      - Pick
      - Theos
      - Others
  - Real-Time
- PC
  - DOS
  - OS/2
  - Macintosh
  - Others
- Operating Utilities
  - Peripheral I/O Management
  - System Subroutine Libraries
  - Data Center and System Management
  - Information Resource Management
  - Information Center
  - System Utilities

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CONSUMABLES

- Paper
  - Cut Sheet
  - Form
  - Label
- Toner and Developer
- Print Ribbon
- Photoreceptor
- Print Element
  - Printwheel
  - Golf Ball
  - Thimble
- Computer Storage Media
  - Flexible Disk
  - Rigid Disk
  - Computer Storage Tape
  - Optical Media
- Transparency
- Other Consumable

SERVICES

- Telecommunications Services
  - Core Services
    - Classification by Type
      - Local Telephone Services
      - Long Distance Services
      - International Services
    - Classification by Technology
      - Analog
      - Digital
        - ISDN
          - HO
          - BRI
          - PRI
        - Others
    - Classification by Product
      - Toll Revenue
      - WATS Outgoing
      - WATS Incoming (800 Service)
      - 900 Service
      - Switched Digital Services
        - Switched 56 Kbps
        - X.21

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

SERVICES

- Classification by Product (Continued)
  - Analog Private Lines
    - Conditioned
    - Unconditioned
  - Digital Private Lines
    - Classification by Capacity
      - 0 to 19.2 Kbps
      - 19.2 Kbps to 64 Kbps
      - 64 Kbps to H11
      - H11 to 772 Kbps
      - T1
      - E1
      - 8 Mbps
      - T3
      - 34 Mbps
      - More than T3
  - Centrex
    - Classification by Type
      - ETN
      - ACD
      - CLASS
      - Routing
      - Billing
      - Network Management
    - Classification by Size
      - 1 to 8 Lines
      - 9 to 24 Lines
      - 25 to 48 Lines
      - 49 to 100 Lines
      - 101 to 400 Lines
      - 401 to 1,000 Lines
      - More than 1,000 Lines
  - B-ISDN
  - Operator Services
- Enhanced Services
  - Audiotex Access Services
  - Voice Mail
  - Cable TV
  - Directory Inquiry
  - Electronic Messaging
    - X400
    - EDI
    - Others

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SERVICES

- ISDN
- Public Data
- Satellite
  - VSAT
  - Others
- Teleconferencing
- Teleport Services
- Telex Services
- Facsimile Services
- Value-Added Networks (VANs)
- VideoConferencing
  - Ad Hoc
  - Carrier Provided
- Virtual Private Network Services
- Videotex Access Services
- X.25
- Voice Messaging

Mobile Services
- Cellular
  - Classification by Technology
    - Analog
      - C450
      - NMT450
      - NMT900
      - TACS
      - ETACS
      - Radiocom 2000
      - AMPS
      - RTMS-Italy
    - Digital
      - GSM
      - Others
- Cordless
  - Portable
    - CT2
    - CT3
    - DECT
  - Mobile
    - GSM
- Global-Positioning Systems
  - Location Identification Systems

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SERVICES

- Personal Communications Networks (PCN)
  - SubGSM
- Public Mobile Radio (PMR)
  - Data Services
- Public Paging Systems
- Messaging Services

Hardware Maintenance
- Contract Maintenance
- Time and Materials

Parts

Software Support

Customer Training/Education

Network Support

Professional
- Systems Integration
- Facilities Management

OTHER PRODUCTS

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

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Geographic Regions

The geographic regions segmentation shows the classification scheme used by Dataquest to define the regions of the world. Dataquest classifies the world into the following regions:

- North America
- Europe
- Japan
- Rest of Asia—Rest of World

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Geographic Regions

Worldwide

North America
Europe
Japan
Rest of Asia—Rest of World

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

North America

North America

United States

East North Central Division
- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin
- East North Central Other

East South Central Division
- Alabama
- Kentucky
- Mississippi
- Tennessee
- East South Central Other

Mountain Division
- Arizona
- Colorado
- Idaho

Mountain Division (Continued)
- Montana
- Nevada
- New Mexico
- Utah
- Wyoming
- Mountain Other

Middle Atlantic Division
- New Jersey
- New York
- Pennsylvania
- Middle Atlantic Other

New England Division
- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont
- New England Other

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

United States (Continued)

- Pacific Division
  - Alaska
  - California
  - Hawaii
  - Oregon
  - Washington
  - Pacific Other
- South Atlantic Division
  - Delaware
  - District of Columbia
  - Florida
  - Georgia
  - Maryland
  - North Carolina
  - South Carolina
  - Virginia
  - West Virginia
  - South Atlantic Other
- West North Central Division
  - Iowa
  - Kansas
  - Minnesota
  - Missouri
  - Nebraska
  - North Dakota
  - South Dakota
  - West North Central Other
- West South Central Division
  - Arkansas
  - Louisiana
  - Oklahoma
  - Texas
  - West South Central Other
- Puerto Rico Division
  - Puerto Rico
- United States Other

Canada

North America Other

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Europe

Western Europe

Western Europe Major

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

Western Europe Other

- Austria
- Belgium
- Cyprus
- Denmark
- Finland
- Gibraltar
- Greece
- Iceland
- Ireland
- Liechtenstein
- Luxembourg
- Malta
- Monaco
- Norway
- Portugal
- San Marino
- Switzerland

European Community (EC)

- Belgium
- Denmark
- France
- Germany
- Greece
- Ireland
- Italy
- Luxembourg

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

European Community (EC) (Continued)
- Netherlands
- Portugal
- Spain
- United Kingdom

European Free Trade Association (EFTA)
- Austria
- Finland
- Iceland
- Norway
- Sweden
- Switzerland

Eastern Europe
- Albania
- Bulgaria
- Czechoslovakia
- Hungary
- Poland
- Romania
- Union of Soviet Socialist Republics
- Yugoslavia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Japan

Japan

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Rest of Asia—Rest of World

Rest of Asia—Rest of World

Four Tigers
- Hong Kong
- Korea
- Singapore
- Taiwan

Other Asia
- Bangladesh
- Brunei
- Burma
- Cambodia
- China
- East Timor
- India
- Indonesia
- Laos
- Macau
- Malaysia
- Maldives
- Nepal
- Pakistan
- Philippines
- Sri Lanka
- Thailand
- Vietnam

Rest of World

Australia/New Zealand
- Australia
- Christmas Island
- Cocos Islands
- New Zealand
- Norfolk Island

Oceania
- American Samoa
- Canton and Enderbury Islands
- Cook Islands
- Fiji
- French Polynesia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Oceania (Continued)
- Guam
- Johnson Island
- Kiribati
- Midway Islands
- Nauru
- New Caledonia
- Niue
- Pacific Islands
- Papua New Guinea
- Pitcairn
- Samoa
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu
- Wake Island
- Wallis and Futuna Islands

Africa
Central America
Caribbean
Middle East
South America
Atlantic
Inner Asia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Distribution

The distribution segmentation outlines the path by which a product moves from the manufacturer to the ultimate end user. This segmentation is used by Dataquest to analyze markups, discounts, and buyer behavior.

Dataquest defines the major distribution classifications as follows:

- Distribution channel
- Distribution method

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Distribution

DISTRIBUTION CHANNEL

- Direct
- Indirect
  - Value-Added Reseller/Systems Integrator
  - Original Equipment Manufacturer
  - Distributor
    - Regional Bell Operating Company (RBOC)
      - Independent Telephone Company
      - Telephone Interconnect Supplier
  - Dealer
  - Mass Merchandiser
  - Manufacturers' Representatives/Agents

DISTRIBUTION METHOD

- Direct Sales Force
- Telemarketing
- Mail Order
- Company-Owned Store

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Applications

The applications segmentation describes the use to which a product is put or the function it performs. Sometimes there are one-to-one relationships between products and their applications and the actual functions that a product performs.

The major applications as defined by Dataquest are as follows:

- General productivity
- Organizational
- Entertainment
- Industry specific

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Applications

GENERAL PRODUCTIVITY

- Document/Media Creation and Editing
  - Computer-Aided Printing and Publishing
    - Electronic Publishing
    - Technical Publishing
  - Graphics
    - Chart and Map Generation
    - Image Generation
    - Graphic Design Art
      - Image Editing
      - Draw/Paint
      - Image Capture
      - Clip Art
      - Illustration
    - Presentation Graphics
    - Color Prepress
      - Input
      - Image Processing
        - Image Manipulation
        - Color Correction
        - Color Pagination
      - Composition and Translation
      - Color Separation
    - Page Composition and Page Makeup
      - Page Description
      - Page Imaging
      - Document Architecture
      - Desktop Publishing
      - Scientific Visualization/Simulation
    - Multimedia
      - Animation
      - Desktop
        - Video
          - Compression
          - Digitizer
          - Full-Motion
          - Real-Time
        - Videodisc

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

GENERAL PRODUCTIVITY

- Holography
- Photo Realism
- Information Retrieval

Forms

Publishing Utilities
- Tagging
- PostScript Printing
- Compression/Decompression
- File Translation/Data Conversion

Document Management
- Author/Editor
- Image Processing
- Scanning
  - Text
  - Image
- Word Processing
- Typography

Communication
- Electronic Mail

Spreadsheet/Decision Support/Executive Information Systems
- Spreadsheet
- General-Purpose Simulation
- Modeling
- Forecasting

Learning/Education/Training
- Instructional
  - Computer Training/Assisted Instruction
- Educational Simulation
- Learning

Project Management
- Calendaring
- Scheduling
- Ticketing
- Library Management

Time Management
- Application Utilities
- Integrated Applications
- Relational Database Management System

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Management and Administration
  - Accounting
    - Accounts Payable
      - Checkbook Management
    - Accounts Receivable
      - Billing/Invoicing
    - General Ledger
    - Payroll
    - Tax Accounting
    - Personal Finance
  - Capital Assets
    - Fixed Assets
    - Lease Accounting
  - Human Resource/Personnel Management
    - Benefits Administration
    - Employment Administration
  - Finance
    - Financial Planning
    - Budgeting
    - Cost Accounting
    - Investment/Portfolio Management
    - Cash/Money Management
    - Deposit/Loan Management
    - Treasury/Stocks/Bonds
  - Purchasing
    - Contract Administration
    - Vendor Management
  - Planning
    - Business Planning
    - Strategic Planning
    - Command, Control, Communications, and Intelligence
  - Facilities Management
    - Facility Planning
    - Facility Simulation
    - Equipment/Maintenance Management
    - Property/Real Estate Management
    - Facility Security Management

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Sales and Marketing
  - Marketing Research
  - Advertising and Promotional
  - Public Relations
  - Order Entry/Processing
    - Customer/Prospect Management
      - Credit Management
    - Sales Support/Administration
- Research, Engineering, and Development
  - Industrial Automation
    - Shop Floor Plan and Control
    - CAM/Automated Assembly
    - Manufacturing Engineering Tools
    - Other Planning and Control
    - Test and Measurement
    - Others
  - Design Automation
    - CAD/CAM/CAE
      - Modeling
        - Two-Dimensional
        - Three-Dimensional
        - Solid
      - Mechanical
        - Documentation/Drafting
          - Detail Drafting
          - Document Management
          - Schematics
          - Technical Illustration
          - Charts
        - Conceptual Design
          - Industrial Design
          - Design Layout
          - Styling
        - Functional Design
          - Component
          - Assembly Verification
          - Linkage/Mechanism
        - Analysis
          - Fatigue
          - Structural

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Analysis (Continued)
  - Thermal
  - Vibrational
  - Magnetic
  - Composite
  - Mass Property
- Manufacturing Engineering
  - Tool Design
  - Fixture Design
  - Part-Processing Design
- Manufacturing Process Simulation
  - NC Part Programming
  - Coordinate Measuring Machines
  - Off-Line Robotics
  - QC Analysis

AEC (Architectural, Engineering, and Construction)
- Architectural
- Civil
- Facility Design
- Process Plant Design

Geographical Information Systems
- GIS/Mapping
- Raster-Based GIS Systems

Electronic Design Automation
- Electronic Computer-Aided Engineering
  - Digital Design
    - Design Entry
      - Schematic Entry
      - Libraries
    - Design Verification
      - Simulation
      - Simulation Acceleration
      - Hardware Modeling
      - Static Timing Analysis
    - Logic Synthesis
    - Test Automation
      - Automatic Test Vector Generation
      - Design for Testability/Test Synthesis
      - Fault Simulation

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Analog Design
  - Design Entry
    - Schematic Capture
    - Libraries
  - Design Verification
    - Circuit Simulation
    - Mixed Signal Simulation
- IC Layout and Verification
  - Editing
  - Layout
  - Verification
  - Module Generation
- PCB Layout

- Software Development
  - Computer-Aided Software Engineering
  - Artificial Intelligence
  - General Software Development

- Earth Resources
  - Seismic Analysis
    - Geophysical Seismic Imaging
  - Oil Field Services
  - Remote Sensing

- Technical Data Analysis
  - General Scientific
    - Scientific Research/Analysis
    - Scientific Visualization
    - Scientific Simulation
  - Chemistry
    - Crystallography
    - Modeling
    - Analysis
  - Simulation
  - Laboratory
  - Analytical Instruments
  - Instrument Automation
  - Quality Control/Assurance
  - Research and Laboratory Analysis
  - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Medical
  - Body Scanning
  - Patient Monitoring
  - Others
- Diagnostic
- Therapeutic

Manufacturing and Distribution
- Distribution Planning and Control
  - Transportation/Fleet Management
    - Route Planning
    - Dispatching
  - Warehouse Management
    - Automated Warehousing and Materials Handling
  - Inventory and Distribution Management and Control

Manufacturing Planning and Control
- Material/Process Requirements Planning, Production and Process Management
- Shop Floor Planning and Control
- CAM/Automated Assembly
- Manufacturing Engineering Tools
- Other Planning and Control
  - Simulation
    - Robot Programming and Simulation
  - Quality Assurance
    - Detection and Tracking
  - Fault Management/Adaptive Control
- Test and Measurement
- Inspection
  - Machine Vision

Others
- Real-Time Data Acquisition and Control
  - Simulation
  - C^3i
  - Others
- Building Automation

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ORGANIZATIONAL

Others (Continued)
- Traffic Control
- Railroad Control
- Power Grid Control
- Water Quality and Sewage Control
- Atmospheric Monitoring

ENTERTAINMENT

INDUSTRY SPECIFIC

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

User Environment

The user environment segmentation is based on industry classifications derived from a format that reflects the United States Department of Commerce's Standard Industrial Classification (SIC) code scheme and the International Standard Industrial Classification of all economic activities used by the United Nations.

Environments are a description of where a product is used ultimately. The major user environments as defined by Dataquest are as follows:

- Home
- Business
- Education
- Government

Dataquest has a classification scheme available at the two-, three-, and four-digit SIC levels, which can be provided on request.

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User Environment

HOME

BUSINESS

Natural Resources and Construction

- Agricultural Production—Crops
- Agricultural Production—Livestock
- Agricultural Services
- Forestry
- Fishing, Hunting, and Trapping
- Metal Mining
- Coal Mining
- Oil and Gas Extraction
- Nonmetallic Minerals, except Fuels
- General Building Contractors
- Heavy Construction, except Building
- Special Trade Contractors

Process Manufacturing

- Food and Kindred Products
- Tobacco Products
- Textile Mill Products
- Lumber Wood Products
- Paper and Allied Products
- Printing and Publishing
- Chemicals Allied Products
- Petroleum and Coal Products
- Rubber and Miscellaneous Plastics Products
- Leather and Leather Products
- Stone, Clay, and Glass Products
- Primary Metal Industries

Discrete Manufacturing

- Apparel and Other Textile Products
- Furniture and Fixtures
- Fabricated Metal Products
- Industrial Machinery and Equipment
- Electronic and Other Electric Equipment
- Instruments and Related Products

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BUSINESS

Discrete Manufacturing (Continued)

- Miscellaneous Manufacturing Industries
- Transportation Equipment

Transportation

- Railroad Transportation
- Local and Interurban Passenger Transit
- Trucking and Warehousing
- Water Transportation
- Transportation by Air
- Pipelines, except Natural Gas
- Transportation Services

Communication

- Communication

Utilities

- Electric, Gas, and Sanitary Services

Wholesale Trade, Durable Goods

- Wholesale Trade—Durable Goods

Wholesale Trade, Nondurable Goods

- Wholesale Trade—Nondurable Goods

Retail Trade

- Building Materials and Garden Supplies
- General Merchandise Stores
- Food Stores
- Automotive Dealers and Service Stations
- Apparel and Accessory Stores
- Furniture and Home Furnishings Stores
- Eating and Drinking Places
- Miscellaneous Retail

Finance

- Depository Institutions
- Nondepository Institutions
- Security and Commodity Brokers

Insurance

- Insurance Carriers
- Insurance Agents, Brokers, and Service

Real Estate

- Real Estate
- Holding and Other Investment Offices

Hotels And Other Lodging

- Hotels and Other Lodging

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BUSINESS

Business Services
- Business Services
- Legal Services

Health Care
- Health Services

Other Services
- Personal Services
- Auto Repair, Services, and Parking
- Miscellaneous Repair Services
- Motion Pictures
- Amusement And Recreation Services
- Social Services
- Museums, Botanical, Zoological Gardens
- Membership Organizations
- Engineering and Management Services
- Services, NEC

EDUCATION

Elementary
Secondary
Higher Education
Four-Year Institution
Two-Year Institution
Public
Private

GOVERNMENT

Government by Function
- Executive, Legislative, and General
- Justice, Public Order, and Safety
- Finance, Taxation, And Monetary Policy
- Administration of Human Resources
- Environmental Quality and Housing
- Administration of Economic Programs
- National Security and International Affairs

Government
- Federal
- State
- Local

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SIZE (BUSINESS, EDUCATION, GOVERNMENT)

Revenue (Millions of U.S. dollars)

- 0 to 99.9
- 100 to 499.9
- 500 to 999.9
- 1 to 4.9
- 5 to 9.9
- 10 to 49.9
- 50+

Employees

- Small
  - 0 to 9
  - 10 to 19
  - 20 to 49
- Medium
  - 50 to 99
  - 100 to 249
- Large
  - 250 to 499
  - 500 to 999
  - 1,000+

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Research Items

The research items segmentation is a listing of general terms used by Dataquest to organize, describe, and analyze data for technology markets and industries. A typical use of research items is to describe market data in terms of shipments, retirements, and installed base.

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Research Items

- Application
- Assembler
- Average Selling Price
- Average Usage
- Average Volume
- Balance of Trade
- Bit
- Byte
- Capital Spending
- Captive Production
- Compound Growth Rate
- Consumption
- Conversion Revenue
- Cost
- End User
- End-User Average Selling Price
- End-User Revenue
- Environment
- Export
- Factory Average Selling Price
- Factory Revenue
- Gross Lease Additions
- If-Sold Value
- Import
- Industry
- Input/Output (I/O) Ratio
- Installed Base
- Internal Transfer
- Inventory
- Joint Venture
- Lease
- Lease/Rental Conversions
- List Price
- Manufacturer
- Manufacturer's Suggested Retail Price
- Market
- Market Share
- Markup
- Merchant Production
- Net Additions
- New Placement Demand
- Placement
- Product
- Product Category
- Production
- Replacement Demand
- Research and Development
- Residual Value
- Retirement
- Return
- Revenue
- Shipment
- Subsidiary
- Tie Ratio
- Unit
- Useful Life
- Users per System
- Year-Average Population

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The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Glossary

This glossary includes definitions of the major terms associated with Dataquest's segmentation of the high-technology marketplace.

III-V discrete semiconductor. 1: A semiconductor device with low noise, low power, and high power in the range of one-half watt to one watt. 2: A device of gate structures based on D-MESFET and E/D MESFET devices.

A

academic support. College expenditures that include expenditures for support services that are an integral part of the institution's primary missions of instruction, research, or public service. Includes expenditures for libraries, galleries, audio/visual services, academic computing support, auxiliary support, academic administration, personnel development, and course and curriculum development.

accounting software. 1: A software application that supports a system of recording and summarizing business and financial transactions and analyzing, verifying, and reporting results. 2: A software application used to manage an organization's money and/or assets. This type of software includes general ledger, accounts payable/receivable, and inventory control.

accounts payable (AP). An application that supports the accounts payable function, which is the amount owed by a business to its suppliers and other regular trading partners.

accounts receivable (AR). An application that supports the accounts receivable function, which is the amount owed to a business by its customers.

ACD. See **automatic call distributor.**

adaptive control. 1: The property of a control system that allows it autonomously to maintain a manufacturing or process environment within predetermined control limits. 2: A device with parameters that adjust automatically to compensate for changes in the dynamics of the process to be controlled.

add-on graphics board. A graphics board that is added to a basic computer to enhance the computer's current graphic capability.

add-on graphics board, Mac-type. Personal computers that were designed to run applications exclusively through a graphical user interface (i.e., windows, menus, and icons). Mac-type systems include Apple's Macintosh series (512E, Plus, SE, and II), Atari's ST series (524 and 1024), and Commodore's Amiga. This term also refers to peripherals intended for use in Mac-type systems.

add-on memory board. A printed circuit board populated with memory integrated circuits (IC), usually DRAMs or SRAMs, that plugs into personal computers via connectors on the central processing unit bus. These boards are used to increase central processing unit storage capacity.

AEC. See **architecture, engineering, and construction.**

aerial. See **antenna.**

AGVS. See **automatic guided vehicle system.**

AI. See **artificial intelligence.**

air conditioner. 1: An apparatus for controlling the temperature and humidity of air. 2: A broad field including numerous processes, among which are refrigeration, heating, ventilation and humidification, and electronic air filtering.

aircraft system (military). Electronic power devices used in airplanes to perform functions like flight control, communication and navigation, lighting computer system (including air data, mission and fire control), engine control, instrumentation, integral targeting system, associated test system, and integrated system.

alarm system. A system designed to warn of an intrusion, a fire, or other undesired occurrence. Alarm systems have three functions in common: detection, control, and annunciation signaling.

alphanumeric CRT controller. A character set of both letters and numbers that is used to control electron beams, which are used to present data in a visual form.

alphanumeric CRT terminal. A display terminal that provides character information to the operator.

amateur radio. A radio used for two-way radio communications by private individuals. It is not used for enterprise activity.

AMH. See **automated materials handling.**

amplifier IC. A linear IC that provides a voltage or power gain to an applied signal.

analog. 1: Representation of data by means of continuously variable physical quantities, such as voltage, current, or frequency. 2: A circuit or system in which the output signals bear a continuous relationship to the input signals. 3: A representation of an event in another form, e.g., the representation of voice sounds as continuously variable electrical signals.

analog design verification. A software application that includes analog simulation, analog synthesis, monte carlo analysis, worst-case analysis, and parametric plotting.

analog loop. A nondigital portion of the telecommunications network.

analog panel meter. 1: An electrical switchboard or instrument board with continuously variable electrical signals known as analog signals. 2: A mounting plate for the controls and/or other parts of equipment, utilizing analog signals.

analysis. Separation of a whole into its parts; proof of a mathematical proposition by assuming the result and deducing a valid statement by a series of reversible steps. Includes mass properties, kinematic and dynamic mechanism analysis, structural, thermal, composite, fluids, and vibration analysis. Finite element and finite difference are common analysis technologies used.

analytical and scientific instrument. Instruments used to measure, access, control, and monitor objects and systems.

animation. A software application to present either continuous pictures or images or to present them in rapid succession.

answering machine. A device, hooked to a telephone, that can record and play messages as they pass through a phone when a user is unable to pick up the telephone.

antenna. 1: A conductor or system of conductors that serves to radiate or intercept energy in the form of electromagnetic waves. 2: A device for transmitting or receiving radio waves. Also called aerial.

AP. See **accounts payable.**

appliance. 1: An instrument or device designed for a specific household or office purpose. 2: A piece of equipment for adapting a tool or machine to a special purpose.

application. The use to which a product is put; the function it performs.

application software. A software program or set of programs designed for a specific application, such as inventory control or linear programming.

application-specific integrated circuit (ASIC). A single-user IC that is manufactured using vendor-supplied tools and/or libraries. (May be sold by an ASIC or standard-product group.)

application utilities. A software application that enhances the operation of other standalone applications; Typically operates concurrently with these standalone applications.

AR. See **accounts receivable.**

architectural. Computer-aided tools intended for use in design and drafting of facilities' architectural aspects.

architecture, engineering, and construction (AEC). The use of computer-aided tools by architects, contractors, plant engineers, civil engineers, and others associated with these disciplines to aid in designing and managing buildings, industrial plants, ships, and other types of nondiscrete entities.

arc-welding robot systems. A system in which a robot carries an arc-welding torch to produce welds.

argon. An inert gas extensively used in discharge tubes.

artificial intelligence (AI). The ability of a machine to perform functions normally associated with human intelligence, such as learning, adapting, reasoning, self-correcting, and improving automatically.

ASCII. Standardized coding for alphanumeric and other standard keyboard characters.

ASIC. See **application-specific integrated circuit.**

ASP. See **average selling price.**

AS/RS. See **automated storage/retrieval system.**

assembler. A company that adds manufacturing value to a product.

assembly. 1: A group of subassemblies and/or parts that, when put together, create a major subdivision of the final product. When two or more components or subassemblies are put together by the application of labor and machine hours, it is called an assembly. An assembly may be an end product or a component for a higher-level assembly. 2: The semiconductor manufacturing steps of mounting a die in a package, bonding the pads to the package leads, and sealing the package.

assembly verification. The integration of various component designs into an assembly to test size/shape and functional characteristics.

asynchronous telecommunications software. A software application that emulates a standard computer terminal (e.g., DEC VT-100) and performs file transfer between asynchronously connected computers and/or provides remote operation of another computer.

ATE. See **automatic test equipment.**

ATM. See **automated teller machine.**

atmospheric monitoring. A real-time software application that monitors weather-related data from satellites and other monitoring sites around the world.

atmospheric/purge cylinder gas. A specialty gas; a cylinder gas for purging certain processing systems and equipment when manufacturers are concerned about possible back contamination of the house lines.

attendant console. A specialized telephone instrument that allows fast and efficient answering and routing of telephone calls.

audio amplifier. A device that uses transistors or vacuum tubes to obtain voltage, current, or power to amplify sound.

audio conferencing. The ability to communicate among more than two people at one time via a speakerphone or the telephone system/network.

audio equipment. Amplifiers, preamplifiers, control consoles, and other equipment used in studio, broadcast, and home environments. Equipment interprets frequencies corresponding to audible sound waves.

automated assembly system. The assembly of parts into subassemblies and/or complete assemblies using programmable equipment that may include robots. In discrete piece manufacturing, this system includes spot- and arc-welding and adhesives. In electronics, this system includes component placement and printed board component insertion. Usually, these automated assembly systems include sensors.

automated guided vehicle system (AGVS). An unmanned mobile transporter under programmable control that moves materials and tooling throughout a factory and/or warehouse. Includes towing vehicles, pallet trucks, light-load transporters, unit-load transporters, and self-loading and unloading vehicles.

automated materials handling (AMH). The automated handling of discrete or bulk materials in manufacturing systems. Materials handling includes the movement, storage, identification, and controlling of materials.

automated storage/retrieval system (AS/RS). All computer hardware, software, and equipment that are used together for mechanical hoists and carriages and that interface with racks and bins for automatic storage and retrieval of unit loads, pallets, and individual parts. An AS/RS moves materials from inventory to operations and back to inventory, frequently for work-in-process inventory.

automated teller machine (ATM). A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **funds transfer terminal.**)

automatic blood analyzer. Equipment used to analyze, detect, and decipher blood types and blood-related diseases.

automatic call distributor (ACD). A computer-based system located at a customer's premises that: (1) provides real-time monitoring of a telephone system's work load; (2) distributes calls to the agent who is idle longest; and (3) uses a queuing or waiting list assignment that holds the callers in queue until an agent is available, averages the random flow of traffic, and decreases peak traffic load. An ACD also contains features known as gates or agent split groups that provide functional divisions within the routing scheme and allow calls to be directed to a specific group or agent.

automatic photoresist processing equipment (colloquial: track). Equipment used to dispense and process photoresist material onto a wafer. Track equipment, as this equipment is usually called, includes wafer clean/bake, wafer prime, wafer coat/bake, wafer develop/bake, and resist stabilization equipment.

automatic test equipment (ATE). Computer-controlled equipment that inspects electronic devices, both active and passive. ATE usually includes analytical and statistical data-reduction capabilities and can document test results by display, hard copy, and electronic storage. ATE can perform printed circuit board (PCB) inspection by mechanical, electrical, and visual means in an automatic, programmable mode. ATE includes both bare boards and boards that have been loaded with electronic devices. In the latter case, diagnostic capabilities are included as a part of the system definition if they are part of the equipment.

automatic warehousing system (AWS). A dedicated storage and retrieval system that is used not on the factory floor but in a warehouse that may or may not be located within a manufacturing facility. An AWS includes a control system and associated material-handling equipment and structures, but excludes the building unless it is a structural part of the automated system. The control system includes both hardware and software.

automation. The system or technique of the production process that minimizes human intervention. Self-controlled machines are used to accomplish human tasks or tasks not able to be accomplished by human intervention.

average selling price (ASP). The average price of a product, inclusive of any discounts. (See also **end-user ASP** and **factory ASP.**)

average usage. The average number of units of product used per unit of time.

average volume. The average number of units of product produced per unit of time.

awarded contract. A binding agreement granted to a specific company.

AWS. See **automatic warehousing system.**

B

balance of trade. 1: The difference between the value of a country's exports and imports of tangible goods over a given period, usually one year. 2: The difference between the value of a country or region's exports of tangible goods to and imports of tangible goods from a second country or region.

banking system. Systems used in the banking/finance industries to facilitate the transmission of funds to improve efficiencies. Systems include: payroll allocation and deduction; demand deposit accounting; savings, both regular and certificates of deposit; and loan processes.

baseband modem. A type of modem that utilizes all of the available analog bandwidth on a line.

basic exchange telecommunications radio system (BETRS). A radio system network that provides cost-effective basic telephone service within remote areas.

benefits administration. A software application with the primary function of administering and aiding in managing an organization's employee benefits.

BETRS. See **basic exchange telecommunications radio system.**

BiCMOS. Bipolar complementary metal oxide semiconductor. See **BiMOS.**

BiMOS (BiCMOS). Bipolar metal oxide semiconductor (MOS). An integrated circuit (IC) manufactured with both bipolar and MOS processes that yields a component with the benefits of both technologies.

bipolar. 1: A semiconductor technology employing two junction transistors. 2: A device in which both majority and minority carriers are present. A transistor structure with electrical properties determined within the silicon material.

bipolar application-specific IC. See **application-specific integrated circuit.**

bipolar cell-based IC. See **cell-based integrated circuit.**

bipolar custom IC. See **custom integrated circuit.**

bipolar digital logic. See **logic circuit.**

bipolar digital microcomponent. See **microcomponent.**

bipolar FPGA. See **field-programmable gate array.**

bipolar gate array. See **gate array.**

bipolar memory. See **memory.**

bipolar nonvolatile memory. See **nonvolatile memory.**

bipolar PLA. See **programmable logic array.**

bipolar PLD. See **programmable logic device.**

bipolar PMD. See **programmable multilevel logic device.**

bipolar standard logic. See **standard logic.**

bipolar transistor. A transistor that uses positive- and negative-charge carriers. Bipolar transistors provide current gain—that is, a current input results in a larger current output.

bit. Abbreviation for binary digit. A unit of information equal to one binary decision, or the designation of one of two possible and equally likely values or states of anything used to store or convey information.

black-and-white television. Television in which the reproduced picture is displayed in shades of gray between black and white. Also known as monochrome television.

board-level computer. A single, or multiple, board-level CPU that is sold individually or incorporated in systems-level products (boxes). Typically, these are products that are not considered complete packaged systems. Prices range from the low hundreds to the low thousands of dollars. Frequently, software is bundled with the board for a specific application.

body control. Electronic equipment used to direct, manage, or guide an automobile or truck. Examples include electronic suspension, cruise control, intermittent wipers, load-sensitive braking, antitheft devices, electronic steering, and electronic mufflers.

book publishing software. Software with the main purpose/use of printing books or written or printed literary works.

boring programmable machine tool. A factory tool designed to machine internal work such as cylinders, holes, and castings.

broadband communications. Communications that utilize a bandwidth greater than a voice-grade circuit.

broadcast. 1: The transmission of packets on a contention bus where all data are heard by all devices on the channel and are selected by each device through address-recognition techniques. 2: To send messages or to communicate simultaneously with many or all points on a circuit. 3: The transmission of radio frequencies from a source to all devices that are capable of receiving the signal. Microwave transmission is one method of transmission. 4: Radio or television transmission intended for public reception.

broadcast and studio equipment. Equipment used to make information public by means of radio or television.

broadcast transmitter antenna. An electronic device for generating and amplifying a radio-frequency carrier for transmission through space from an antenna.

bubble memory. A storage medium that allows information to be stored on magnetically charged crystal chips. Bubble memories can hold data without electricity to sustain them; blackouts, changes in current, and static charges do not affect them. Such memories process material 75 times as fast as disk memories. However, bubble memory processors cannot handle multiprogramming, i.e., performing parallel operations with several programs.

budgeting. An application that supports future resource planning.

building automation. A software application with the primary functions of managing the operations of a facility, including fire detection, energy management, and alarm systems. Large manufacturing plants and skyscrapers use real-time computers to control and monitor conditions. This may include fire detection and control systems; security systems; clocking, documenting, and energy management for heating, ventilation, and air conditioning.

bulk gas. A discrete delivery of gas in a liquid state.

bundled distribution and warehouse package. Hardware and/or software modules used for planning and control of warehouse or product distribution systems. These packages are not available separately from the total warehouse or distribution system.

business. A commercial or mercantile environment usually referred to as a vertical market. See "User Environment" section.

byte. 1: A single group of eight bits processed together. 2: The number of bits that a computer processes.

C

C^3I. See **command, control, communications, and intelligence.**

cable. An assembly of one or more conductors within an enveloping protective sheath, constructed to permit the use of the conductors singly or in groups.

cable television equipment. All equipment for both the head and subscriber ends of a cable television system.

cache. A fast, small memory (typically SRAM) used to enhance CPU performance, separate from main processor memory.

cache controller. A device that governs the area of a system that stores only data the system may need in the immediate future.

CAD. See **computer-aided design, drawing, or drafting.**

CAE. See **electronic computer-aided engineering** and **mechanical computer-aided engineering.**

CAGR. See **compound annual growth rate.**

calculator. A device capable of performing logical and arithmetical digital operations of any kind.

calendaring. 1: An application to support the scheduling of meetings and other events. It is usually a tickler file, reminding people of upcoming commitments. 2: In the papering industry, paper with a hard, smooth finish.

call management systems. The equipment and service that records the calling activity of a centrex, PBX, or key telephone system in order to generate reports that support telephone cost allocation and other telephone management information needs.

call processing equipment. Call processing equipment provides additional functions and capabilities beyond traditional call processing. This classification includes add-on products such as voice-messaging systems, call accounting systems, and automatic call distributors.

CAM. See **computer-aided manufacturing.**

capacitor. A commonly used component that stores electrical energy. It is sometimes referred to as a condenser.

capital assets. An application that assists a company in managing its capital assets, which are any physical property or right that is owned and has a money value.

capital spending. The purchase of a capital asset or an asset that is needed to create a product and is acquired with the intention of keeping (rather than being resold).

captive production. The sale of a good to a division within the manufacturing company.

carrier equipment. A cable-based system that provides transmission of multiple signals over a common metallic or fiber-optic cable. This segment includes subscriber carrier systems, trunk carrier systems, Basic Exchange Transmission Radio (BETR) systems, and repeaters.

cartography. An application that supports map production and/or resource management. May contain a spatially indexed data structure.

cartridge tape drive. A tape drive that uses a special metal and plastic protective device for the tape, which can be used for 1/4-inch or 1/2-inch tape products.

CASE. See **computer-aided software engineering.**

cash register. A device that automatically registers visibly the amount of a specific sale. Many are used to trace inventory and other product information through the sale of the product.

cassette tape drive. A tape drive that uses a small container of tape similar to that used for commercial audio recording purposes.

cathode ray tube (CRT). A television-like display screen which, on receipt of information bearing electronic signals, produces a visual display of the information (text, graphics). The CRT consists of a vacuum tube display in which a beam of electrons is projected onto a fluorescent surface of phosphors, producing a visual display. Used in most computer display terminals. Also referred to as video display terminal/visual display tube (VDT).

CAT scanner. A computerized axial tomography—frequently shortened to CT. A reconstructive imaging technique employing an X-ray source and array of detectors rotated about the body of the patient. The host computer calculates an image based on the appearance of a thin volume in the plane of the rotation.

CBIC. See **cell-based integrated circuit.**

CCD. See **charge-coupled device.**

CCIT. A French acronym for the International Telegraph and Telephone Consultative Committee, a committee of the international standards organization made up of telecommunication authorities of member countries. The committee's primary purpose is to develop and produce standards for telecommunication networks.

CCME. See **computational chemistry/molecular engineering.**

CCTV. See **closed circuit television.**

CD. See **critical dimension** and **compact disc.**

CD-ROM (compact disc read-only memory). See **CD-ROM disc drive.**

CD-ROM disc drive. All CD-ROM discs are 4.7 inches (12cm) in diameter, have a 1.6-micro-inch-pitch single-spiral track, and have 2.048 data bytes per sector.

cell-based integrated circuit (CBIC). An ASIC device that is customized using a full set of photomasks and uses automatic placement of cells and automatic routing.

cellular handset. See **cellular telephone.**

cellular service. One type of mobile communications, where a low-power radio is used between limited-distance "cells."

cellular telephone. Mobile radio equipment associated with cellular radio services.

central office (CO). 1: The physical location that contains the equipment that supports the telephone network. 2: The switching equipment that connects local access lines to toll circuits.

central office switching equipment. Equipment comprised of electronic systems that interconnect local telephone lines (loops) and connect local telephone lines to long distance trunk lines.

central processing unit (CPU). A microprocessor or microcontroller. Central processing unit of a computer.

centrex. An optional service that provides voice/data switching by using the utility's central office.

charge-coupled device (CCD). ICs that combine charge-coupled signal transfer with arrays of photosensors to provide image sensing. CCDs are available as linear or area arrays.

chart. Any table, graph, or drawing depicting a range of technical data.

chart and map generation. A graphics software application that is designed specifically for charts and predefined maps.

check-handling system. A system to improve the speed and accuracy of check-handling processes within the banking and finance industries.

chemical vapor deposition (CVD). A formation of a stable compound on a heated substrate by thermal reaction or decomposition of gaseous compounds. A process that chemically isolates and deposits a specific material on a wafer. CVD equipment includes atmospheric-pressure CVD (APCVD), plasma-enhanced CVD (PECVD), and low-pressure CVD (LPCVD) techniques. Historically, the CVD market was split into APCVD, PECVD, and LPCVD technologies, because each had its own applications. Now, because of advanced reactors that are crossing application boundaries, it makes more sense to divide the market by film application rather than by equipment technology.

chemistry. 1: An application to support the science dealing with the composition structure and properties of substances and with the transformations that they undergo. 2: Chemical processes and phenomena.

circuit. 1: The electrical path between two or more points. 2: A means of two-way communication between two points, consisting of a sending and a receiving channel or a combined sending and receiving channel. 3: A transmission path between two or more points.

CISC MPU. See **complex-instruction-set computing microprocessor.**

citizens band: mobile and base. A frequency band allocated for private individual radio service (460 to 470 megahertz or 26.965 to 27.405 megahertz).

civil aerospace. Civilian travel in space.

civil aircraft flight system. Same as military aircraft, except related to civilian activity.

civil application. A software application used for civil engineering tasks, typically for design and drafting of sites for buildings, streets, highways, bridges, dams, airports, and utilities.

civilian space. Equipment used by civilians to explore the earth's atmosphere. Includes satellites, reconnaissance equipment, and ground control equipment.

civil navigation/communication. Same as military navigation/communications, except related to civilian activity.

civil radar. Same as military radar, except related to civilian activity.

civil simulation and training. Same as military simulation and training, except related to civilian activity.

closed circuit television (CCTV). A television system where television signals are not broadcast, but are transmitted over a closed circuit and received by interconnected receivers.

CMOS. See **complementary MOS.**

CO. See **central office.**

coaxial cable. Type of transmission cable with one or more central conductors, surrounded by an insulator.

CODEC. See **coder/decoder circuit.**

coder/decoder circuit. An integrated circuit that codes a voice signal into a binary waveform or decodes a binary waveform into a voice signal. Such circuits now are used in digital communications applications.

college. A postsecondary school that offers general or liberal arts education, usually leading to an associate, bachelor's, master's, doctor's, or first professional degree. Junior colleges and community colleges are included under this category.

color prepress. A process that converts visual material to electronic signals.

color separation. A process of photographing objects using three filters, each corresponding in color and light transmission to one of the additive primary colors; analogous to seeing.

color television. An electronic system that transmits signals to a visual image that can be viewed in an array of colors on a screen.

combined elementary and secondary school. A school that encompasses instruction at both the elementary and secondary levels. Examples of combined elementary and secondary school grade spans would be 1 through 12 or 5 through 12.

combined PCB tester. Testing equipment that combines functional and in-circuit test techniques and capabilities that result in a test strategy to suit any given board's production history and fault spectrum to achieve the highest board fault coverage at the lowest cost.

command, control, communications, and intelligence (C^3I). Systems used to display the ongoing status of tactical or strategic operations in dynamic scenarios for rapid decision making.

commercial antenna. See **antenna.**

commercial meteorological and general-purpose instrument. Equipment used to obtain quantitative information about the weather.

communication. 1: The transmission of information from one point or person or equipment to another. 2: The sensing of a measurement signal or phenomenon for display, recording, amplification, transmission, computing, or processing into useful information.

communication management. The organization of stations, peripherals, and devices capable of intercommunications but not necessarily on the same channel.

communication peripheral. An interface device for machine-to-machine connections.

compact disc (CD). A disc from which data are read optically by means of a laser.

compact disc player. 1: A recording and playback system used to play recorded music by means of a small plastic optical disc similar to multiplex stereo broadcast and reception. Each wall of the record groove carries a single channel of information. 2: A recording device in which the sounds are mechanically impressed onto a disc.

comparator. A type of amplifier that produces a logic output (1 or 0) based on comparison of an input voltage with a fixed reference voltage. A widely used form of linear integrated circuit.

compiler. 1: Computer routine that translates symbolic instructions to machine instructions and replaces certain items with subroutines. 2: An automatic coding system in a computer that generates and assembles a program from instructions written by a programmer. 3: A computer language system consisting of various subroutines that have been evaluated and computed into one routine handled by a computer. 4: Software used to convert application programs from computer language to machine language.

complementary MOS. A semiconductor technology that uses both P-channel and N-channel transistors on the same silicon substrate to gain the primary advantages of very low power and high noise immunity.

complex-instruction-set computing (CISC) microprocessor. The number of instructions a microprocessor runs for a specific application. Known as a general-purpose processor.

component. An assembly, device, or piece of equipment that is part of a larger assembly or system.

component design. Design of the individual components in an assembly.

composite analysis. The analysis of composite materials (such as carbon fiber) as they change in the manufacturing process and are used in the final assembly.

compound annual growth rate (CAGR). The average rate of growth compounded over a specified period. The formula used to calculate CAGR is:

$$\left(\frac{\text{Value in period } 1+n}{\text{Value in period } 1}\right)^{\left(\frac{1}{n}\right)} - 1$$

computational chemistry/molecular engineering (CCME). The use of computers to model molecular structures, to predict physical properties of molecules, and to design new compounds for specific purposes.

computer-aided design (CAD). Systems that function as tools to expedite mechanical and electronic design. Most CAD systems consist of a graphics computer terminal linked with a computer and a software package with features that aid in design and drafting, keep track of parts, run simulations, and provide illustrated parts or circuit diagrams. Programs complete the layout, geometric transformations, projections, rotations, magnifications, and interval (cross-sectional) views of a part and its relationship with other parts.

computer-aided manufacturing (CAM). The use of computers to program, direct, and control production equipment in the fabrication of manufactured items.

computer-aided software engineering (CASE). A combination of artificial intelligence and structured programming techniques used to aid in the development of large software programs.

computerized energy control system. A system with the resources for producing heat, electricity, and/or power and the capability of running on computers.

computer plotter. A visual display on which a dependent variable is graphed by an automatically controlled pen or pencil or other image development device/technique as a function of one or more variables. See also **plotter.**

computer storage media. The substance upon which data are stored electronically. Media may be flexible disks, rigid disks, tape, or optical disks.

computer storage tape media. Long, thin, flexible tape appropriate for digital magnetic recording and storage of computer data.

computer system. A combination of hardware, software, firmware, and peripheral components that has been assembled to satisfy a particular goal or set of goals.

computer systems performance segments. The following are Dataquest segments for computer systems performance: Level I—low-performance minicomputers, microcomputers, and personal computers; Level II—medium-performance minicomputers and microcomputers, very low end workstations, and high-end personal computers; Level III—low-performance superminis, midrange workstations, and high-performance minicomputers; Level IV—midrange superminis, low-end mainframes, and high-end workstations; Level V—high-performance superminis and midrange mainframes; Level VI—low-end supercomputers and very high performance superminis; and Level VII—supercomputers and high-end mainframes.

computer to PBX interface/digital multiplex interface (CPI/DMI). Two different standards for communication between systems.

computer to plate. A process that merges type and black-and-white images and combines the functions of typesetting, camera photography, and contact platemaking.

conceptual design. An application that supports styling, industrial design, and other design applications emphasizing visualization, aesthetic, and ergonomic considerations.

connector. A device used to join or fasten transistors, establishing a relationship between active and passive devices.

consortium. An international business agreement; an association or society.

consumable. Material that is capable of being consumed.

consumer electronics. The application of electronics in consumer equipment.

consumer integrated circuit (IC). An analog circuit that meets specific consumer end-market applications. These circuits are dedicated to specific applications, such as audio or radio, and would not be used for general purpose.

consumer N.E.C. Consumer equipment not elsewhere classified.

consumer radio. A device used by the general public for communication by electromagnetic waves transmitted through space to produce sound.

consumption. The markets' purchase and use of goods and services, including lease or rental.

contract administration. The management of agreements between a company and its vendors and/or customers.

contract maintenance service. Ongoing repair services based on agreed upon terms and conditions (such as hours of coverage and level of services) as stipulated in a written agreement between the customer and the service provider.

controller. A device or group of devices that serve to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

controller board. A printed circuit board that provides programmable logic that controls the sequence of operations of the functional stages of a peripheral device.

conversion revenue. The revenue generated by changing from an equipment rental contract to a purchase or lease contract.

coordinate measuring machine. Machine used to measure the physical dimensions of a part.

copier. A reproduction device designed to produce replicas of hard-copy originals. Copiers may use either an analog or a digital scanning system.

coprocessor. A logic device that operates in association with a microprocessor to enhance system performance. Coprocessors are not capable of independent operation.

cordless telephony. The transmission of speech or other information via radio, enabling two persons to converse over almost any distance without a connecting cord to a base unit.

corporate publishing. Publishing that supports the main business of an organization or person; printed and published products are produced in the normal course of operations, but not as a primary source of revenue.

corporate supercomputer. An information system priced at more than $2 million. Performance speed is more than 200 mflops; current upper limit is approximately 2 Gflops. Currently used mainly for batch applications, but the trend is toward interactive use. Optimized for very heavy, numerically intensive applications. Requires special environmental controls and cooling techniques.

cost. The expenditure necessary to produce a product.

cost accounting. An application that supports a branch of accounting that is concerned with the collection, determination, and control of costs, particularly those costs associated with producing products or services.

counter/timer circuit. A circuit that receives uniform pulses representing units to be counted and provides a voltage proportional to their frequency.

counting device. A device register or location in computer storage for storing numbers or number representations in a manner that permits these numbers to be increased or decreased by the value of another number or to be changed or reset to zero or to an arbitrary value.

CPE. See **customer premise equipment.**

CPI/DMI. See **computer to PBX interface/digital multiplex interface.**

CPU. See **central processing unit.**

critical dimension (CD). Refers to a line, element, or feature that must be manufactured and controlled to very tight specifications.

CRT. See **cathode ray tube.**

CT2. See **digital cordless telephone.**

custom/contract programming. Programming services that include applications development and software systems conversions.

customer management. A software application used to maintain lists of purchasers of a company's products and services.

customer premise equipment (CPE). Telecommunication equipment used at an end user's location, as compared with use at the local telephone utility.

customer training/education service. Activities designed to instruct customers in the installation, usage, programming, management, and maintenance of hardware, software, and networking products.

custom integrated circuit. A handcrafted, single-user integrated circuit that is customized using a full set of photomasks and requires manual placement and routing. Can be either bipolar or MOS technology process.

CVD. See **chemical vapor deposition.**

D

daisywheel. See **printwheel.**

DAT. See **digital audiotape.**

data acquisition and control. See **real-time data acquisition and control.**

database. The entire body of data that has to do with one or more related subjects. Typically, it consists of a collection of data files stored in a computer system.

database administration. A control program function that provides access to data sets, enforcement of data storage conventions, and regulation of the use of input/output devices.

database management system (DBMS). 1: A software application that provides storage maintenance functions for data stored in sequential, hierarchical, relational, or object format. Example of DBMS products include FOCUS (hierarchical), Ingres (relational), and GBASE (object oriented). 2: A systematic approach to storing, updating, and retrieving information stored as data items, commonly referred to as data files.

database publishing. A system with the main purpose/use of printing the ordered collections of data.

data capture. A process that takes possession or control of information.

data center. A program designed primarily to acquire, analyze, process, store, retrieve, and disseminate one or more types of data.

data center construction/relocation services. Services in which a vendor performs or manages the contracting of site management services including the design and building of a customer's data center and/or the relocation and installation of customer's equipment.

datacom equipment. See **data communications equipment (DCE).**

data communications equipment (DCE). Equipment used for transmitting data between points of origin and reception. It includes products such as modems, statistical multiplexers, T-1 multiplexers, front-end processors, data PBX systems, data network management systems, DSU/CSU equipment, local area networks, and private packet data switching equipment.

data converter. An integrated circuit that changes alternating current to direct current or direct current to alternating current.

data creation. The process of producing or originating information.

data network management system. A product or device that diagnoses, isolates, reinstates, or accumulates information for network components or provides reports and analysis of network performance.

data PBX system. A digital private branch exchange system that allows terminals to switch and contend for computer ports by providing RS-232-C connections. This system does not provide voice switching. Data PBX base units and add-on channels also are included in this classification.

data processing (DP). 1: The preparation of source media that contain data or basic elements of information and the handling of such data according to precise rules of procedures to accomplish such operations as classifying, sorting, calculating, summarizing, recording, and computing. 2: The handling of information in a sequence of reasonable operations.

data service unit (DSU) and channel service unit (CSU). These provide an interface to digital services, such as the AT&T Dataphone Digital Service (DDS).

data storage device. A product designed to hold data until needed. Storage devices are rated by technology (rigid, flexible, and optical disk drives and tape drives), physical size in inches (diameter for rigid and flexible disk drives, width for tape drives), and capacity in bytes. (See also **disk drive, tape drive.**)

data translation. 1: A device that transforms computer information to data from one language to another language without affecting the meaning. 2: To change one binary word to another.

DBMS. See **database management system.**

DCE. See **data communications equipment.**

dealer. 1: Independent businesses selling products under contract to one or more vendors. 2: A product reseller selling to end users. A dealer's primary added value is distribution; secondary added values are service, training, and support.

defibrillator. An electronic instrument used for stopping spontaneous, local contraction of muscle fibers (fibrillation) during a heart attack by applying controlled electronic pulses to the heart muscles.

departmental supercomputer. An information system with price ranging from $100,000 to $2 million. Performance speed ranges from 10 to 200 mflops. Acquired usually by users who need heavy number-crunching capabilities but cannot afford a full-scale supercomputer costing more than $2 million. This computer is a vector processor and thus uses a fundamentally different execution technique from scalar processors, such as mainframe computers and superminicomputers, and is typically configured as a uniprocessor rather than a parallel processor. Typical environment is a "cool room" with a raised floor and/or an ordinary office with no special environmental controls. Number of concurrent users typically ranges from 10 to 50.

deposition. The layering of various chemicals on a wafer. The introduction of dopant to wafers in high-temperature furnaces, chemical vapor deposition (CVD), sputtering, and implant.

deposit/loan management. An application that facilitates the control and earning potential of loans and deposits.

design layout. An initial design process in which the major components and part interfaces are defined.

desk-side personal computer. The desk-side personal computer meets all the qualifications listed for desktop personal computers but is further defined as being a personal computer that has been specifically designed to be placed next to or under the computer operating or desk surface, including foot/stand on bottom of system.

desktop personal computer. The desktop computer classification includes all personal computers except those products that are designed and sold as local area network servers, desk-side personal computers, and all forms of portable computers. Further, these systems are based on keyboard input devices.

desktop publishing. 1: Generalized computing platforms used to perform electronic publishing tasks as one of many applications. 2: The formatting of text and graphics into publishing-quality printed output.

desktop terminal equipment. Telecommunications equipment that is actually used on a desktop. This segment includes products such as single-line telephone equipment and integrated voice/data workstations.

desktop video. Tabletop televised images.

detail drafting. The representation of a part in standard geometric drafting format. This representation will include all part geometry dimension and notations describing mechanical/structural, functional, and material characteristics.

detection and tracking. A real-time application that detects, tracks, and controls various systems and processes. (See also **data acquisition and control.**)

device interface. 1: An electronic device that enables one piece of gear to communicate or control another. 2: A device linking two incompatible devices. 3: A card containing circuits that allow a device to interface with other devices.

diagnostic. 1: Pertaining to the detection, discovery, and further isolation of a malfunction or mistake. 2: Medical applications that aid in diagnosing medical problems. X-rays, CAT scans, and ultrasound are examples.

dialysis. The separation of substances in solutions by means of their unequal diffusion through semipermeable membranes.

diathermy. The therapeutic use of high-frequency electric currents to produce localized heat in body tissue.

dictating/transcribing machine. A device that automatically records human speech onto a form of magnetic tape that can be played back for transcription.

diffusion. 1: A process used in the production of semiconductors that introduces minute amounts of impurities into a substrate material. 2: The movement of particles away from regions of higher concentration caused by the random thermal motion of atoms and molecules to areas of lower concentration.

digital. 1: Pertaining to the class of devices or circuits in which the output varies in discrete steps. 2: Circuitry in which data-carrying signals are restricted to either of two voltage levels, corresponding to logic 1 or 0.

digital access cross-connect system. A system that is composed of multiplex equipment that allows digital lines to be remapped electronically at a different digital level.

digital audiotape (DAT). A 4mm helical scan device (i.e., data recorded at an angle rather than parallel).

digital cordless telephone. Mobile telephone that uses digital radio transmission technology. CT2 is a standard for these devices.

digital design verification. A software application that includes logic simulation, timing analysis, hardware accelerators, hardware modelers, electrical rule checking, mixed signal simulation, transmission line simulators, and signal noise analysis.

digital panel meter. 1: An electrical switchboard or instrument board using continuously variable electrical signals known as analog signals. 2: Digital signals versus analog signals.

digital radiography. Equipment used for electronically detecting the arrival of X-ray photons transmitted through or emitted from an object on various media and converting the sensed analog signals to digital signals.

digital signal processor (DSP). High-speed general-purpose arithmetic unit used for performing complex mathematical operations such as Fourier transforms.

digitizer. A device used for the creation of digital information from alphanumeric or line artwork. More sophisticated digitizers are able to reproduce halftone images and usually are termed scanners.

diode. 1: A semiconductor device used to permit current flow in one direction in a circuit and to inhibit current flow in the other direction.

direct channel. The sale of equipment directly to the end user by a vendor that contributes significant development or integration to the product. Can be either sales of complete systems by turnkey vendors or sales of components of systems sold by individual suppliers.

direct memory access (DMA). A computer feature, set up by the central processing unit (CPU), that provides for high-speed direct data transfer from a peripheral device to the computer memory or to magnetic disk or tape storage units. This feature releases CPU time to perform other procedures. Most DMA devices employ a CPU-cycle-stealing approach.

direct sales force. A sales method that employs a sales force to move a product through the distribution channel by making face-to-face contact with the consumer. Also referred to as outside sales.

direct thermal printer. A printer that uses point-specific heat and heat-sensitive substrate that change color when exposed to heat.

direct write e-beam. Equipment used in semiconductor manufacturing where electron beams are used to create heat that will expose selected areas of a wafer's surface to create a specific design. (See also **lithography.**)

disaster recovery and contingency planning. The planning and implementation of data backup and recovery procedures for a customer's site, based on an analysis of the critical business functions.

discrete component testers. Equipment used to test, check, and monitor the functionality of devices that have a single functional capability per package. These devices include resistors, capacitors, diodes, transistors, and other devices not classified as integrated circuits.

discrete device, security energy management. A circuit complete in itself used in the security and energy industries.

discrete semiconductor. An individually packaged semiconductor component complete in itself, such as a diode or transistor.

disk. 1: A high-capacity random-access storage device. Data are written onto and read from the surfaces of a stack of revolving record-like disks coated with magnetic material. May be fixed or removable. Capacity ranges from 0 to more than 1,000 pages per disk. Referred to as a rigid disk. (See also **random access.**) 2: A random-access magnetic storage medium in the form of a platter or thin wafer. (See also **magnetic disk.**)

disk drive. The unit that controls the reading and writing of disks.

disk drive IC. An analog IC designed for the mass-storage peripheral market. These ICs include read/write amplifiers, data separators, data processors, servo controllers, and motor controllers.

diskette (floppy disk). A record-like disk of magnetically coated Mylar enclosed in a protective square envelope. Holds from 80 to 250 pages of text. Unlike cassettes or cartridges, which store text serially, diskettes are formatted in a random manner, which allows faster access.

disk, magnetic. A storage device containing information recorded on the magnetizable surface of a rotating disk; a magnetic disk storage system is an array of such devices, with associated reading and writing heads mounted on movable arms.

disk operating system (DOS). 1: A computer system based on the Intel 80XX or 80XXX architecture that use the MS/PC-DOS operating system software. 2: An operating system that uses magnetic disks as its primary on-line storage.

dispatching. A software application used to execute the route plans of multiple vehicles, taking real-world events into account.

display peripheral. A component used to address the man-to-machine interface, whereas communication peripherals are used to address the machine-to-machine interface.

distribution. 1: The act or process of distributing. 2: The path by which a product moves from the manufacturer to the ultimate end user. 3: To place or position so as to properly apportion over or throughout an area.

distribution channel. The route taken either by the title to a product or by the physical product itself as it moves from the producer to the ultimate end user. The channel for a product extends to the last consumer who buys it without requesting any significant change in its form. When form is altered and another product emerges, a new channel is started.

distribution frame. A unit for terminating telephone wiring. This unit is typically used for terminating and cross-connecting telephones to the switching system.

distribution method. A method employed to move a product through the distribution channel. It is separate and distinct from the channel in that many channel members may employ the same distribution method.

distributor. A wholesaler that sells to other resellers or end users. The distributor's primary function is to stock the inventory of multiple manufacturers to provide volume buying power to its end users.

DMA. See **direct memory access.**

documentation/drafting. A software application that includes detail drafting, schematics, technical illustration, charts, specifications, bills of materials, training manuals, and other drawing- or drafting-related applications. International standards such as ISO, DIN, or ANSI can be used to define text and feature format.

document management. A documentation system, generally computerized, that links and tracks all documents (drawings, procedures, specifications) related to an assembly or process.

dopant. Atoms of materials such as phosphorus, boron, or arsenic that are diffused into silicon to create resistors, diodes, and transistors.

DOS. See **disk operating system.**

dot matrix printer. A printer that produces images through selective printing of dots chosen from a dot array matrix. Dot matrix printers are segmented by the number of wires in the printhead: 9, 18, or 24 and greater wires. Within these technology segments, additional segments are defined by speed of printing, expressed in characters per second (cps).

DP. See **data processing.**

DRAM. See **dynamic random-access memory.**

DRAM controller. A device that governs DRAMs in some predetermined manner. Holds a process or condition at a desired level or status as determined by comparison of the actual value with the desired value.

drilling programmable machine tool. A machine tool fitted with an end-cutting tool that is rotated with sufficient power to create a hole or enlarge an existing hole in solid material.

drive. See **tape drive.**

drive, disk cartridge. A disk drive using a removable one- or two-platter cartridge; may incorporate a fixed-media capability.

drive, fixed Winchester. A disk drive that includes all fixed-media Winchester drives.

driver information. An electronic device used to assist the driver by giving visual or audio signals for direction. Examples include digital gauges, service reminders, digital clocks, trip/navigation computers, heads-up display, audio annunciator, CRT display, miles-to-empty indicator, and shift indicator.

dry etch. A technique in semiconductor manufacturing used to produce more uniform pattern definition on wafers without immersing the wafer in a liquid bath. Techniques include plasma etching and reactive etching through which gases and energetic ions remove unwanted chemical material from a wafer.

dry silver. A photosensitive film or paper coated with silver compounds that is developed by the application of heat. Popularized by 3M.

dry strip. A process in semiconductor manufacturing for removing photoresist from the wafer after etching. Dry strip comprises barrel strippers and single-wafer strippers.

DSMPU. See **DSP microprocessor.**

DSP. See **digital signal processing.**

DSP microprocessor (DSMPU). A general-purpose, programmable integrated circuit similar to a conventional microprocessor. Its distinction is characterized by the efficiency with which it implements repetitive multiplications and additions required by DSP algorithms.

DSU/CSU. See **data service unit (DSU) and channel service unit (CSU).**

DTMF. See **dual-tone multifrequency signaling.**

dual-disk drive. A system that provides for the use of two disks at the same time.

dual-tone multifrequency signaling (DTMF). A standard signaling method for touch-tone telephones using a combination of two different tones for any button pushed.

duplicator. 1: A small offset printing press that uses a planographic image carrier. These presses are usually capable of one or two colors and are smaller, easier to operate, but less sturdy than offset presses. 2: Machine that requires a special master to make copies but produces copies at a higher rate of speed than copying. It differs from printing in that a direct-image master is used that yields a limited number of copies. Offset, spirit, gelatin hecto, stencil, and sometimes xerography are considered duplicating processes. (See also **copier.**)

dynamic random-access memory (DRAM). A random-access memory device that must be electrically refreshed frequently (many times each second) to maintain information storage. DRAM densities can range from 16K, with approximately 16,000 bits, to 16Mb, with approximately 16 million bits.

E

8mm tape cartridge. A class of tape drives using 8mm cartridges; used in camcorders.

E-1 multiplexer. An electronic device that consolidates or pools multiple digital streams representing voice or data signals onto a single high-speed E-1 data line. An E-1 line operates at 2.048 Mbits/second, a standard within Europe. See **T-1 multiplexer** for U.S. standard.

earth resources application. Studying the earth resources by performing seismic analysis, mapping, and oil field services.

EATE (electronic automatic test equipment). See **automatic test equipment.**

e-beam. A sophisticated system used in semiconductor manufacturing that uses an electron beam for maskmaking or for projecting patterns onto wafers. E-beam equipment allows smaller geometries (typically less than 1 micron) than are possible under other production methods.

ECAE. See **electronic computer-aided engineering.**

ECL. See **emitter-coupled logic.**

EDA. See **electronic design automation.**

education. The process of providing schooling or training by formal instruction and supervised practice.

educational publishing. A system with the main purpose/use of printing materials used for the process of educating.

EEPROM. See **electrically erasable programmable read-only memory.**

elapsed time meter. An electronic measuring instrument that counts the actual time taken to observe a recurring event.

electrically erasable programmable read-only memory (EEPROM). A nonvolatile memory device that can be erased and programmed electrically.

electrocardiograph. An instrument used to graphically record electrical manifestations of heart activity obtained from the body's surface.

electroencephalograph. An instrument used to graphically record electrical discharges of the cerebral cortex by electrodes attached to the surface of the scalp.

electronic calculator. A product with components that perform calculations and digitally display results. (See also **calculator.**)

electronic computer-aided engineering (ECAE). Computer-aided tools used in the engineering or design phase of electronic products (as opposed to the physical layout phase of the product). Examples of ECAE applications are schematic capture, simulation, and test pattern creation. ECAE systems are used most often by electrical engineers.

electronic design automation (EDA). Computer-based tools that are used to automate the process of designing an electronic product, including boards, ICs, and systems. Formerly referred to as ECAD.

electronic forms generation. The process of automatically producing documents requesting information.

electronic game. Home electronic games that typically are attached to television receivers.

electronic keyboard. A keyboard on which characters are generated or encoded by electronic means, usually by contact closure, as opposed to mechanical linkages. Electronic keyboards have a different feel, and some have a built-in artificial bottoming feel and/or audible click to assure the operator a key actually has been depressed.

electronic mail (e-mail). An application that supports the movement of information between users connected to a networked computer system.

electronic musical instrument. An instrument that allows the transmission of musical sound by the use of transistors.

electronic publishing. Fully integrated automation of the printing procedure.

electronic warfare (EW). Electronic operations between enemies. Includes warning receivers, jammers, assorted electronic countermeasure systems, and associated test equipment.

electrostatic plotter. A plotter using the corona from high voltages applied to needles or nibs to produce shaped electrostatic charges on paper; toner is attracted to the charged area, and heat and pressure are used to fuse the toner to the paper.

elementary/secondary school. A regular school, defined as schools that are part of state and local school systems and most nonprofit private elementary/secondary schools, both religiously affiliated and nonsectarian.

e-mail. See **electronic mail.**

emerging technology. A technology that is not in widespread use and that appears to have potential for widespread acceptance.

emitter-coupled logic (ECL). 1: A form of integrated circuit used to implement very high speed logic functions. 2: The emitters of the input logic transistors are coupled to the emitter of a reference transistor.

employees. All civilians, who, during a reference time period, did any work for pay or profit (minimum of an hour's work) or worked 15 hours or more as unpaid workers in a family enterprise.

encryption. Process of encoding data, voice, or video transmissions for security purposes.

encryption unit. A device that encodes/decodes data, voice, or video transmissions for security purposes.

end user. The final purchaser of a finished product.

end-user average selling price. The average price that a user pays for a product inclusive of channel markups and discounts.

end-user revenue. End-user average selling price multiplied by shipment quantity.

enhanced service. Equipment and service charges associated with enhanced data communication networks, which may include protocol, electronic mail, or facsimile.

enrollment. In education, the total number of students registered in a given school unit at a given time, generally in the fall of a year.

entertainment system. 1: Electronic equipment used for amusement or pastime and not intended to, but may, increase productivity or skill. Examples include: radio, seek/scan, graphic equalizer, power amplifiers, noise reduction, cellular telephone, optical disk, CB radio, and digital audiotape. 2: A computer application to keep or hold the mind, something directing or engaging.

entry-level workstation. A low-cost computer workstation, priced less than $15,000. It is targeted at the end user who is sensitive to price. This segment tends to be dominated by occasional users who are not paid for producing documents on their system. Entry-level workstations mainly run 2-dimensional graphics and have a rating of less than 12 mips and a rating of 0.5 to 1.5 mflops.

environment. Where a product is used ultimately.

epitaxial wafer. Single-crystal silicon grown on a crystalline silicon substrate.

EPROM. See **erasable programmable read-only memory.**

equipment/maintenance management. A software application that assists in the management of equipment and the respective maintenance requirements and contracts. May also calculate depreciation.

erasable programmable read-only memory (EPROM). A nonvolative memory device that can be erased by ultraviolet (UV) light and reprogrammed by the user.

ET. See **typewriter.**

etch-and-clean equipment. Equipment used in semiconductor manufacturing to remove and clean material from wafers.

EW. See **electronic warfare.**

expenditure. Charges incurred, whether paid or unpaid, which are presumed to benefit the current fiscal year. These include all charges for current outlays plus capital outlays and interest.

export. The delivery of products to a foreign country for the purpose of trade or sale.

F

fab. Abbreviation for wafer fabrication. See **fabrication.**

fabrication. A manufacturing operation that makes components rather than assemblies.

fabric ribbon. Fabric ribbons are struck repeatedly by the print mechanism until all the ink is depleted. Such ribbons are used commonly for general-purpose printing and are the most economical and durable ribbon substrate. Most fabric ribbons are made of nylon and are available in several forms, e.g., cartridge or web ribbon.

facilities design/management. A software application used to lay out, inventory, and manage assets (such as personnel, space, equipment, and utilities) within a building or geographic service area.

facilities management service. The responsibility of providing ongoing administration of a data processing or communications facility by a vendor.

facility planning and simulation. A facility system model is exercised and refined through a series of simulation steps until a detailed, optimum configuration is reached.

facsimile (fax). 1: An electronic device that uses telephone lines to transmit documents to and receive documents from a second facsimile machine. 2: An exact copy or the process of transmitting printed matter or still pictures by a system of either telephones, telegraph, or radio for reproduction.

factory automation equipment. Equipment that includes various types of capital equipment that are automated and used throughout a manufacturing facility.

factory average selling price. The average price per unit that is paid for a product. This figure takes into account discounts given to the distribution channel and multiple-purchase discounts.

factory revenue. The amount of money received by a manufacturer for its goods.

fast packet switch. A packet-switching technique in which small packets are switched at high-speed using hardware for the transport of voice, data, and video.

fast SRAM. A static RAM device that runs at speeds less than 70 nanoseconds. (See also **static random-access memory.**)

fatigue. In electronics, the degradation of the performance of materials, parts, or circuits with time.

fault detection, fault management, and adaptive control. A software application that determines if a manufacturing system or a process is functioning or performing within control limits. Fault management and adaptive control is a control method in which control parameters are continuously and automatically adjusted in response to measured process variables to achieve near-optimum performance.

fax. See **facsimile.**

FDDI. See **fiber distributed data interface.**

federal government. A form of government in which power is distributed between a central authority and a number of constituent territorial units.

FERRAM. See **ferroelectric random-access memory.**

ferroelectric random-access memory (FERRAM). A nonvolatile, radiation-hard, fast read/write memory that can store data over long periods of time without power.

fiber distributed data interface (FDDI). A standard for high-speed packet switched data.

fiber optic. 1: The technique of transmitting light through long, thin, flexible fibers of glass, plastic, or other transparent material. Bundles of fiber can transmit complete images. 2: A technique used in electromagnetic wave propagation in which infrared and visible light frequencies are transmitted by a light-emitting diode (LED) or a laser through a low-loss glass fiber. This method is used in very high frequency (VHF) radiation transmission.

field-programmable gate array (FPGA). An integrated circuit incorporating an array of programmable logic elements that are not preconnected. Interconnections between the various elements are user programmable and consist of predetermined levels of interconnect that can be connected to, or disconnected from, other interconnect lines as defined by the user. Can be of either bipolar or MOS technology.

field-programmable logic array (FPLA). A logic array in which programming is accomplished by blowing fuse links or shorting base-emitter junctions.

film ribbon. See **single-strike ribbon** or **multistrike ribbon.**

finance. An application to support the management of money or other liquid resources and their respective management within an organization.

fixed asset. An application that supports the management of an organization's fixed assets, which are a capital asset that cannot be readily liquidated, such as plant, land, equipment, and long-term investments. Management of expected costs based on a specific level of production or other activity.

fixed disk. A memory disk that cannot be removed from the read/write device, as opposed to a removable hard disk, diskette, or magnetic tape.

fixed media rigid disk drive. A fixed media rigid disk drive has the platter enclosed in a housing that is not designed to be accessible to the user.

fixture design. The design of a variety of structural aids that hold the component or assembly during the manufacturing process.

flexible disk. See **flexible disk computer storage media.**

flexible disk computer storage media. A flexible disk made of a 3-mil polyester substrate coated with gamma ferric iron oxide particles dispersed in an epoxy binder and encased in a vinyl jacket. These are commonly supplied in 3.5- or 5.25-inch diameters.

flexible manufacturing system programmable machine tool. A manufacturing system that typically consists of a computer-integrated group of numerical control (NC) machines or workstations linked with material transfer devices for complete automatic processing of differing product parts or the assembly of these parts into different units.

floating-point coprocessor. A separate microprocessor used in the efficient handling of floating-point operations.

floppy (flexible) disk. A small, thin, electromagnetic media used for storing digital information.

floppy disk controller. A device controlling the storage and retrieval of data from a floppy disk.

font generation. Process whereby typeface and size is selected.

font management. The understanding, use, and control of fonts or typefaces that are displayed on a terminal or monitor, or printed out on a device such as a printer, plotter, or typesetter. Font management requires the understanding of the physical location of where the fonts reside—whether in diskette, hard disk, ROM, RAM, card, or cartridge. It also requires the knowledge of the type of font—whether bit map or outline, scalable or fixed point and pitch—and the applications and print system capability to address and place the fonts accurately on the screen or printing media.

forecasting. To estimate in advance or anticipate; to predict future events, trends, business conditions, etc.

form. 1: Any material that has been printed for the primary purpose of facilitating the entry of written information by hand or machine. A form has repetitive information printed in fixed positions. Blank paper may be included, especially if it is continuous and has undergone some alteration such as punching or perforating to facilitate manual or machine entries. 2: Allows the user to graphically design a form for publication—may include data entry and database capabilities.

four-year institution. An institution legally authorized to offer and that does offer at least a four-year program of college-level studies wholly or principally creditable toward a baccalaureate degree.

FPGA. See **field-programmable gate array.**

FPLA. See **field-programmable logic array.**

front-end processor. A computer-based product expressly designed to relieve host computers of certain communications processing tasks. Included are remote concentrators that are not attached directly to a host computer. This segment does not include general-purpose computer systems functioning as front-end processors.

full-color copier. A reproductive device that can recognize the full range of colors on an original and reproduce them using the three subtractive primary colors and produce a full-color copy.

fully formed printer. A printer that prints fully formed characters by applying pressure on or to the paper and obtaining the characters from a wheel, band, type train, or drum. Such devices can be serial, fully formed printers and line, fully formed printers.

functional design. An application that supports component design, assembly verification, linkage and mechanism design, and other detail or functional design activities.

functional PCB tester. An equipment tester that accesses the normal input/output interface of the unit under test (UUT). Generally, this consists of the edge-connector pins, plus any special interface that may have been provided for testing. Provides stimulus patterns and measurement verification that the UUT actually operates correctly.

funds transfer terminal. A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **automated teller machine.**)

G

GaAs. See **gallium arsenide semiconductor.**

GaAs analog IC. There are two overlapping subsets in this segment; analog products and monolithic microwave integrated circuits (MMICs). Analog products have output that are linearly proportional to their inputs and function at a varying range of frequencies across the spectrum, depending on particular device design. MMICs operate in the microwave frequency spectrum (above 3 GHz).

gallium arsenide semiconductor (GaAs). A compound of gallium and arsenic used as a semiconductor material. GaAs devices are relatively expensive devices exhibiting very low internal noise and very high speed.

game. A software application or activity engaged in for diversion or amusement.

gas. A consumable material used throughout the fabrication of semiconductor devices. Includes both bulk and specialty gases.

gate array. 1: An ASIC device that is customized using the final layers of interconnect. (Included in this category are generic or base wafers that include embedded functions such as static RAM.) May be of either bipolar or MOS process technology.

gateway. Equipment or conceptual point that connects two otherwise incompatible systems. (See also **protocol converter.**)

general analysis. A software application designed to solve various technical problems and to further research subjects. The analysis is usually mathematical in nature and performed by scientists, physicists, chemists, biologists, and engineers.

general ledger. A software application that supports the business function of entering accounting transactions and their subsequent transferring and reporting.

general operating system. An operating system with use not restricted to a particular type of computer or a specialized application.

general productivity. A software application that is used to enhance productivity within general disciplines.

general-purpose computer system. A computer system that is not configured for a specific purpose but rather for a general application. This category includes supercomputers, minisupercomputers, parallel processor computers, mainframes, workstations, and the like.

general-purpose input/output (I/O) circuit. A circuit that permits a system to communicate via a wide variety of input/output (I/O) devices with the outside world, which can include printers, modems, and monitors.

general test equipment. Test equipment not included under the definition of automatic test equipment (ATE).

geographic information system (GIS). A mapping software application that contains the functions of cartographic software and also allows data analysis through Boolean operations on multiple data layers.

geophysical instrument. An instrument used to observe and measure the physics of the earth and its environment.

GIS. See **geographic information system.**

global positioning system. Equipment that calculates location based on one of several technologies such as radio or internal navigation.

golf ball. A type of print element invented by IBM for use in the IBM Selectric typewriter. It is a round, metal element with raised characters.

government. The organization, machinery, or agency through which a political unit exercises authority and performs functions and which is usually classified according to the power within it. Includes the executive, legislative, judicial, administrative, and regulatory functions.

graphic design art. A method of applied art used to form a visual end product that conveys information. Methods include drawing, painting, photography, printing, and bookmaking.

graphics. Software that permits the pictorial representation of information at a screen or printer. Early graphics packages showed bar charts or line graphs on a character-based terminal by placing characters such as + or * on grids created by repetitions of characters such as | and or _ . The term has come to apply usually to bit-mapped graphics, which are capable of processing images, freehand input, and icons on a pixel-by-pixel basis. Examples of graphics software include MacDraw and MacPaint.

graphics/animation/imaging. A software graphics application used by scientists and engineers to process and display complex technical data. It also includes applications that use computers to generate or manipulate graphics images that are the end product, i.e., cartoons.

graphics board. An add-on board connected to the bus that provides video capabilities for a personal computer.

graphics controller. A device that governs information flow used to create visual images of data.

graphics draw/paint. A software application that creates, retrieves, modifies, and prints graphic images.

graphics supercomputer. The performance of mips, mflops, transforms per second, and shaded polygons per second distinguishes graphics supercomputers from superworkstations. Performance ratings range from 20 to 40 mips and 16 to 40 mflops. The best distinction between graphics supercomputers and superworkstations is the graphics performance ratings, 100K to 600K 3-D vector transforms/second and 25K to 150K Gouraud-shaded polygons/second. The average price ranges from $75,000 to $150,000.

graphics terminal. A display terminal that provides graphical presentation of information to the operator. 1: Data conversion graphics terminals support the use of graphics to summarize or otherwise relate discrete data that were not originally graphics data. 2: Concept design graphics terminals support graphics displays that help realize accurate images of ideas conceived in the human mind. 3: Imaging graphics terminals display a real image, visible or nonvisible, that was digitized to allow enhancements or data extraction.

grinding programmable machine tool. A standalone machine with expanding use of computer numerical control (CNC) and with advance efforts to incorporate grinders into flexible, automated systems. Creep-feed is a type of grinding technology.

gross lease additions. The total volume of new equipment leases.

H

hand-held personal computer. The hand-held personal computer is a less-than-2-pound, fully functional personal computer. To be considered a hand-held personal computer, units must operate using a fully implemented version of MS-DOS and be able to run some of the shrink-wrapped MS-DOS-based applications. These units are expected to have a subsize keyboard and utilize nonstandard mass storage devices. The criterion for inclusion in this classification is that the device may be held in one hand using the other hand for data entry via the included keyboard. They are fully battery powered units.

hard disk. See **rigid disk.**

hard disk controller. A device that controls the storage and retrieval of data from a user's hard disk drive.

hardware. Electronic equipment, systems, or peripheral devices.

hardware maintenance service. Remedial repair services for equipment, systems, and peripherals. Hardware maintenance can include on-site support, telephone/remote support, preventive maintenance, and other activities necessary to maintain hardware operation.

HDTV. See **high-definition television.**

head; manganese-zinc, landable. A type of head used in sealed fixed-media drives where heads land on the lubricated media surface and use hot-pressed manganese-zinc pole pieces.

health care. An environment or industry that includes establishments primarily engaged in providing medical, surgical, and other health services.

helical scan tape drive. A storage tape drive that records data on an angle rather than parallel. Tape dimensions can be 4mm, 8mm, 13mm, or 19mm. Segments of this category are VHS, DAT, 8mm, and other. (See also **VHS, DAT.**)

high-definition television (HDTV). A television standard with high-resolution, digitized images; wide, theater-like screen; and digital stereo sound. Requires a broader video bandwidth to accommodate increased picture transmission.

higher education. Study beyond secondary school at an institution that offers programs terminating in an associate, baccalaureate, or higher degree.

high school. A secondary school offering the final years of high school work necessary for graduation, usually including grades 10, 11, and 12 or grades 9, 10, 11, and 12.

home. The usual place of residence. A home-based business is an enterprise producing goods or services that is operated in or from the home.

horizontal-turning programmable machine tool. The tool of a machine that holds a piece along the horizontal axis for a certain function to be performed such as cutting, boring, or drilling.

host/vendor independent terminal. A host-independent display terminal produced by an independent manufacturer. It may operate in either character or block mode. The independent manufacturer does not supply mainframes or minicomputers to which its display terminals may attach. Not included is any terminal that is from an independent manufacturer and that is protocol-specific to either a minicomputer-based or a non-IBM, protocol-specific terminal.

hotels and lodging. An environment or industry that includes commercial and noncommercial establishments engaged in furnishing lodging, or lodging and meals, and camping space and camping facilities.

household. The set of persons occupying a housing unit. Thus, counts or estimates of households, householders, and occupied housing units are always defined the same.

hybrid. 1: Made up of several different components. 2: A hybrid integrated circuit is made by putting several integrated circuit die and/or passive components on a ceramic substrate with a metal pattern. 3: A substrate containing more than one component. The substrate consists of multiple ceramic layers and also can contain multiple packages. 4: A device in a speech transmission system consisting of transformers that convert a two-wire channel into a four-wire channel, thus creating a separate wire pair for each direction of transmission.

hybrid analog IC. An analog IC that combines one or more semiconductor chips with other technologies, such as chip capacitors and film resistors, on a single substrate.

hydrogen. A chemical element used for hydrofining for sulfuration of petroleum products or to reduce metallic oxide ores.

I

IBM 3270 protocol terminal. A terminal that is protocol-specific to IBM's 3270 Information Display System. Included is any IBM 3270-type terminal or 3270-compatible terminal produced by another manufacturer. A terminal that can provide the appearance of a 3270 device when used with a protocol converter is **not** included.

IBM/VM/MVS. An IBM standard multiuser operating system.

IC. See **integrated circuit.**

IC layout and verification. A software application tool that is used to create and validate physical implementations of an integrated circuit (IC). IC layout tools include polygon editors for creating geometric data, symbolic editors, placement and routing (gate array, cell, and block), and DRC/ERC verification tools.

IDVT. See **integrated voice/data workstation.**

if-sold revenue. The amount of money paid for products based on list price. List price does not take into account discounts or markups.

if-sold value. A measure that reflects unit shipments multiplied by list price.

IGBT. See **insulated gate bipolar transistor.**

illustration software. An object-oriented software program that allows the user to create original artwork consisting of lines, arcs, and other mathematically generated geometric objects. (Line art is a term sometimes used to describe the results of illustration software.) Some illustration software can perform raster-to-vector conversion by allowing users to trace over scanned raster art. This trace can occur on screen or on a graphics tablet. Illustration software usually offers raster-fill patterns that extend to cover an area in an illustration bounded by geometric objects.

image communication. Equipment used in a business or residence to transmit image and text. Facsimile equipment, video teleconferencing, telex, and videotex are included in this classification.

image-editing software. A software program that allows a user to modify existing artwork existing in raster format. This art may have been scanned or captured as analog signal data and converted to digital data. Image-editing software can handle binary data, in which case it is called print software; or it can handle grey-scale and/or color data, in which case it is called image-retouching software.

image generation. Synonymous with *image* synthesis and equivalent to the historical use of graphics.

image management. The process of directing, controlling, or handling something that closely resembles another.

image processing. A series of actions, changes, or functions that bring about a particular result for something that resembles another.

imaging. See **graphics/animation/imaging.**

imaging subsystem. A peripheral device that does not possess video display terminal (VDT) functionality, but acts as output devices for the display of graphics and/or image data.

impact printer. A family of printers that use direct impression impact of a type bar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

import. The supply of products from a foreign country for the purpose of trade or sale.

in-circuit PCB tester. An equipment tester that incorporates pin electronics (drivers and receivers) that verify the functionality of each part on an assembled circuit board. Verifies each component's parameter and limited functionality.

indirect channel. A variety of distribution channels in which product is brought to the end user. It includes value-added resellers (VARs) and original equipment manufacturers (OEMs).

inductor. A passive component that stores energy in the form of a magnetic field (flux) around a core body.

industrial design. A process that integrates the design tools defining the style and functional aspects of the total design.

industrial electronic equipment. Electronic equipment used in a manufacturing environment or industry.

industrial marking. A specified format on media that is recognized by electronic or visual means. Examples are the printing and use of forms, bar codes, ticket printing (lottery and airline, for example), and labels.

industry. A collective term for many of the productive activities of a nation or other large group. A collective term in which a number of firms produce the same kind of commodity or service or are engaged in the same kind of operation.

INEWS. See **integrated electronic warfare system.**

information center. A center designed specifically for storing, processing, and removing information for dissemination at regular intervals, on demand or selectively, according to the user's needs.

information resource management. A program that works with definitions, uses, values, and distribution of information that is processed by a user and handled by a computer system.

infrared. Those radiations, such as are emitted by a hot body, with wavelengths just beyond the red end of the visible spectrum. Wavelengths longer than those of visible light and shorter than those of radio waves.

ink jet. An image-producing process currently used in electronic printers, plotters, and full-color copiers that uses piezoelectric technology to expel a very small droplet of liquid ink through nozzles onto the output paper.

ink jet printer. A nonimpact printing method that uses ink droplets to form a printed image. This technology usually is classified by the nature of the drop stream; two major categories are continuous flow and drop-on-demand.

input/output (I/O) device. 1: Equipment used to communicate with a computer. 2: A general term applied to equipment used in communicating with a computer and the data involved in the computer. 3: The transmission of information from an external source to a computer or vice versa.

input/output (I/O) ratio. 1: A ratio of the value of a resource input to the value of the final product output, typically expressed as a percentage. 2: A measure of throughput for a computer system.

inspection. The process of testing or measuring an object or process by remote sensing in imaging technology.

installed base. The total number of product in active, day-to-day use.

institutional support. In higher education, the expenditures that include day-to-day operational support for colleges, excluding expenditures for physical plant operations. Examples of institutional support include general administrative services; executive direction; planning, legal and fiscal operations; and community relations.

instruction. In higher education, expenditures of the colleges, schools, departments, and other instructional divisions of higher education institutions and expenditures for departmental research and public service that are not separately budgeted. Includes expenditures for both credit and noncredit activities. Excludes expenditures for academic administration where the primary function is administration.

instructional. Products used to increase the understanding (either problem-solving or self-improvement) of a specific subject matter. The primary focus of these products is the imparting of knowledge or skills to the user.

instructional staff. In education, the number of full-time equivalent positions, not the number of different individuals occupying the positions during the school year.

instrumentation. Designing, manufacturing, and using instruments for detection, observation, measurement, automatic control, automatic computation, communication, or data processing.

insulated gate. A gate that is separated from other conducting surfaces through a nonconducting material.

insulated gate bipolar transistor (IGBT). A power transistor that has the insulated gate properties of a MOS transistor with the low saturation ON voltage of a bipolar transistor.

insurance. An environment or industry that covers carriers of all types of insurance and insurance agents and brokers.

integrated application. A software application that combines several functions into one software package, which may include word processing, database management, and spreadsheet capabilities but is not exclusive to these functions. Data must be able to be shared among these functions.

integrated circuit (IC). A combination of interconnected semiconductor elements inseparably associated on or within a continuous substrate. Complete module of components manufactured as single, solid units made by either a film deposition or a diffusion process.

integrated electronic warfare system (INEWS). A combination of interconnected circuit elements associated on or within a continuous substrate to produce integrated systems used specifically in military operations.

Integrated Services Digital Network (ISDN). A digital network having the capabilities of simultaneous signaling, switching, and transporting over a single facility. A new worldwide telephone standard that will make it easier to communicate information such as voice, data, and video over phone lines.

integrating and totalizing meter for gas and liquid. A meter that registers consumption and positive displacement, including meters, fuel dispenser meters, and gas meters.

integrated voice/data workstation (IDVT). Terminal that possesses both telecommunications and computational capability.

integration. Integration of data types can be achieved using page composition and pagination applications.

intelligent terminal. An interactive terminal in which part of the processing is accomplished by a small computer or processor contained in the terminal itself. This type of terminal is sometimes referred to as a smart interactive terminal. Such a terminal has the following characteristics: (1) self-contained storage; (2) user interaction—with the terminal or the central computer; (3) stored program; (4) part of processing accomplished in the terminal; (5) on-line via communications line with large central computer and database; (6) human-oriented input—such as keyboard and light pen; and (7) human-oriented output—such as serial printer and CRT.

interactive language. Within a system, a human user or device serviced by the computer can communicate directly with the operating program or language.

intercom systems. A system that provides internal communication, allowing calling to be confined to inside the system. In most cases, key systems provide the intercom lines that allow quick communication between stations on the key system.

interconnect and bare-board tester. Equipment designed to check, monitor, and identify printed circuit boards for electrical connectivity and detect manufacturing defects.

interface IC. An analog IC that is dedicated to interfacing digital information (in bits) with external nonsemiconductor devices such as displays, lines, solenoids, and other peripheral devices.

internal transfer. The process of conveying or moving goods and services from the producer within a company.

international telephone service. Telecommunication services between offices or stations in different states or between mobile stations that are not in the same state or are subject to different states.

interrupt controller. 1: An internal controller chip that can break into the normal flow process of a routine such that the flow can be resumed from that point at a later specified time. 2: A condition or event that temporarily suspends normal processing operations. 3: A temporary disruption of the normal operation of a routine by a special signal from the computer. 4: Copying technology: A feature that allows a job to be stopped to allow another job to be run without the loss of programming for the first job.

intrusion-detection alarm system. A warning system used to detect when someone or something has intruded in a specified area. (See also **alarm system.**)

inventory. Items used in the process of manufacturing a product and distributing it to the end user. Inventory can be stored at a stock point or at a work-in-process location. Inventory may consist of finished goods, parts of intermediate items, work-in-process, or raw materials.

inventory and distribution management. An application that monitors the status of materials at all levels of production, including receipts, issues, and inventory balances. It identifies both unit quantities and dollar values and provides essential input to both the general ledger for cost accounting and the production planning modules.

I/O device. See **input/output device.**

ion implantation. The use of an ion beam to bombard a silicon wafer, altering the concentrations of p-type and n-type material. This method of doping allows for very precise control of the device parameters. This process introduces dopant atoms into the surface of silicon wafers and accelerates them so that they bombard the wafer, causing them to penetrate the exposed portions of the wafer.

ion milling. A technique in semiconductor manufacturing in which a beam of charged particles is used to remove material from a wafer.

I/O ratio. See **input/output ratio.**

IR. See **infrared.**

ISDN. See **Integrated Services Digital Network.**

IVR. See **interactive voice response system.**

J

joint venture. Two or more companies providing capital or other resources to invest or make available for investment in the ownership of a new enterprise.

K

keyboard. An input device that allows an operator to enter alphanumeric characters through a typewriter-style key arrangement augmented with special function keys—manual operation of keys will generate electrical signals or cause tape to be punched, or both.

keyboard controller. A device that governs the functions of a keyboard transmitting a command to do something within a system.

key entry equipment. Data entry equipment such as key disk, key tape, or keypunch equipment.

key telephone system. A customer premises telephone switching system that allows telephones to interface to the public telephone central exchange or office without using an access code. This category includes the electromechanical 1A2 and electronic segments.

L

label. 1: A set of symbols used to identify or describe an item, record, message, or file. May be the same as the address in storage. 2: Matter attached to a document to identify or provide information. 3: To assign a symbol, acronym, or word as a means of identification to create a specialized record or filing handle. 4: A descriptive or identifying word or phrase. 5: To address, using self-adhesive addressing labels.

laboratory. 1: A software application that involves the use of computers inside analytical instruments and in linking these instruments together (instrumentation automation). Mass spectrometers and blood/gas analyzers are examples. 2: A place equipped for experimental study in a science or for testing and analysis.

laboratory and scientific apparatus. Any instrument, material, or equipment designed for a specific operation or particular use in the laboratory.

LAN. See **local area network.**

LAN-based e-mail. A software application that enables users of a local area network (LAN) to send and receive textual data. Some LAN-based e-mail software can send and receive computer files and graphic images.

language. In software, a set of commands that permits the programmer to perform arithmetic functions on data and/or give commands to specific hardware components of the computer system, such as the printer, terminals, disk, or memory. Statements in languages are generally required to be performed in a fixed order, although the order may be affected by loops and branches in the program and the values of parameters that control the looping and branching. Examples of low-level languages are C and assembler; high-level, or third-generation, languages include FORTRAN, COBOL, BASIC, and PL/1.

language editor. A set of computer commands forming code to edit files. May involve deleting undesired information, selecting desired information, inserting invariant symbols, and applying standard processes.

laptop A/C. The laptop A/C units reflect the standard laptop design, i.e., clamshell-style case with the display mounted in the top portion of the shell and covering the keyboard until the unit is opened for use. These units, like transportables, are designed to be easily moved from place to place but operate only on A/C power and do not contain batteries of any kind.

laptop D/C. The laptop D/C units are identical in style to the laptop A/C units except that they are powered by batteries and can be operated without direct connection to A/C power lines. Some of these laptop D/C units have a combination of battery- and A/C-power capability.

laptop personal computer. The laptop-case style is conducive to operation on the user's lap and is designed to be used in areas where space is restricted. This case style is referred to as the clamshell-type of system, with the display screen mounted in the top of the unit in such a way as to cover the keyboard when closed and be at the proper viewing angle in relationship to the keyboard when opened and ready for operation. This unit is completely self-contained and can be carried as a single unit that includes the keyboard, display, mass storage, and main system unit.

large-format plotter. This plotter uses media engineering size C (17 x 22 inches) or larger and corresponding metric sizes. (See also **plotter.**)

laser (light amplification by stimulated emission of radiation). 1: A device that transmits an extremely narrow and coherent beam of electromagnetic energy in the visible light spectrum. 2: A laser that operates at optical frequencies. In communications, lasers may be amplitude-modulated and used to carry speech information that is received by a light beam detector.

laser diode. A laser diode is a laser that is constructed with a semiconductor material. Many III-V semiconducting materials can be made to emit coherent light, creating a laser.

laser plotter. A device that produces an inscribed visual display of the variation of dependent variable as a function of one or more variables by the use of intense coherent beams of light.

laser printer. A type of nonimpact printer that combines laser beams and electrophotographic technology to form images on paper.

laser system. Any electronic device or system that is actuated by beams of coherent visible and infrared light to accomplish a task.

LCD. See **liquid crystal display.**

learning. An application that assists the user in learning. The subject can range from classic school subjects to games, art, and languages.

lease. A contract by which one conveys equipment, facilities, or property for terms specified.

lease accounting. An application that supports the management of leases.

leased circuit. A service offering that provides a customer with permanent (rather than dialed) connections to all points on the circuit for the duration of a contract.

lease/rental conversion. The volume of contractual conversions between rental and lease options.

LED. See **light-emitting diode.**

library management. A software application that supports the administration of a library, including cataloging.

LIDM. See **line, impact, dot matrix.**

LIFF. See **line, impact, fully formed.**

light communication system. Electromagnetic radiation of a wavelength originating at one place and reproduced at a distant point.

light-emitting diode (LED). A pinhead-size device with a pn junction formed from combinations of gallium, arsenic, and phosphorus. Light emission is the result of hole-electron recombinations that take place near the junction of the p-doped and n-doped regions. As the electrons in the n region of the diode travel through the area near the junction, they recombine with a hole. As a result of this recombination between an electron and atom, light in the form of photons is produced. The wavelength of color of the light is determined by the energy level.

light-emitting display. Light-emitting diodes grouped together in a matrix of dots to form characters.

linear array/ASIC. An ASIC that is purely analog.

linear IC. An IC that is purely analog; both inputs and outputs are analog signals. Sometimes, linear and analog ICs are used interchangeably. Dataquest uses linear as an analog-only segment of the analog market (mixed signal analog/digital is the other segment).

line conditioner. Equipment that changes/enhances the transmission characteristics of a circuit.

line, impact, dot matrix (LIDM). A printer that prints one line of dots at a time using an array of elements in a printhead.

line, impact, fully formed (LIFF). A printer that creates one line of characters at a time by placing characters—from a band, type train, or drum—on the paper by the pressure of an impact mechanism (hammer).

line, nonimpact, thermal transfer (LNTT). A printer that prints a line at a time, using an electrically heated element to produce images.

line printer. A printer that usually prints one line at a time at a higher speed than a character printer. Typical line printers use a drum, chain, or train of print elements and have a hammer for each print position in the line. They usually have a buffer to hold one print line. Line printers are segmented by technology (dot matrix, fully formed, thermal) and by speed, expressed in lines per minute (lpm).

linkage mechanism. An assembly of components, with two or more movable parts usually providing some means of power, control, or fastening application.

liquid crystal display (LCD). A high-contrast, black-on-white display screen that uses closely spaced crystal segments on a square dot matrix. The crystal segments butt together to form solid characters. A liquid crystal hermetically sealed between two glass plates.

list price. The price of a product as indicated in the seller's price book. This figure is usually quantity one and is synonymous with manufacturer's suggested retail price.

lithography. 1: A printing process that prints from a planographic image on a printing plate. Lithographic presses are configured as sheetfed and web presses, depending on the format of the paper used. 2: A technique used in semiconductor manufacturing in which a silicon wafer is coated uniformly with a radiation-sensitive film (the resist) and an exposing source illuminates selected areas of the wafer's surface through a mask or template for a particular design.

LNTT. See **line, nonimpact, thermal transfer.**

local area network (LAN). The hardware, software, and peripherals that enable connection of a device to a cable-based network system that serves a building or a campus environment. Excluded are connections that are point-to-point, or go through PBXs or data PBXs. Ethernet and Token-Ring are popular LAN technologies.

local government. The political unit or organization governing counties, municipalities, townships, school districts, and numerous kinds of special districts.

local loop. The portion of the telecommunications system that connects the customer's equipment with the local telephone company's network.

local telephone service. A service that includes message telecommunications services, private line services, wide-area telecommunications services (WATS), and centrex services.

logic circuit. 1: A circuit (usually electronic) that provides an input-output relationship corresponding to a Boolean-algebra logic function. 2: An electronic device or devices used to govern a particular sequence of operations in a given system. 3: Circuits that perform basic logic decisions *and/or/not*, used widely for arithmetic and computing functions. Circuits can be of either bipolar or MOS technology.

long distance telephone service. The revenue generated by all long distance carriers for interstate and intrastate long distance telephone services.

M

machining-center programmable machining tool. A machine that is designed to fabricate a complete or near complete part of a single machine, with machining centers that perform a number of different operations in a single setup.

machining robot system. A robot that can pick up parts and place them in a new location. Parts are usually moved in and out of machinery or transferred from station to station.

mag card/mag tape. A tape or card that is coated or impregnated with magnetic material, on which information may be stored in the form of coded polarized spots.

magnetic. The effects of magnetism/flux on the system.

magnetic disk. 1: A random-access storage device consisting of magnetically coated disks accessible to a reading and writing arm, similar to an automatic record player. Data are stored on the surface of each disk as small, magnetized spots arranged in circular tracks around the disk. The arm is moved mechanically to the desired disk and then to the desired track on that disk. 2: A flat, circular plate with a magnetic surface on which data can be stored by selective magnetization of portions of the flat surface.

magnetic ink recognition. Property of automatic devices that can detect or read ink-containing particles of magnetic substance, i.e., the ink used for printing on some bank checks for magnetic ink character recognition (MICR).

magnetic media. Any of a wide variety of belts, cards, disks, or tapes (as contrasted with paper tape) coated or impregnated with magnetic material for use with the appropriate equipment and on which dictation or keystrokes can be recorded and stored.

magnetic recording head. A magnetic head that transforms electric variations into magnetic variations for storage on a magnetic medium such as tape or disk.

magnetic resonance imaging. Equipment used on an object placed in a spatially varying magnetic field that is subjected to pulses of radiation; the resulting nuclear magnetic resonance spectra are combined to give cross-sectional images.

magnetic tape. A serial-access magnetic storage medium. Typically, a flat ribbon of metal, plastic, or paper that is coated on one side with material that can be magnetized; information is stored on the tape by a combination of magnetized spots in certain patterns. (See also **magnetic media.**)

mailing/letter-handling/addressing equipment. Mailing systems and equipment that have been automated with components to increase capabilities and to streamline efficiencies.

mail order. A sales method by which a consumer may order products through a catalog.

main distribution frame (MDF). A unit used in telephone wiring for terminating and cross-connecting telephone wiring to the telephone-switching system. The MDF is the primary (or first) distribution point. (See also **distribution frame.**)

mainframe computer. A general-purpose information system with price range of $350,000 and up. CPU bit width ranges from 32 to 64 bits. Physical environment can be either with or without special environmental controls and requires full-time support by professional computer systems support staff with 10 or more members. Number of concurrent users is 250 or more.

maintenance management. The upkeep of property, equipment, or tooling through planning, analysis, and documentation of maintenance functions.

management. An application that supports the management of data that can be achieved using document image management software and systems.

manufacturer. A producer or assembler of goods.

manufacturer's representative/agent. An independent contractor who represents multiple manufacturers. She or he does not take title to the product.

manufacturer's suggested retail price. See **list price.**

manufacturing automation. The use of a computer to aid and improve a manufacturing process.

manufacturing EATE N.E.C. Equipment that tests electronic systems that are composed of a number of subsystems. The testing equipment must verify operability and be capable of locating a faulty subsystem or component in event of failure.

manufacturing engineering tools. The small segment of manufacturing engineering that is concerned with tool and fixture design and the development of manufacturing processes.

manufacturing system. A system used to process raw material into a finished product.

mapping. Computer-aided tools that allow geographically related data to be captured, edited, analyzed, and managed. Typical users are civil and utility engineers, geophysicists, and geologists.

market. The demand for a product or service.

market share. A comparison of a company's performance with the total market so that its relative position and the amount of the market it captured is derived.

markup. 1: The amount added to the cost to determine the selling price for a specific product. 2: The amount added to the cost to determine the selling price for a specific product.

maskmaking e-beam. Semiconductor production equipment utilizing a method that allows submicron pattern generation for producing semiconductor mask plates or maskless lithography. (See also **lithography.**)

mask ROM. A semiconductor read-only memory programmed to the customer's specified pattern during the manufacturing process. (See **read-only memory.**)

mass merchandiser. A segment of the distribution channel with storefront locations. It differs from a dealer in that its primary business is the sale of a broad range of consumer goods.

mass property. The analysis of the physical characteristics of a part, assembly, or system. The evaluation of multiple properties—measures volume, weight, and surface area and locates center of gravity.

mass storage peripheral. A device that interfaces with the system or machine to external memory storage.

material. The designation of a number of basic metals, compounds, and gases to make up thermoelectric materials.

material-handling equipment and systems. Equipment such as 1: Movement—Automated guided vehicle systems, conveyors, and monorails;

cranes and lift trucks are included only when they are computer-controlled; material-handling robots are included in Robotics in Manufacturing. 2: Storage—Automated storage and retrieval systems; miniload, microload, and carousels. 3: Identification—Bar codes, radio frequency, machine vision, and other sensors used for identification are covered in Sensors in Manufacturing. 4: Controls—Computers, programmable controllers, and software used in material handling are included in Computers in Manufacturing and Software in Manufacturing.

material-handling/loading robot systems. Robotics used in the loading, moving, storage, and unloading of materials.

material requirement planning (MRP). A planning method that uses bills of material, inventory data, and a master production schedule to calculate material requirements. This method makes recommendations to restock materials inventory. Further, because material requirements planning is time-phased, this method makes recommendations to reschedule open orders when due dates and need dates are not in phase. Originally seen only as a better way to order inventory, material requirements planning is thought of today primarily as a scheduling technique, i.e., a method to establish and maintain valid due dates on orders.

matrix printer. An impact printer that uses wire, hammer-like bristles, or needles to create characters formed by small dots. Matrix printers produce either serial or line output. The serial printer employs a moving printhead with a matrix block (i.e., 5 x 7 or 7 x 9) of needles. The printhead sweeps across the page to print full characters one at a time. The line printer uses a horizontal band with raised dots that moves from left to right across the paper. The individual needles strike programmed character dots to form one row of dots per sweep across the page. Successive passes of the line printer form complete characters and complete rows of textual data. High-resolution text, comparable to daisywheel output, may be produced by overlapping matrix printers that print characters via a highly concentrated matrix or successive, staggered passes of the printhead. Fonts for matrix printers are stored in ROM or PROM memory.

MBE. See **molecular beam epitaxy deposition.**

MCAE. See **mechanical computer-aided engineering.**

MCU. See **microcontroller.**

MDF. See **main distribution frame.**

mechanical. Mechanical CAD/CAM is the software application of computer-aided tools to design, analyze, document, and manufacture discrete parts, components, and assemblies.

mechanical assembly equipment. 1: Machinery or equipment that assembles mechanical parts into subassemblies or final products. 2: Dial or rotary assembly machines; in-line transfer machines; flexible assembly equipment (except robots).

mechanical computer-aided engineering (MCAE). The application of CAD/CAM tools for mechanical design and analysis. MCAE applications range from conceptual product design through detailed product design and analysis to supporting production design. Commonly used MCAE products are solid modeling and finite element analysis technology.

mechanical computer-aided manufacturing. See **mechanical.**

media-to-media data conversion equipment. Computer output-to-microfilm recording units, tape print units, card-to-tape conversion units, as well as document entry devices.

medical. An environment or industry that uses computers to control and/or collect and analyze data from patients, medical equipment, and/or instruments.

memory. 1: A device into which data can be entered and stored for later retrieval. 2: An integrated current (IC) designed for the storage and retrieval of information in binary form; can be either bipolar or MOS technology and includes dynamic random-access memory (DRAM), static random-access memory (SRAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), and electrically erasable programmable read-only memory (EEPROM).

memory management unit (MMU). 1: An integrated circuit that manages the storage and retrieval of data found by cell location or address. 2: A component (or set of components) that implements the memory management function in a processor-based system.

merchant production. The sale of a good to a company other than the manufacturing company.

merger and acquisition. In financial terms, it means to absorb or acquire one company by another.

metalorganic CVD (MOCVD). A technique used to deposit material onto a wafer.

metal oxide silicon (MOS). 1: A circuit in which the active region is a metal oxide semiconductor sandwich. The oxide acts as the dielectric insulator between the metal and the semiconductor. 2: A process that results in a structure of metal over silicon oxide over silicon. 3: Technology that employs field effect transistors having a metal or conductive electrode that is insulated from the semiconductor material by an oxide layer of the substrate material.

meteorological instrument. An instrument used to monitor and observe the weather.

metropolitan statistical area. A large population nucleus, together with adjacent communities, that has a high degree of economic and social integration with that nucleus. Each metropolitan statistical area (MSA) must include at least: (a) one city with 50,000 or more inhabitants, or (b) a census bureau-defined urbanized area of at least 50,000 inhabitants and a total MSA population of at least 100,000 (75,000 in New England).

microcomponent. 1: An integrated circuit (IC) with high-speed, low-power density considered as a single part. 2: An IC that contains a processing unit or acts as an interface chip to such a device. Types of microdevices include microprocessor (MPU), microcontroller (MCU), microperipheral (MPR), and digital signal processor (DSP).

microcomputer. An information system with price ranging up to $100,000, with the majority priced at less than $50,000. CPU bit width is normally 32 bits, but can be as low as 8 bits. Traditionally used as a desk-side or desktop system configuration. Normally a multiuser system used in a common work area. Usually has a merchant (nonproprietary) microprocessor.

microcontroller (MCU). An integrated circuit, containing a CPU, memory, and I/O capability, that can perform the basic functions of a computer.

microperipheral (MPR). A support device or circuit for a microprocessor or microcontroller that either interfaces with external equipment or provides system support.

microprocessor (MPU). A single-chip component, or a collection of architecturally interdependent components, functioning as the central processing unit (CPU) in a system. A microprocessor may contain some input/output circuits, but it usually does not operate in a standalone environment.

microprogrammable digital signal processor (MPDSP). An integrated circuit that allows high-performance, modular DSP architectures to be designed using standard off-the-shelf components. Products include bit-slice and building block components.

microwave. 1: Any radio wave with a frequency higher than 890 MHz or a wavelength of between 1ml and 1m. 2: A form of electromagnetic radiation that has frequencies of 1 GHz. These high-frequency bands of energy are used extensively for radar and wideband communications.

microwave antenna. A device used for receiving and transmitting microwave signal beams. (See also **antenna.**)

microwave monolithic integrated circuit (MMIC). An electronic circuit employing monolithic integrated circuit technology fabricated by microelectronic techniques and capable of operating at frequencies above 1 GHz.

microwave oven. An oven that uses electron waves to produce heat for faster cooking of foods.

microwave radio equipment. Equipment that includes transmitter/receiver systems, power supplies, repeaters, and other equipment used in microwave radio systems. It also includes analog and digital equipment used both in common carrier and in private industrial systems.

midrange. The combination of microcomputer, minicomputer, and superminicomputer.

military/aerospace electronic equipment. Electronic equipment used in the military and civilian aerospace industries.

military communication equipment. Voice, data, and cryptographic equipment used for communication in the military.

military computer system. A computer system used for military purposes; a set of hardware components that form a system intended solely for military applications. This category includes general-purpose CPUs, storage, input/output, and terminals and includes both commercial, ruggedized, and mil'spec versions for integration into military systems and for government-sponsored programs.

military electronic equipment. Electronic equipment used exclusively by the military. Usually, this equipment must meet government specifications and regulations.

military simulation and training. The performance of military maneuvers/exercises as training for real-life military situations. This category includes flight and battle simulators and equipment operation and maintenance systems.

milling programmable machine tool. A machine tool for the removal of metal by feeding a workpiece through the periphery to remove the material through the motion of workpiece and cutter.

minicomputer. An information system with prices ranging from $10,000 to $300,000 but mainly falling between $25,000 and $150,000. CPU bit width ranges from 8 to 16. Minicomputers are situated usually in a common work area and occupy more floor space than most tower configurations. Number of concurrent users ranges from 15 to 100. System usually incorporates proprietary processor, with notable exceptions, and is often packaged with third-party application software and/or peripherals and then resold into specialized applications or vertical markets. Examples of models are the HP 1000, HP 3000/70, PDP-11/84, and IBM Series/1.

minicomputer-based terminal. A display terminal provided by a minicomputer manufacturer or a display terminal that is protocol-specific to an IBM System/34, /36, or /38 computer. This terminal may operate in either character or block mode. Excluded from this category is any minicomputer-compatible terminal supplied by an independent manufacturer.

miscellaneous military equipment. Equipment that includes classified systems, test equipment (N.E.C.), vehicle control, medical equipment, assorted development and office equipment, and research and development equipment; all used in the military.

mixed signal ASIC. An ASIC that has one analog input or output and one digital input or output.

mixed signal IC. An integrated circuit that has one analog input or output and one digital input or output.

MMIC. See **microwave monolithic integrated circuit.**

MMU. See **memory management unit.**

mobile communications equipment. Equipment (base stations, mobile units, and antenna) used primarily for portable public or private communications.

mobile infrastructure. The central base station and other central equipment that provide mobile communication services.

mobile radio base station equipment. The base/centralized station equipment associated with cellular radio systems. This category includes both switching equipment and radio transmitter/receiver equipment.

mobile radio service. Service or network revenue associated with cellular radio systems. (See also **mobile service.**)

mobile radio system equipment. Electronic equipment used in the transmission and receiving of radio signals. Equipment includes main central control, base control mobile stations, and handheld car units. Used primarily with cellular and other mobile communication technologies.

mobile service. Radio service between a fixed location and one or more mobile radio stations, or between mobile stations.

mobile telephone service (MTS). Radio communication between a mobile (portable) unit and the public switched network including cellular service.

modeling. An application that supports the representation of a process or system by using equations that simulate and represent behavior under varying conditions.

modem. 1: An electronic device that provides modulation and demodulation functions of transmitted data signals over telephone lines. They convert digital data signals to analog for transmission over leased lines or the analog public switched telephone network. 2: The integrated circuits used in a modem.

molecular beam epitaxy deposition (MBE). A technique used in semiconductor manufacturing to deposit a single crystal layer on a substrate by use of a molecular beam.

molecular engineering. See **computational chemistry/molecular engineering.**

money management. An application that identifies and controls the source, flow, location, and earning potential of an organization's cash and investments.

monitor. 1: To check the operation and performance of a system or circuit by examining parts of transmissions. 2: The physical CRT unit, associated electronics, and housing used in display systems. 3: A station or equipment arranged to supervise system operation. 4: To supervise and verify the correct operation of a system, device, or program. 5: The screen of a video display terminal. 6: An analog monitor can display an almost infinite number of colors, while a digital monitor can display a more limited range of colors.

monolithic analog integrated circuit. An analog IC constructed from a single piece of material. All circuit components are manufactured in or on top of a single crystal of semiconductor material.

MOS. See **metal oxide silicon.**

MOS application-specific IC. See **application-specific integrated circuit.**

MOS cell-based IC. See **cell-based integrated circuit.**

MOS custom IC. See **custom integrated circuit.**

MOS digital. A semiconductor technology in which the active devices are n-channel, p-channel, or complementary MOS transistors that operate in a digital or binary mode. (See also **digital.**)

MOS FPGA. See **field-programmable gate array.**

MOS gate array. See **gate array.**

MOS logic. See **logic circuit.**

MOS memory. See **memory.**

MOS microcomponent. See **microcomponent.**

MOS microcontroller. See **microcontroller.**

MOS microperipheral. See **microperipheral.**

MOS microprocessor. See **microprocessor.**

MOS nonvolatile memory. See **nonvolatile memory.**

MOS PLA. See **programmable logic array.**

MOS PLD. See **programmable logic device.**

MOS PMD. See **programmable multilevel logic device.**

MOS standard logic. See **standard logic.**

MOS transistor. A field-effect transistor (FET) with a gate that is insulated from the semiconductor substrate by a thin layer of silicon dioxide. Being field-effect transistors, MOS-FET provide a voltage-input-to-current-output relationship called transconductance. MOS-FET are excellent switches because voltage at the gate turns the output current on or off.

mouse. A hand-held device that is moved on a surface to provide coordinate input to a graphics system. It is used most often to position a pointer or cursor.

MPDSP. See **microprogrammable digital signal processing.**

MPR. See **microperipheral.**

MPU. See **microprocessor.**

MPU load programmer. A device that allows engineers and IC designers to program a variety of programmable devices (ICs), thereby speeding up the design process. The device to be programmed is loaded directly on the device programmer.

MTS. See **mobile telephone service.**

multilingual publishing. A system with the purpose/use of printing in a variety of languages.

multimedia. A process that uses more than one form of communication.

multiplexer equipment. Public telecommunication equipment used to combine a number of channels for transmission over a common medium, such as satellite, microwave radio, cable carrier, or fiber-optic cable. Excluded from this are data-only customer premises multiplex equipment and multiplex equipment that is integral to carrier or microwave radio systems.

multistrike ribbon. A ribbon that advances only part of a character width; characters slightly overlay one another on the ribbon, but no character hits the exact same spot on the ribbon.

multiuser system. A computer system inherently designed for environments with multiple users.

N

natural resources and construction. An environment or industry that includes establishments primarily engaged in agricultural production, forestry, commercial fishing, hunting and trapping, and related services; and mining or quarrying, developing mines, or exploring for nonmetallic minerals except fuel. Also, certain well and brine operations and primary preparation plants, such as those engaged in crushing, grinding, washing, or other methods of concentration.

navigation, military. A process for directing ships, aircraft, spacecraft, and other crafts to a specific destination. Equipment determines position, distance, and course of vessel or craft.

n-channel metal oxide semiconductor (NMOS). Pertaining to MOS devices made on p-type silicon substrates in which the active carriers are electrons that flow between n-type source and drain contacts. The opposite of PMOS. NMOS is two to three times faster than PMOS. (See also **MOS.**)

net additions. 1: The change in stock, such as installed base or inventory. 2: The relative increase or decrease in the total installed base of a product.

NETVIEW. IBM network management product.

network management. A software application that controls the logical connections and information flow among computers on a network. This software may have additional functions such as performance measurement and diagnostic and accounting functions.

network support services. All services that help customers better utilize their networking facilities. The services include site planning, installation, and ongoing on-site and remote maintenance support, as well as professional services such as network design/planning, integration, administration, and operations management.

network terminating devices. Equipment that connects a data network to the data terminal.

new placement demand. The total end-user demand for new products (as compared with replacement products).

newspaper publishing. A system with the main purpose/use of printing newspapers; typically daily or weekly publication containing such elements as news, feature articles, and advertising.

nitrogen. A chemical element.

NMOS. See **n-channel metal oxide semiconductor.**

non-IBM, protocol-specific terminal. A terminal that is protocol-specific to a Burroughs, Honeywell, or Sperry mainframe computer. Included is any terminal of this type that connects to another computer by means of protocol emulation.

nonimpact printer. A hard-copy computer output device that forms images through electrostatic or other nonimpact methods. These printers include ink jet, laser, and thermal printers. (See also **ink jet printer.**)

nonvolatile memory. An integrated circuit using two-junction transistor technology where memory retains information when the power is off. Also known as core or permanent memory. Can be either bipolar or MOS technology process.

nonvolatile random-access memory (NVRAM). A read/write semiconductor memory device that does not lose information when the power is turned off.

notebook personal computer. The notebook personal computer is a system that resembles a laptop personal computer in general form factor and appearance. This personal computer is smaller and lighter in weight than a laptop D/C unit. The "standard" notebook size is 8.5 inches by 11 inches by 2 inches or less, and the weight of these units is in the 5- to 7-pound range. Notebook computers also, presently, make use of industry-storage mass storage media including 3.5-inch floppy disk.

nuclear radiation detection and monitoring instrument. An instrument used to detect, inspect, monitor, and control alpha particles (neutrons, protons, and electrons) that emanate from the atomic nucleus as a result of radioactivity and nuclear actions.

numerical control. 1: Computer instructions that automate machining and drafting tools. 2: A technique of simulating the operation of a machine tool. 3: Descriptive of systems in which digital computers are used for the control of operations, particularly of automatic machines. A technique of controlling a machine or process through the use of command instructions in coded numerical form.

numerical-control (NC) part programming. The programming of a numerical-control machine tool or automated processing system. Graphics and language-based programming tools are available.

NVRAM. See **nonvolatile random-access memory.**

O

OCR. See **optical character reader.**

OEM. See **original equipment manufacturer.**

office equipment. Equipment used in a business or office environment. Equipment may include copiers and duplicators, electronic calculators, dictating machines, electronic typewriters, word processors, banking systems, cash registers, and mail- and letter-handling equipment.

off-line robotics programming. A special-purpose process simulation that graphically represents the sequence of steps to program a robot for a particular operation. The resulting data can be downloaded to a robot to update its control program.

oil field services. A software application that uses small computers in the oil rigs or the wellhead areas to log and analyze data from sensors in the well.

OLTP. See **on-line transaction processing.**

one-time programmable read-only memory (OTP ROM). An EPROM packaged in plastic without a quartz window for erasure. Such a device is therefore programmable only once.

on-line transaction processing (OLTP). The input, tracking, and output of a well-defined record of information, processed in real time rather than batch. Examples include ATMs and airline reservations systems. OLTP systems are usually large and complicated enough that each one is customized, so there are few generic OLTP products. The RAMP-C and Debit-Credit benchmarks are examples of OLTP standards.

op amp. See **operational amplifier.**

open systems interconnection (OSI). A communication standard for network architecture that allows communication between various equipment.

operating environment. A set of conventions for screen appearance, keyboard, mouse and screen operations, and program functions. Operating environments function within an operating system.

operating system. 1: The software program in a computer that maps logical constructs to physical locations in the computer. The operating system is the program that lets a user access data by a file name without knowing where the file is physically located on the disk. 2: The operating system controls the computer's operations by managing disk, screen, file maintenance, and printer activity, while loading and running application programs.

operating utilities. A program or routine of general usefulness and applicable to many jobs or purposes.

operational amplifier (op amp). A type of integrated circuit (IC) that generates an amplified output that is exactly proportional to its input.

operator support system. Special equipment and/or software that facilitates the operation of a switchboard or comparable equipment.

optical CD/wafer inspection. Critical dimension (CD) refers to the line, element, or feature that must be manufactured and controlled to stringent specifications. Wafer inspection refers to the inspection of a patterned wafer for process defects by visual image process techniques.

optical character reader (OCR). 1: A device or scanner that can read printed or typed characters and convert them into a digital signal for input into a data or word processor. 2: The machine identification of printed characters through the use of light-sensitive devices; computer-input-only hardware.

optical disk controller. A device that controls the storage and retrieval of data from a video disk that is sensed through a laser beam.

optical disk drive. A data storage device utilizing laser technology. Types include CD-ROM, WORM, and erasable optical disk drives.

optical jukebox. A library system that holds multiple disk drives and optical disks to create a large storage environment on optical media.

optical media. The substance on which data are stored electronically and read by laser technology.

optical-scanning equipment. See **optical character reader.**

opto. See **optoelectronic.**

optocoupler. 1: A device that transmits electrical signals, without electrical connection, between a light source and a receiver. Also called an optoisolator. 2: A device that consists of an LED separated from a photo detector by a transparent, insulating, dielectric layer, all mounted in an opaque package. A current pulse in the LED causes a radiation pulse to flow across the dielectric layers to a photo detector, which produces a current pulse at the output. The input and output circuits are coupled with high-standoff voltage isolation.

optoelectronic (opto). A semiconductor device in which photons cause electron flow or vice versa. Optoelectronic chips contain transducers used between photonic circuit media and electronic media; they also may contain amplifiers, logic functions, and/or other photonic or electronic functions.

order entry and sales support. An application to support the process of accepting and translating what a customer wants into terms used by the manufacturer. This can be as simple as creating shipping documents for a finished goods product line to a more complicated series of activities including engineering effort for make-to-order products.

order entry/processing. Acceptance and translation of customer requirements into terms used by a manufacturer.

organization operation. A software application that supports the day-to-day running of an organization.

original equipment manufacturer (OEM). 1: An OEM may manufacture a product for assembly into another system or larger configuration by another manufacturer or vendor. 2: A purchaser of materials, components, or equipment to be incorporated into its product line. 3: A product reseller that integrates hardware, software, and/or services. The reseller may or may not own the hardware or software. An OEM differs from a VAR in that it adds its own label to the product and backs up its warranties.

OSI. See **open systems interconnection.**

OS/2. Computer systems based on the Intel 80XXX architecture and using OS/2 operating system software.

other. A subject or segment that is not distinctly defined within the Dataquest High-Technology Segmentation scheme.

OTP ROM. See **one-time programmable read-only memory.**

P

PABX. See **private automatic branch exchange.**

pacemaker. An electronically pulsed oscillator implanted in the body to deliver electric pulses to the heart at a fixed rate in response to a sensor that detects when a person's heart rate slows.

packet assembler/disassembler (PADS). A system element that buffers data sent to and from character-mode devices and assembles and disassembles the packets needed for X.25 operation.

packet data switching. Data network switches that connect terminals and packet assemblers/disassemblers to a pre-edit node using a high-speed link (56,000 bps). Can be public or private.

PADS. See **packet assembler/disassembler.**

page composition. Refers to the page composition software used to produce finished draft or camera-ready pages whereby text and graphics have been aesthetically laid out using an editable WYSIWYG display environment.

page, nonimpact, plain paper (PNPP). A printer with the ability to buffer, in part or in whole, a page of images received from an electronic source and then to transfer these images to a receiving substrate.

page printer. A printer that prints characters one at a time to full-page format. Page printers are rated by speed categories, expressed in pages per minute (ppm).

paging equipment. Communication equipment that produces an audio signal in a radio receiver carried by an individual to tell him that he is needed at the telephone. Communication system for summoning individuals or making public announcements.

paging system. The equipment necessary to selectively alert individuals by tone or voice paging, either by pocket radio receivers or speakers within a building.

painting robot system. A system consisting of a number of robots programmed to paint by carrying spray guns and applying a coating of material. Also known as finishing robot.

PAL. See **programmable array logic.**

panel-type instrument. 1: Switches, dials, and buttons that are mounted on an electronic unit that controls and monitors a system. 2: Electronic instrumentation devices mounted on a panel for a variety of equipment purposes.

paper. Sheets of fiber formed on a fine screen from a water suspension. There are hundreds of different types of paper based on weight, brightness, color, opacity, and coating.

particle accelerator. A device that accelerates electrically charged particles (protons, electrons) to high energies.

part process design. The design of the actual manufacturing process and sequence.

parts service. Spare hardware modules or components used in the repair and/or replacement of failed hardware units.

passive device. 1: An inert component that may control, but does not create or amplify, energy. 2: A device that exhibits no transistance. A component that does not provide rectification, amplification, or switching but reacts to voltage and current. 3: Pertaining to a general class of device that operates as signal power alone.

patient monitoring. Equipment used to monitor, control, and record data on activity concerning or affecting a patient's health.

pay phones. A telephone instrument located in a public location that accepts coins for operation.

payroll. A software application that supports an organization making payment to its employees for work performed.

PBX-private branch exchange. See **PBX telephone system.**

PBX telephone system. A telephone switching system on the customer premises that, by dialing an access code, permits a telephone to interface to the public telephone central exchange or office.

PC. See **personal computer system.**

PCB layout. Products that are used to create the layout of the traces and components to be placed on a printed circuit board.

p-channel metal oxide semiconductor (PMOS). An MOS device made on an n-type silicon substrate in which the active carriers are holes (p) flowing between p-type source and drain controls.

PC logic chipset. A semiconductor device (or set of devices) that integrates standard logic and controller functions onto a very large scale integration (VLSI) chip, resulting in a reduced component count on the PC motherboard.

PCN. See **personal communications network.**

pen-based personal computer. This is a new classification of portable computers for 1991. The general identifier for this class of machines is that they utilize a pen or stylus for data input and do not normally require a keyboard to operate. (Keyboard options are included in some of these models, but the system can be fully utilized without the inclusion of a keyboard.) Pen-based computers do not have to be able to run MS-DOS or applications that run under DOS. It is expected that there will be three or more operating systems utilized in this product: PenPoint by GO Corporation, Pen Windows by Microsoft, and others that have not been made public at the time of publication.

percent retirement. See **retirement.**

periodical publishing. A system with the main purpose/use of printing publications issued at intervals.

peripheral device. 1: Any instrument, device, or machine that enables a computer to communicate with the outside world, or areas in the operation of the computer. 2: Equipment that is connected to a computer but is not part of the computer. Examples include printers, terminals, and disk drives.

peripheral I/O management. 1: A program that interacts with the central processing unit (CPU) of a computer to communicate with devices beyond the CPU. The program interprets and responds to instructions from the CPU. 2: Information flows between the CPU and a unit of peripheral equipment.

personal communications network (PCN). A class of communications technology that allows communication with a mobile entity. Sample technologies include mobile radio, cellular, and paging services.

personal computer operating system. A personal computer operating system is a program that supervises and controls the operation of a personal computer.

personal computer system. A personal computer intended for use on the user's desk or work surface and not designed to be readily moved from place to place. Personal computers are those systems that include, as part of the basic system, a BIOS- or ROM-based software code that is designed to permit the use of the system with any of the existing personal computer operating systems.

personal electronics. Electronic equipment for personal use.

personal finance. A software application that records, processes, and reports on personal financial data, including personal banking, credit card management, and budgeting. These applications are suitable for small businesses as well as home use.

personnel management. A software application that supports an organization in managing its employees; may include many subapplications.

photoblank. A blank glass plate that is processed to become a photomask for use in semiconductor manufacturing.

photomask. A glass plate covered with an array of patterns, used to form circuit patterns on semiconductor wafers. Photomasks may be made of emulsion, chrome, iron oxide, silicon, or a number of other materials.

photoreceptor. The photoreceptor is the central element in an electrophotographic copier or nonimpact printer. The photoreceptor consists of two parts; a support or substrate, usually in the form of a drum or flexible belt, and a photoconductive coating consisting of one or more layers.

photoresist. The light-sensitive film spun onto semiconductor wafers and exposed using high-intensity light through a photomask.

photosensitive. Capable of emitting electrons when struck by light rays.

photosensitive plotter. A plotter that uses photosensitive properties to create an image.

photosensor. An optoelectronic semiconductor that responds to radiant energy. Examples are photodiodes and phototransistors.

physical property test, inspection, and measurement. An instrument designed to inspect and measure physical property.

physical vapor deposition (PVD). A process through which specific materials are physically layered on a wafer. Includes sputtering and evaporation.

pin diode. A diode made by diffusing the semiconductor with p-dopant from one side and n-dopant from the opposite side with the process so controlled that a thin or intrinsic region separates the n and p regions. (See also **power diode.**)

PLA. See **programmable logic array.**

placement. End-user consumption of a product that is either purchased, leased, or rented.

planning. An application that facilitates the quantitative aspects of business planning, such as modeling, budgeting, analysis, and forecasting.

plasma etchant. A highly ionized gas (plasma) in the manufacture of high-density semiconductors.

plastic-processing machinery. Numerically controlled machinery used for injection, structural foam, extrusion, blow molding, thermoforming, and reaction injection.

plastics. 1: A polymetric material of large molecular height that can be shaped by flow; usually refers to the final product. Examples include polyvinyl chloride, polyethylene, and urea formaldehyde. 2: Displaying or associated with plasticity.

PLC. See **programmable logic controller.**

PLD. See **programmable logic device.**

plotter. 1: A recorder that charts, in graph form, a dependent variable as a function of one or more variables with an automatically controlled pen or pencil. 2: Any (vector or raster) computer hardcopy devices that perform mainly graphics functions. These devices include pen plotters, electrostatic plotters, photographic and laser plotters, and ink jet plotters.

PMD. See **programmable multilevel logic device.**

PMOS. See **p-channel metal oxide semiconductor.**

PMR. See **private mobile radio.**

PMR. See **projection microradiography.**

PNPP. See **page, nonimpact, plain paper.**

point-of-sale terminal. A terminal device that operates as a cash register in addition to transmitting information.

polysilicon. A silicon layer grown on a wafer in a furnace.

population. The total of individuals occupying an area or making up a whole. A *de facto* population should include all persons physically present in a country (state, province, region, city, or town) or designated area at a reference date. A *de jure* population, by contrast, should include all usual residents of a given country or designated area, whether or not they are physically present at the reference date. By definition, therefore, a *de facto* total and a *de jure* total are not entirely comparable.

portable electronic measuring instrument. An electronic measuring instrument that can be carried or transported with ease.

portable radio receiver transmitter. A device for converting radio waves into perceptible signals.

portfolio management. A software application that allows investors to clarify, estimate, and control the sources of risk and return in their portfolio.

postsecondary education. The provision of formal instructional programs with a curriculum designed primarily for students who have completed the requirements for a high school diploma or equivalent.

potentiometer. A device for the measurement of an electromotive force by comparison with a known potential difference.

power diode rectifier. A diode is a two-terminal device that permits current flow in only one direction. This property is used in diodes and rectifiers to convert AC current to DC.

power grid control. See **power management.**

power IC. An analog integrated circuit that can control one or more amps of current, dissipate one or more watts of power, or is capable of operating with voltages exceeding 100 volts.

power management. A real-time application that monitors and controls power generation equipment and power line grids.

power supply. 1: A unit that supplies electrical power to another unit. 2: Energy source that provides power for operating electronic apparatus.

power train. The mechanism by which power is transmitted from the engine to other part of the vehicle that it drives. Examples include ignition, spark timing, fuel control, turbo control, emissions systems, voltage regulator, alternator, engine control, and diagnostics.

power transistor. 1: A transistor that dissipates power of one or more watts. 2: A transistor designed for high-current, high-voltage applications.

premises switching equipment. Voice equipment that provides switching or call-routing functions. Includes equipment such as PBX telephone system and key telephone system.

presentation graphics. 1: A software application with a principal function of formatting text or numeric data into specified formats for the presentation of ideas. This may include graphs, charts, and/or lists suitable for professional presentations. 2: An image written, printed, drawn, or engraved; an image outlined or set forth for commercial, professional, or industrial purposes.

print element. The mechanisms used in fully formed character printers and typewriters by which marks are made on the paper. The three types of print elements are printwheels, also known as daisywheels, golf balls, and thimbles.

printer. The unit that produces copy on paper—a typewriter or a line printer. Often connected to a CPU that transforms electronic data into hardcopy form. (See also **ink jet printer** and **line printer.**)

printer controller. 1: Within a printer, the device used to regulate, accelerate, decelerate, start, stop, reverse, or protect devices connected to an electric controller. 2: A device or instrument that holds a process or cartridge at a desired level. 3: Hardware and/or software, usually either printed circuit board- or diskette-based, that takes data streams from software and converts it to printer-specific commands. The controller may reside in a CPU; may be connected to the print engine by an interface cable, a diskette or chip set in the CPU or printer; or, as in most cases, may be a physical attachment to or integrated component of the printer itself.

printer controller board. See **printer controller.** (Except all devices are loaded onto a board.)

printer, impact. Family of printers that use direct impression impact of a typebar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

printer, nonimpact. A printer capable of imaging on a substrate without physically striking it; these include ink jet, laser, and thermal printers.

print system network. Hardware and software that is integrated to manage the information sent to one or a number of printers, usually shared by more than one user. The system may be as simple as a switch box connected to two CPUs and one printer, or as complex as a full local area network that controls print streams to many printers from multiple CPU systems and controls job-queuing management, printing error conditions, spooling, and rerouting.

printwheel. A print element for certain character printers. The characters are engraved at the end of spokes, the entire printwheel resembling a daisy. Also known as daisywheel.

private automatic branch exchange (PABX). One type of telephone switching system that is typically used in larger businesses. The PABX allows computer-like programming of incoming and outgoing calls to optimize network configurations and provide additional call management features.

private line. A telecommunications network connection for the exclusive use of one organization. (See also **leased circuit.**)

private mobile radio (PMR). See **cellular service.**

private packet data switching. A private packet data network switch connects terminals and packet assemblers/disassemblers to a packet node using a high-speed link (56,000 bps). (See also **packet data switching.**)

private school or institution. A school or institution that is controlled by an individual or agency other than a state, a subdivision of a state, or the federal government; usually supported primarily by funds other than public funds; and is operated by other than publicly elected or appointed officials.

process control, nonunified system. System-type instruments and related equipment for process control activated from standardized electrical transmission signals, in which control and signal conditioning are separated from the display and operator interface.

process control system. 1: Monitoring and maintaining the operation of plants that manufacture homogeneous materials such as oil, chemicals, and paper. Process control systems are capable of detecting errors in input variables and environment and taking corrective action. Closed-loop systems are self-correcting, and open-loop systems alert an operator. 2: A computer-based system that controls physical transformation and/or the mixing of products in a fluid state.

process control system, auxiliary station. Peripheral equipment of a process control system not in direct communication with the central processing unit or system.

process control system, controller. The controller describes that portion of a process control system that continuously measures the value of a variable quantity or condition and then automatically acts on the controlled equipment to correct any deviation from a desired present value.

process control system, indicator. A portion of the process control system that produces a diagram measuring the pressure volume changes in a running system.

process control system, industrial process computer. A computer that monitors the manipulations and changes of numerous conditions within a process control system automatically.

process control system, recorder. A portion of a process control system that makes a graphic or acoustic record of one or more variable quantities.

processing terminal. A display terminal that has local processing capability but is dependent on communication with a host, controller, or server to provide files and application programs. Such a terminal does not have a mass data storage device.

process manufacturing. 1: *Continuous process* produces a continuous stream of products, the units of which are not differentiated from one another (i.e., gasoline). 2: *Batch processing* produces product by reference to a recipe (i.e., bread).

processor. A device for handling information in a sequence of reasonable operations. Any device that can perform operations on data.

process planning and control. See **process control system.**

process simulation. The computerized simulation of the sequence and interdependencies of manufacturing processes. Also involves process modeling and includes NC part programming as a subset.

product. A good or service.

product category. A grouping of similar products.

production. The manufacture of goods.

production planning and control. Software used to plan for factory resources of a manufacturing company.

professional publishing. Systems dedicated exclusively to the job of publishing; typically, PC-based professional publishing systems focus on a single task or stage in the document production cycle, rather than managing the entire document production process.

professional services. A range of services including consulting on information technology, contract/custom programming, systems integration, facilities management, education, and ongoing maintenance.

programmable array logic (PAL). PAL is a trademark of Monolithic Memories, Inc. (now part of Advanced Micro Devices), referring to a family of logic devices that are customer programmable.

programmable logic array (PLA). 1: A form of programmable logic device containing a structured, partially interconnected set of gates and inverters that are fuse programmed by the user. Can be manufactured in bipolar or MOS technology.

programmable logic controller (PLC). A device or transmission control unit in which hardwired functions have been replaced with software or microcode. A programmable controller enables a user to add, change, or tailor computer capacities to the user's needs; programmable solid-state devices that replace mechanical relays for controlling sequential operations, timing, counting, and similar simple control actions. Where the capabilities exist as a function of the PLC, this definition includes more sophisticated tasks such as mathematical computations, data acquisitions, reporting, and process equipment control.

programmable logic device (PLD). A type of application-specific integrated circuit (ASIC) that is user programmable (after assembly) rather than mask programmable. The function of a PLD is determined by blowing fuse links or programming memory devices to create the desired interconnections between the fixed logic elements on the device. Can be either a bipolar or MOS technology. (See also **programmable logic array.**)

programmable machine tool. Numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and flexible machining centers used for metal cutting and metal forming.

programmable multilevel logic device (PMD). A semiconductor that can be manufactured by a bipolar or MOS technology process. The device, evolved from the basic programmable logic array (PLA), incorporates architectures to implement complex logic functions efficiently. PMDs can implement multiple levels of logic without sacrificing input/output or I/O cells or pins.

programmable read-only memory (PROM). A nonvolatile fuse-programmable solid-state memory circuit that is programmable only once, with special equipment. It is a programmed ROM that may be programmed after manufacture by blowing fuse links or shorting base-emitter junctions. PROMs provide high-speed access to frequently needed data and instructions. They allow a vendor company to customize a system before delivery to the user.

projection/aligner. Wafer fabrication lithography equipment that uses mirrors instead of lenses. The wafer and mask are separated by distance, not allowing the entire wafer to be exposed. This process lines up two or more layers of a wafer so that the components of one layer are compatible with the components of the other layer. (See also **lithography.**)

projection microradiography (PMR). An electron beam is focused onto an extremely fine pencil, generating a point source of x-rays; enlargement is achieved by placing the sample very near this source and several centimeters from the recording material.

project management. A software application that supports the ordering of activities across time. This application assists in planning and implementing projects by providing tools for forecasting requirements, projecting costs, and providing other charting and analysis features.

PROM. See **programmable read-only memory.**

prosthetic medical equipment. Equipment used in the surgical and dental specialties concerned with the artificial replacement of missing body parts.

protocol. A set of rules (not a program) for software programs to conform with in data communications. A program that reacts properly to data sent to it in a form that does not conflict with these rules and that sends data in conformance with these rules is said to support, or be in compliance with, the particular protocol. An example of a protocol is the one used by humans over two-way radio: the protocol is that one person finishes speaking by saying "over"; the other party then speaks, until finished and says "over"; the end of transmission is signalled by saying "over and out." Examples of protocols in data communications are BSC (IBM) and T201 (Tymnet).

protocol converter. Equipment that converts data from one format (protocol) to another. (See also **gateway.**)

proximity/contact aligner. Equipment that places a mask in direct contact with the wafer after the mask is aligned. With proximity, the mask does not come into direct contact with the wafer. (See also **lithography.**)

PTT. Postal, telegraph, and telephone organization. An organization that provides basic telecommunications services. For U.S., see regional bell operating companies.

public data network service. A packet-switched or circuit-switched network service available for public use. It includes the equipment and service charges associated with data communications networks that are offered to the general public. These networks connect user terminals and computers to the network and may offer enhanced or value-added services, such as conversion of speeds, codes, protocols, electronic mail, or facsimile.

public packet data switching. See **packet data switching.**

public school or institution. A school or institution controlled and operated by publicly elected or appointed officials and deriving its primary support from public funds.

public switching equipment. Equipment used in public telecommunications to switch or route voice and data calls. This segment includes equipment such as digital central office switching equipment and digital access cross-connect systems.

public telecommunications equipment. Equipment that includes public network services and equipment. It includes the various voice and data communications services provided by common carriers and the transmission and switching equipment used to implement these networks.

public telecommunications service. A service provided by public telecommunications carriers. It includes services such as local telephone, long distance telephone, international telephone, leased circuit, public data network, enhanced network, and mobile communications.

public transmission equipment. The equipment used in public telecommunications to transmit voice and data signals. It includes equipment such as multiplex equipment, carrier equipment, microwave radio equipment, and satellite earth state equipment.

publishing. 1: The business or profession of the commercial production and issuance of literature and information. 2: Computer-aided systems to automate the creation and printing of documents.

punch/shear/bend programmable machine tool. Describes the action that occurs to a composite or material, generally metal, on a machine. Punching literally punches a hole in the material, shearing cuts the material, and bending forms the material to a specified predetermined shape. These three activities are performed on three separate machines.

purchasing. A software application that has computer-assisted generation or procurement documents specifying materials, quantities, and delivery times.

purchasing and vendor management. Contains statements as to the quantity, description, and price of the goods; agreed terms as to payments, discounts, date of performance, and transportation.

PVD. See **physical vapor deposition.**

PW—private wire leased circuits. See **private line.**

Q

QC. See **quality control.**

QC analysis. Quality control analysis is generally performed throughout the manufacturing process, comparing the actual part shape or feature size to the design specification.

quality. The measure of how well a product or service meets customer expectations. Alternately, the ability to produce consistently a product or service within control limits or well-defined specifications.

quality assurance. The establishment and execution of procedures to measure product quality and adherence to acceptance criteria.

quality control. Process by which product is measured to ensure conformance to specification and standards.

query language. A generalized computer language that is used to interrogate a database.

R

R&D. See **research and development.**

radar. A radio device used to locate objects by frequency waves reflected off the object and received by the sender, allowing the sender to determine characteristics of an object. Includes airborne, shipboard, and ground search, flight control acquisition, detection, tracking, and associated test systems.

radio. 1: The use of electronic waves/signals to produce sound. 2: Home radio receivers including AM, AM-FM, and FM radios that are classified as table models, clock models, and portable radios. This category does not include high-fidelity receivers, radio-phonograph combinations, and television receivers, nor does it include automobile radios, stereos, or tape players.

railroad control. An application that monitors and controls railroad and urban rapid transit traffic.

RAM. See **random-access memory.**

random-access memory (RAM). An integrated circuit permitting read-and-write access to any memory cell or address in a completely random sequence. Can be of either bipolar or MOS technology process. A memory device with the qualities of allowing arbitrary reading or writing of a desired data location. The system accesses the addressed material without reading through intervening data. Information may be retrieved more speedily from RAM than from serial media, such as tape. Also called read-and-write and scratch-pad memory.

rapid thermal processing (RTP). Process that uses machines of low temperature for contact alloying and systems for the deposition of thin gate oxides. Similar to the diffusion furnace.

RBOC. See **regional bell operating company.**

reactant gas. Molecules that act upon one another to produce a new set of molecules.

read-only memory (ROM). 1: Computer memory that can be read from but not written to. Permanent memory on chips wherein information can be retrieved but not stored. Memory is not lost when the power to the computer system is turned off. 2: A memory device the contents of which can be read but not altered. (See also **mask ROM.**)

real estate. An environment or industry that includes owners, lessors, lessees, buyers, sellers, agents, and developers of real estate.

real-time clock. A clock that indicates actual time, such as elapsed time, as opposed to a fictitious time established by a program.

real-time data acquisition and control. 1: The process by which events in the real world are translated to machine-readable signals. 2: Automated systems in which sensors of one type or another are attached to machinery. 3: Data processing is performed so that the results are available in time to influence the controlled or monitored system.

reconnaissance. Equipment used to secure data/information about activity and resources concerning an enemy or potential enemy's territory.

reduced-instruction-set computing microprocessor (RISC MPU). The number of instructions a microprocessor runs for a specific application are reduced from a general-purpose complex-instruction-set computing (CISC) microprocessor to create a more efficient computing engine.

reel-to-reel tape drive. A tape format in which the running tape is wound onto a separate take-up reel. Also known as open reel.

regional bell operating company (RBOC). Seven holding companies formed by the divestiture of AT&T to provide regulated and nonregulated telecommunications services in the United States.

relational database management system. A software application for the storage, retrieval, update, and analysis of multiple databases. These databases are linked (related) through one or more identical fields, called keys.

relay. 1: An electronic or electromechanical device for transferring a signal from one electrical circuit to another. 2: To forward a message through an intermediate station. (See also **passive device.**)

remote batch. A method of entering jobs into the computer from a remote terminal.

remote control. Any system of control performed from a distance. The control signal may be conveyed by intervening wires, sounds, light, or radio signals.

remote processing. A procedure in which the operating system can be used to process messages received from remote locations via telephone lines and telephone equipment. In effect, it is an extension of the data processing and programming facilities of the computer to remote locations.

remote sensing. The acquisition of information (usually in the form of an image) about an object or area by recording electromagnetic radiation emanating from or reflected from the target. The electromagnetic energy is received and processed by a detector system that is not in physical contact with the target under study. Common platforms for detector systems are aircraft and satellites, but the definition is not restricted to these two.

removable media disk drive. Removable media rigid disk drive has the platter enclosed in a housing that is designed to be user-accessible.

replacement demand. The subsequent demand by end users for new equipment.

research and development (R&D). Basic and applied research directed toward the discovery, invention, design, or development of new products and processes.

research supercomputer. An information system defined by a minimum of 32 low-performance computing nodes. Optimized to run highly parallel applications. Price ranges between $300,000 and $2 million.

residual value. The value of a product at the end of its useful life. Typically used with depreciation and leasing calculations.

resistor. A passive device that measurably opposes the passage of an electric current (e.g., doped silicon). (See also **passive device.**)

respiratory analysis. Equipment used to examine, detect, and analyze the respiratory system.

retail trade. An environment or industry that includes establishments engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of the goods. In general, retail establishments are classified by kind of business according to the principal lines of commodities sold.

retirement. The number of products that are removed from use. A product is considered retired from the installed base if it is scrapped, returned to the manufacturer, or placed in storage.

return. The number of units previously sold outright that have been returned or retired by the customer. (See also **retirement.**)

revenue. The amount of money that a company receives from its customers for goods and services.

rewritable optical disk drive. An optical disk drive that uses removable media that can be erased and reused many times (also called erasable optical disk drive).

ribbon. A strip of inked material or fabric, which when struck with a print element forms a character on paper. (See also **single-strike ribbon, web ribbon, film ribbon, multistrike ribbon.**)

rigid disk. See **rigid disk computer storage media.**

rigid disk computer storage media. A rigid disk has a nonflexible substrate and can be made of aluminum, plastic, glass, or other rigid material.

RISC MPU. See **reduced-instruction-set computing microprocessor.**

robot. A reprogrammable multifunctional manipulator designed to move objects through variable motions for the performance of a variety of tasks. Intelligent robots commonly rely on vision systems to control their behavior through their ability to recognize objects.

robotic electronic assembly. Electronic manipulative machines that can perform functions ordinarily ascribed to humans in the assembly of material.

robotic nonelectric assembly. Same as robotic electronic assembly except that robots are mechanically maneuvered rather than through the methods and principles of electronics.

robot programming and simulation. The use of computer-controlled manipulators or arms to automate a variety of manufacturing processes such as welding, material handling, painting, and assembly.

robot system. Programmable manipulative machines that can perform functions ordinarily ascribed to humans. Included are robotic mechanisms, control hardware and software, and all associated peripheral equipment. These peripherals include end effectors and grippers that are used for the processing of parts, tools, and assemblies within the factory.

ROM. See **read-only memory.**

routing. An application that supports route planning. It is used to schedule the sequence of stops a transport vehicle makes.

RTP. See **rapid thermal processing.**

S

safety and convenience. Equipment related to the automobile and truck industry including devices that prevent loss, hurt, or injury, or that lend ease and comfort to passengers. Examples include: climate control, light reminder, keyless entry, heated windshield, sensing wipers, automatic door lock, automatic headlights, dimming, rear window defogger, antiskid braking, window control, and airbags/restraint control.

satellite. 1: A specialized radio transmitter/receiver placed in orbit around the earth to provide transmission channels for information to be transmitted over great distances. 2: A celestial body orbiting another of larger size.

satellite communication equipment. Equipment used for communication by use of an active or passive satellite to extend the range of a radio, or other transmitter, by returning signals to earth from an orbiting satellite.

satellite earth station equipment. The total earth-based equipment used in connection with orbiting, geostationary satellites. This category includes the Very Small Aperture Terminals (VSAT), as well as the antennae and electronic transmitting/receiving terminals.

scanner. Input devices used for the optical sensing of images and text and/or graphics for conversion to dot patterns for incorporation into a document. This category includes both ICR and OCR scanners with a resolution of less than 400 dpi.

scheduling. An application that supports the scheduling of events.

schematic. This is a detailed diagram. In a mechanical application, schematics are used to describe hydraulic and pneumatic systems. A set of symbols are available for both applications representing standard components.

scholarships and fellowships. College expenditures applying only to money given in the form of outright grants and trainee stipends to individuals enrolled in formal coursework, either for credit or not. Aid to students in the form of tuition or fee remissions is included. College work-study funds are excluded from this category and are reported under the program in which the student is working.

Schottky TTL (STTL). A form of transistor-transistor logic using Schottky diodes as transistor clamps to increase the speed of circuit operation. A high-speed form of bipolar logic.

scientific application. A diverse group of software applications covering varied subject matter and research on the natural sciences when these are concerned with the physical world and its phenomena. Applications are divided into two subcategories: general analysis and scientific research. General analysis is the use of computers to solve various technical problems and to further research on subjects; this use is generally mathematical in nature. Scientific research applications are used specifically in the following fields: thermonuclear chemistry, nuclear physics, general physics, mechanical sciences, electronics research, geophysics, fluid dynamics, thermodynamics, materials research, and genetic engineering.

scientific research. A software application that pertains to research and development, not to applied science.

scientific visualization. An image computer is used for scientific modeling, technical data analysis, medical imaging, or similar large-volume data analysis.

security. 1: The existence and enforcement of techniques that restrict access to data and the conditions under which data can be obtained. 2: A measure taken by a command to protect a system from espionage, observation, sabotage, annoyance, or surprise. 3: Protection of a system by use of commands and codes.

security/energy management. Safety and power management within industrial equipment and manufacturing.

seismic analysis. 1: Seismic analysis helps support exploration activities by indicating favorable conditions for finding oil or coal reservoirs. 2: Analysis relating to an earth vibration caused by earthquakes, or other natural phenomena.

semiconductor. 1: A group of materials that are electrical nonconductors in a pure state that can be altered by the selective introduction of impurities into its crystalline structure. Its resistivity can sometimes be changed by light, an electric field, or a magnetic field. 2: An electronic device made using semiconductor material.

semiconductor tester. Equipment designed to test, check, and monitor the functionality of electronic circuit packages of varying complexity and functionality.

serial, impact, dot matrix (SIDM). A printer that creates a character image by selectively placing individual dots on the substrate using mechanical force.

serial, impact, fully formed (SIFF). A printer that prints one character at a time using type elements to create fully formed character impressions.

serial input/output (SIO). 1: A device that permits data to be transmitted into and out of a computer over a single conductor one bit at a time. 2: Pertaining to time sequential transmission of, storage of, or logical operations on parts of data words. 3: A technique for handling binary data words (which have more than one bit). 4: A device or technique where data are transferred to or from an I/O port in a serial or in-line manner.

serial, nonimpact, direct thermal (SNDT). A printer that creates the desired image a dot at a time using point-specific heat and a heat-sensitive substrate that changes color when exposed to heat.

serial, nonimpact, ink jet (SNIJ). A printer that creates the desired image a character at a time by emitting ink from an array of orifices or nozzles.

serial nonimpact, thermal transfer (SNTT). A printer that creates the desired image a dot at a time using point-specific heat to transfer ink from a ribbon to a receiving substrate.

server. A processor that provides a specific service to a network, such as connecting nodes of different networks.

services. Intangible items of trade, such as education, transportation, banking, and legal and medical care.

SFDSP. See **special-function DSP products.**

sheet feeder. A sheet feeder is mounted on top of a printer and automatically inserts cut sheets into the printer and receives the ejected paper in a hopper. Sheet feeders may be single or dual tray for the feeding of letterhead and second sheets, or they may incorporate an envelope-feed tray for the printing of letters and envelopes simultaneously.

shipment. The number of products delivered.

shop floor and cell control. A system for utilizing data from the shop floor as well as data-processing files to maintain and communicate status information on shop orders and work centers. Provides actual output data for capacity control purposes.

shop floor planning and control. See **shop floor and cell control.**

SIDM. See **serial, impact, dot matrix.**

SIFF. See **serial, impact, fully formed.**

silicon epitaxy deposition. A process through which vaporized silicon is deposited on a wafer. (See also **deposition.**)

silicon precursor gas. A specialty gas used in semiconductor manufacturing. Gases such as silane, dichlorosilane, trichlorosilane, and silicon tetrachloride are used in epitaxial and chemical vapor deposition (CVD) processes to deposit layers of silicon or silicon components onto silicon substrates.

silicon wafer. A nonmetallic element that is the most widely used semiconductor material today. Silicon is used in its crystalline form as the substrate of semiconductor devices.

simulation. An application or system that uses representative or artificial data to reproduce various conditions in a model that are likely to occur in the actual performance of a system. Simulation frequently is used to test the behavior of a system under different operating policies.

simulation and training equipment. Equipment used to augment the acting out of real-life maneuvers/exercises as training in preparation for real-life situations. Equipment includes aircraft, flight and situation simulators, equipment operation, and maintenance systems.

single-strike ribbon. A film ribbon. Each time a character strikes the ribbon, the ribbon advances far enough so that the next character has a completely new ribbon area to strike. The ink formulation is such that the ink on the ribbon is depleted from the area where the print element strikes the ribbon. These ribbons produce the highest print quality, but ribbon life is low compared with that of fabric and multistrike ribbons.

single-user enhanced system. See **workstation computer.**

SIO. See **serial input/output.**

slow SRAM. A random-access memory (RAM) integrated circuit (IC) that runs at speeds greater than 70 nanoseconds. (See also **static random-access memory.**)

small-format pen plotter. A computer plotter that uses engineering-size A (8.5 x 11 inches) or B (11 x 17 inches), architectural-size 1 (9 x 12 inches) or 2 (12 x 18 inches), or metric-size A4 (21 x 29.7 centimeters) or A3 (29.7 x 42 centimeters) media. (See also **plotter.**)

small-signal diode. A diode with a forward current of less than 100 milliamperes (0.1 amperes). The sides of the silicon chip are metallized and encapsulated in a tubular glass package.

small-signal transistor. A transistor that dissipates power of less than 1 watt.

smart card. A credit card or credit-card-size device that contains one or more integrated circuits. These devices usually are carried by an individual. Common applications include financial transactions, record keeping, and user identification.

smart interactive terminal. See **intelligent terminal.**

smart power. An integrated circuit (IC) that contains both control logic circuits and power control elements.

smoke alarm. A detector that is activated automatically when exposed to smoke.

SNA. See **system network architecture.**

SNDT. See **serial, nonimpact, direct thermal.**

SNIJ. See **serial, nonimpact, ink jet.**

SNTT. See **serial, nonimpact, thermal transfer.**

socket. An opening that supports and electrically connects to vacuum tubes, bulbs, or other devices or components when they are inserted into it.

software. 1: Any set of explicit procedures constituting a computer program. 2: Programs, procedures, rules, and any associated documentation pertaining to computer operations.

software support service. Activities that assist the end user in use and implementation of software products. Software support includes bug fixing, updates, and documentation, as well as support of ongoing operating problems including product-specific consulting, programming services, and training.

solar cell. A pn junction device that converts the radiant energy of sunlight directly and efficiently into electrical energy.

solid modeling. An application that represents the external and internal part geometries, allowing the solid nature of an object to be represented in a computer. Solid models are constructed in two ways: using primitive building blocks (constructive solid geometry) and/or using boundary definitions (boundary representation).

solid state. Pertaining to circuits and components using semiconductors. (See also **semiconductor.**)

solid-state subsystem. Computer memory products that comprise a block of semiconductor memory, a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

sonar. A device used to detect submerged objects by sonar waves reflected off the object. Also can be used to measure depth or distance. Includes search, detection, tracking, guidance, navigation, communication, sonabuoys, and associated test systems.

SONET. See **synchronous optical network.**

space military equipment. Military equipment used beyond the earth's atmosphere. Includes satellites with accompanying communication and reconnaissance equipment, various other space platforms, launch vehicles, and ground control.

special automotive IC. An analog IC designed for a specific automotive application.

special consumer IC. An analog IC designed for use solely in consumer home entertainment and appliance products.

special-function analog IC. An analog integrated circuit function used in specialized applications. Examples are sensors, timers, and oscillators. These devices differ from application-specific standard products (ASSPs) in being functional blocks rather than complex configurations of functions for specific applications.

special-function DSP products (SFDSP). Products built using DSP techniques and architectures but designed for specific functions. Examples include: modems, codecs, speech processors, digital television circuits, digital filters, and fast Fourier transform (FFT) chips. Generally, these devices cannot be programmed by users to perform operations other than their defined function.

special-function IC. A linear IC that does not fall into the standard product categories. This product has a specific function such as timer, oscillator, signal generator, or sensor but is not limited to a single application or market.

special-purpose computer system. A computer system designed for a specific purpose. For example: a banking computer system, word processor, or cash register.

specialty gas. A gas used in manufacturing semiconductors that is supplied in gas cylinders rather than in bulk because smaller volumes are used.

splice. A joint used to connect two lengths of conductor with good mechanical strength and good conductivity. (See also **passive device.**)

spot-welding robot system. A robot carries a resistance welding gun to produce welds.

spreadsheet. An application with the principal function of organizing data into columns and rows to allow the user to perform numerical analysis.

SRAM. See **static random-access memory.**

standard cell. An integrated circuit designed to a customer's specifications using precharacterized cells as building blocks.

standard logic. Off-the-shelf integrated circuits belonging to "families." Bipolar digital families include AS, FAST, LS, and ALS. MOS digital families include HC, HCT, and FACT. Standard logic is available from a number of suppliers and may be used in many different applications. Sometimes referred to as glue logic. Normally has less than 150 logic gates.

start-stop tape drive. A tape drive that starts and stops on reading or writing a data record.

state government. One of the constituent units of a nation having a federal government.

static random-access memory (SRAM). A RAM that maintains memory as long as power is applied and does not require refreshing. SRAM densities can range from 1K, with approximately 1,000 bits, to 4Mb, with approximately 4 million bits.

statistical multiplexer. An electronic device that consolidates several data streams onto a single high-speed bit stream for transmission over a telephone line.

stepper. A semiconductor manufacturing device that uses a step-and-repeat process to transform the pattern image of a reticle or mask onto the surface of the semiconductor wafer.

stereo headphone. A device worn on the head that permits the transmission of sound through two earphones connected by a band.

stereo (hi-fi) component. Equipment that produces high-fidelity reproduction of sound.

storage controller board. 1: A board containing input data or parameters for an application of a general routine. 2: Those parts mounted on a board that carry out the instructions in proper sequence, interpret each instruction, and apply the proper signal.

storage management. Functions that manage the storage of information in which information can later be retrieved. Includes storage protection, storage temperature, storage print, and storage allocation.

storage subsystem. Computer memory product that comprises a storage device(s), a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

streamer tape drive. A tape drive that uses a continuously moving tape; one that does not start and stop on each data record.

streaming tape drive. Tape drives (1/4-inch and 1/2-inch width) where the data stream over the head without stopping (continuous flow).

structural. The dynamics of the physical system; usually refers to the static stability/integrity of a part, assembly, or system.

structural modeling/analysis. A software application for modeling and analysis of the integrity of a structure.

STTL. See **Schottky TTL.**

studio transmitter link. Equipment used to generate and amplify a radio signal.

styling. A detailed design process where aesthetic considerations are foremost. Systems supporting this application have special refinements for rendering, modeling, and editing functions.

subsidiary. A company partially or wholly owned by another company.

supercomputer. A high-performance computer designed for numerically intensive applications. The current price ranges from approximately $100,000 to $20 million.

superminicomputer. An information system with price ranging typically from $100,000 to $1 million, with a minority below $100,000. CPU bit width ranges from 32 to 48 bits, with emphasis on 32. Environment is almost exclusively an ordinary office with no special environmental controls. Equipment typically is supported full-time by a professional computer systems support staff of fewer than 10 members. It usually is built around proprietary processor and typically supports from 32 to 350 concurrent users. Examples of models are the HP 3000/930 and 950, DEC VAX 8700 and Micro VAX 3500, and IBM 9370.

superworkstation. A superworkstation has higher graphics performance than a traditional workstation. It also has a higher processing performance rating to support graphic computations. The average price is $40,000 to $80,000 with performance ratings of 8 to 20 mips and 2 to 16 mflops.

surgical support. Equipment relating to, or having connection with, surgery.

surveying and drafting instrument. An instrument used to detect, access, and measure radiation. The instrument is used in the drawing of objects, structures, or systems by engineers and scientists.

switch. 1: A mechanical or electrical device that competes with or breaks the pattern of a current or sends it over a different path. 2: A device that connects, disconnects, or transfers one or more circuits and is not designated as a controller, relay, or control valve. (See also **passive device.**)

switch/multiplexer IC. Analog switches gate analog signals under the control of logic. Multiplexers are specialized analog switches that select only one of many inputs.

synchronous optical network (SONET). An emerging standard for optical networks.

system management. The administration and operation of a computer system including staffing, scheduling, equipment, and service contract administration, equipment utilization practices, and time-sharing.

system network architecture (SNA). An IBM standard for data communication.

systems integration service. The implementation phase of tying together dissimilar devices. Services are coordinated by a single contractor who manages the procurement, installation, integration, and support of all software, hardware, and communications devices.

systems integrator. See **value-added reseller.**

system software. Software that provides support structure in which applications may operate. This includes operating systems, operating environments, and utilities.

systems planning and design. "Front-end" consulting services that are required to determine the nature of a customer's needs and the actions necessary to meet those requirements.

system subroutine library. An organized collection of computer programs that is maintained online with a computer system by being held on a secondary storage device and is managed by the operating system.

system support peripheral. An integrated circuit (IC) considered a traditional peripheral, where each processor has a set of six to eight dedicated peripherals that provide rudimentary functions necessary to construct a microprocessor (MPU)-based system. (See also **traditional peripheral.**)

system utilities. Products that aid in the maintenance and/or repair of computer hardware, operating systems, or data recovery.

T

2-D modeling. The representation of a part in two dimensions (has an x and y coordinate). This format requires three or more views (top, front, side) to depict all aspects of the part. This is the most common geometric modeling format and is used extensively with a drafting function.

3-D modeling. The representation of a part in three dimensions, usually in a wire-frame format (has an x, y, and z coordinate). This format is used commonly in high-level CAD systems to determine the placement and fit of components in an assembly. This format is not generally used for final drafting, although some systems have the capability to translate the 3-D image to a 2-D standard drafting format.

T-1. A high-speed, time-division, digital network link operating at 1.544 Mbps and above.

T-1 multiplexer. A unit that allows multiplexing, or combining, several voice and/or data channels onto one communications link, in this case, a high-speed T-1 channel.

tape drive. A class of computer backup device that uses reel-to-reel, cartridge, or cassette tapes as media.

tape recorder. A device that records and plays sound from magnetic tape.

tax accounting. An application concerned with keeping records for tax purposes, setting up accounts for paying taxes, making tax computations, and preparing tax returns.

TDM. See **time-division multiplexer.**

teaching machine and aid. Equipment designed to assist in the training, educating, and instructing of persons to acquire knowledge or skill in a particular field(s) of interest.

technical data analysis. An application that analyzes technical or experimental data. The data may have been generated from instruments, captured from other electronic measuring devices (such as thermocouples or strain gauges), or generated by other analysis programs.

technical illustration. A drawing of a component or assembly that generally is intended for publication. This drawing will omit unnecessary dimensions and other detailed drating items and will be drawn so as to depict the part realistically.

technical productivity. An application that enhances the productivity of technical disciplines and is specialized for the engineering, scientific, or manufacturing fields.

technical publishing. The printing of user manuals or guides.

telecommunication integrated circuit (IC). An analog IC designed for the voice and data communication market.

telecommunications. Products and services that provide or manage the flow of information from person to person, person to machine, machine to person, or machine to machine. The telecommunications market is segmented into a combination of the premises and public telecommunications market segments.

telecom services. Includes that portion of telecommunications charges related to access and use of the public network. These charges typically are seen as a monthly usage charge for local, long distance, and private line access/utilization.

teleconferencing. Equipment and services related to one-way and two-way video communications that use specialized video equipment and/or transmission networks. These communications enable conferencing between locations.

telemarketing. A sales method that employs a sales force to move a product through the distribution channel by contacting the consumer via the telephone. Also referred to as inside sales.

telemetering system. See **telemetry.**

telemetry. Transmission of data from remote measuring instruments by electrical or, usually, radio means.

telephone. A terminal or handset used for voice and data transmission and communications. It functions as an interface between a user and a telephone switching system.

TELeprinter EXchange (TELEX). A worldwide dial-up telegraph service enabling users to communicate directly and temporarily among themselves by means of start-stop apparatus and circuits of the public telegraph network.

teletex. An interactive communications network designed for transmission of text and graphics to televisions or other low-cost terminals.

TELEX. See **TELeprinter EXchange.**

tension arm tape drive. A 1/2-inch reel-to-reel tape drive that uses mechanical tension arms to provide tape tension and buffing.

terminal equipment. 1: A device at a node of a network through which information can be entered, extracted, or monitored. 2: Any device capable of sending and/or receiving information over a communications channel. Includes a keyboard and display that cannot stand alone because it lacks processing capability. Terminals are usually simple ASCII text-entry devices.

terms and conditions. The provisions of a contract that are stated or offered for acceptance that determine the nature and scope of the agreement.

test and measurement. The process of determining the magnitude of the response of an object to a given stimulus. Also the degree to which an object may be characterized along a dimension (quantification of an entity). Computer-based inspection and test systems used for quality and/or process control data analysis; data may be collected by manual input or sensory devices.

test equipment. Equipment designed to test, check, monitor, and identify varying degrees of device functionality and complexity that may include quality, speed, and performance. Automated test systems and equipment such as IC testers and PC-board testers, as well as general test equipment (such as oscilloscopes, spectrum analyzers, and digital multimeters).

text capture. Process whereby words or groups of words are controlled.

therapeutic. Medical applications involved in treating specific medical conditions.

thermal. The effects of temperature on the system.

thermal plotter. 1: A process that produces a visible image by heat-induced chemical reactions or chemically reactive media. 2: A thermally induced phase change process of a pigment-binder mixture, which is transferred from a donor sheet to the media.

thermal transfer printer. An imaging process using heated printing elements to produce prints or copies; can be either dye diffusion (coated paper) or wax based (plain paper). This process currently is used in electronic printing, facsimile machines, and full-color copiers.

thimble. A thimble-shaped print element that floats freely across the platen of a character printer, working in a similar fashion to a daisy-print element. It is shaped like a cup, with the spokes extending around the rim of the cup, with characters positioned at the end of the spokes.

thyristor. A type of diode that consists of a four-layer slice of silicon. The device is characterized by continuous switching. Once a thyristor has been triggered into conducting current, it will continue to conduct current until the main current falls to zero.

ticketing. A software application that supports the sale and management of tickets. The application may be as simple as ticketing a single event or as complex as ticketing airline reservations.

tie ratio. A ratio that describes the relationship between two or more product units, usually used when one product is part of or connected to another product. For example, a disk drive tie ratio to PCs of 0.8 indicates that 80 percent of the PCs contain a disk drive.

time and materials service. Remedial repair services on a per-call basis. Pricing is based on the actual length of time-to-repair, travel charges, and specific parts or materials required to complete repairs.

time-division multiplexer (TDM). One of several technologies used to multiplex, or combine, several voice and/or data channels onto one communications link. TDM uses "time slicing" to allocate blocks of time to each channel. See also **statistical multiplexer.**

TLX. See **TELeprinter EXchange.**

toner. The substance used that develops a latent xerographic image from a photoreceptor onto a substrate, usually paper. Monocomponent toner contains both the imaging material and the carrier (usually called developer) needed to transport the toner to the latent image. In dual-component toner, the imaging material and developer are held separately until they are mixed by the copier or printer itself. Liquid toner has the imaging material suspended in a solvent.

tool design. The design of custom-made tooling to facilitate an effective manufacturing process.

tools. A software program that is used by application developers or users to create applications. Examples are spreadsheets, word processors, editors, macro languages, screen painters, and report generators. Tools are higher-level products than languages; a tool is written in a language. Unlike languages, most tools are nonprocedural, i.e., they do not require users to create code that is sequentially executed. A good example of this is a spreadsheet, where the developer/user navigates up, down, and sideways with the arrow keys or mouse and can add or delete rows and columns at any time. Examples of tools include Lotus 1-2-3 (spreadsheet); Multimate (word processor); EDLIN (line editor); and Ojectworks (graphical editing and object manipulation environment).

trading turret/dealer board. A specialized type of telephone system that allows simultaneous access to multiple telephone lines. This system is used in any business that requires frequent conversations between two or more parties (i.e., stock brokers).

traditional peripheral. An integrated circuit that has an intermediary control device, which links a peripheral unit to the control processors.

traditional workstation. A midrange workstation priced between $15,000 to $50,000. Its performance ratings are 4 to 15 mips and 0.5 to 2 mflops.

traffic control. A real-time software application, mechanism, and system used to monitor and control, exert control over, and/or enforce the movement of vehicles.

transducer. Any device or element that converts an input signal into an output signal of a different form. (See also **passive device.**)

transistor. A transistor is as a current-amplifying device or switch, as follows: 1: Current amplifying—a small change in a small current flows between the collector and the emitter. 2: Switch—a sufficiently large voltage applied to the base causes the maximum amount of collective current to flow. It can be manufactured in bipolar or MOS technology process. A bipolar transistor consists of a sandwich of doped silicon layers. The transistor has three electrical connections: base, emitter, and collector. Each of these areas provides access to one of the doped regions.

transistor-transistor logic (TTL). A logic circuit design with the diode inputs replaced by a multiple-emitter transistor.

translator. The process performed by an assembler, compiler, or other routine that accepts statements in one language and converts them to another language. 2: A device that transforms signals from one form to another form. 3: A system that has a number of inputs and outputs and is connected so that input signals representing information expressed in a certain code result in output signals that represent the input information in a different code.

transmitter. 1: A device for transmitting a coded signal. 2: The carbon device in the telephone handset used to convert speech to electrical energy.

transparency. 1: The property of being insensitive to the meaning of a code being manipulated. An example is a paper-tape transmitter capable of transmitting any code submitted to it. If a device interprets and reacts to coded information that it is handling, it is said to be code sensitive (not transparent). 2: Clear substrates upon which images can be written, copied, or printed for projection onto a screen by an overhead projector.

transportable personal computer. The transportable personal computer is a self-contained system that can be moved from place to place as a single unit. These systems include, in a single unit, the keyboard, display, mass storage, and main system unit. Such a personal computer operates on A/C power only (no battery power).

transportation. An environment or industry that includes establishments providing, to the general public or the other business enterprises, passenger and freight transportation.

transportation electronic equipment. Electronic equipment used in the automotive railway and airline industry.

transportation management. The planning, analysis, and control of activities for transporting or being transported.

TTL. See **transistor-transistor logic.**

two-year college. A postsecondary school that offers general or liberal arts education usually leading to an associate degree or courses that are creditable toward a baccalaureate degree.

two-year institution. An institution legally authorized to offer and offering at least a two-year program of college-level studies that terminates in an associate degree or is principally creditable toward a baccalaureate degree.

typewriter. A machine for writing in characters by means of a keyboard operated by striking through an inked ribbon. Usually refers to the standard office typewriter (mechanical, electrical, or electronic).

U

UART/USART. See **universal asynchronous receiver/transmitter/universal synchronous asynchronous receiver/transmitter.**

ultrasonic cleaners, drills. 1: An instrument used to clean debris and swarf from surfaces by immersion in a solvent in which ultrasonic vibrations are excited. 2: A drill in which ultrasonic vibrations are generated by the compression and extension of a core electrostrictive or magnetostrictive material.

ultrasonic generator. A generator consisting of an oscillator driving an electracoustic transducer used to produce acoustic waves.

ultrasonic scanner, medical. A device that produces a picture display of ultrasonic frequency waves sent through the sample to be inspected or examined.

ultraviolet electrically programmable ROM. An EPROM that is erasable with an ultraviolet light source.

unit. A single quantity.

universal asynchronous receiver/transmitter/ universal synchronous asynchronous receiver/ transmitter (UART/USART). An electronic circuit that converts data between the parallel format and the serial format transmitted sequentially over a communication line.

UNIX. An operating system designed to be used with microprocessors and with the C programming language.

useful life. The economic life of a product. Typically used to determine depreciation and leasing schedules.

user interface. 1: The point at which a user interacts with a computer. 2: An interactive computer program that sends messages to and receives instructions from a terminal user.

users per system. The typical number of simultaneous users that a computer system will support.

utilities. An environment or industry that includes establishments providing electricity, gas, steam, water, or sanitary services to the general public or to other business enterprises.

UV EPROM. See **ultraviolet electrically programmable ROM.**

V

vacuum column tape drive. A 1/2-inch reel-to-reel tape drive with start-stop capability that uses vacuum columns to provide tape tension and buffing.

value-added network (VAN). A data communication network that provides enhanced services such as protocol conversion.

value-added reseller (VAR) systems integrator. A product reseller that integrates hardware, software, and/or services; it does not apply its label to the product. Systems integrators are a type of VAR and may or may not own the hardware or software.

VAN. See **value-added network.**

VAR. See **value-added reseller systems integrator.**

VAX/VMS. A Digital Equipment Corporation standard multiuser operating system.

VCR. See **videocassette recorder and player.**

vertical-turning programmable machine tool. The tool of a machine that holds a workpiece along the vertical axis for a certain function to be performed such as boring, drilling, and cutting.

vibrational. The effects of vibration and shock on the system.

video. 1: Relates to the bandwidth (megahertz) and spectrum position of the signal arising from television scanning. 2: The reception or recording of electronic signals that create images on a screen or display.

video camera. A camera that records visual images and sounds on magnetic tape.

videocassette recorder and player (VCRs or VTRs). A complete system that has a tape format such as beta, VHS, or 8mm.

videodisc player. A complete video system that has a disc format.

video equipment. Equipment includes amplifiers, television cameras, and other equipment such as synchronization equipment, live cameras, and control consoles.

video home system (VHS) helical scan tape drive. A 13mm helical scan tape drive commonly used for recording television broadcasts.

videotex. An information delivery system that uses information from a database that allows the user to interact with the service, selecting information to be displayed on the user's CRT providing financial services, electronic mail, and teleshopping.

virtual private network (VPN). Similar in function to a leased circuit with the exception that the circuit is not dedicated to one customer.

VLSI. Very large scale integration.

VMS. See **voice-messaging system.**

voice-messaging system (VMS). A computer-based system that enables flexible, nonsimultaneous voice communications. This definition does not include personal-computer-board-level products.

voice-recognition computer device. The capability of a computer to recognize spoken commands. Each user must first "train" the computer by speaking a series of words that the computer can analyze and match with stored information.

voice response unit (VRU). A computer-connected device that selectively links sentences of stored words, creating a spoken word.

voice synthesizer. A device that simulates speech by assembling a language's elements under digital control.

voice terminal. See **telephone.**

voltage regulator and reference IC. 1: A device that provides power to other circuits at a specified DC voltage. 2: A device that provides a specified constant DC voltage to a load over a wide range of variations in input voltage and output current.

VPN. See **virtual private network.**

VRU. See **voice response unit.**

VTR. See **videocassette recorder and player.**

W

wafer. A thin (10 to 20 mils) disk of semiconductor material from which semiconductors are fabricated.

wafer fab. The integrated circuit production process—from raw wafers through a series of diffusion, etching, photolithographic, and other steps to finished wafers.

wafer fabrication equipment. Machinery used to produce wafers in the semiconductor industry. (See also **e-beam, etch-and-clean equipment, stepper.**)

wafer inspection. Inspection of patterned wafers for process defects by visual and image-processing techniques.

water quality and sewage control. A real-time software application that monitors and controls water quality and sewage.

WATS. See **wide area telephone service.**

web ribbon. Web or towel ribbons are wide ribbons used on line, dot matrix, and line, fully formed printers. They are as wide as the print line is long—usually approximately 15 inches.

wet chemical. A chemical used in semiconductor wafer fabrication. Examples are acids and solvents.

wet etch. Immersing method for wafers in an etching solution. Chemical removal of a material by bathing the wafer in acid.

white-collar worker. A person working in an occupation classified by the Bureau of Labor Statistics under the following category headings: managerial and professional specialty and technical, sales, and administrative support.

wholesale trade. An environment or industry that includes establishments or places of business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, construction contractors, or professional business users; or to other wholesalers; or acting as agents or brokers in buying merchandise for or selling merchandise to such persons or companies.

wide area telephone service. An enhanced telephone company service allowing reduced costs of certain telephone call arrangements. This service can be in-wats or 800-number service (calls can be placed to a location from anywhere at no cost to the calling party) or out-wats (calls can be placed out from a central location).

word processing. A software application with the principal function of editing, entering, and formatting text.

word processor (WP). A standalone word processor capable of functioning independently from a central controller or storage device, although they may communicate with each other. These products generally have removable magnetic media. Products that have evolved from electronic typewriters generally are not included in this category. The ability to share a printer among workstations does not disqualify a product from being a standalone word processor; shared-system word processors are connected to an external file server or controller; word-processor file servers are centralized data storage devices that are accessible and dedicated to shared word processing units.

work force. All persons of either sex who furnish the supply of labor for the production of economic goods and services during a specified time period.

workstation computer. A single-user computer that is distinguished from a personal computer by its features and by the user's potential migration path within the platform. A technical workstation is a system designed with integrated networking; high-performance graphics; floating point; coprocessor; and a virtual, multiuser/multitasking operating system (DOMAIN, UNIX, VMS).

WORM. See **write-once/read-many.**

WP. See **word processor.**

write-once/read-many (WORM). 1: The WORM optical disk market includes drives that can read and write data using various optical diskette media. 2: A data storage device using laser technology that uses a removable disk ranging in size from 3.5 to 14 inches.

X

X-ray (lithography). A machine that uses an X ray for generating a mask plate of direct image transfer to a semiconductor wafer.

X-ray, medical. Equipment used to detect, examine, treat, or analyze body systems through photographic X-rays.

X.25. A CCITT standard that defines the interface between a public data network and a pocket-mode user device; also defines the services that these user devices can expect from the X.25 public data network.

Y

year-average population. The installed base of a product computed at the midyear between the beginning installed base and the ending installed base of the same year.

Z

zener diode. 1: A diode that has a controlled, reverse-voltage/current relationship. 2: A two-layer device that has a sudden rise in current above a certain reverse voltage.

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Semiconductor Consumption and Shipment Forecast

Introduction

Semiconductor consumption and shipment data comprise a set of detailed tables that estimate the size of the semiconductor total available market (TAM) worldwide and for four major geographical regions for the years 1985 through 1995 and 2000. Semiconductor consumption and shipment tables contain both historical data and forecasts. Historical data begin with 1985 and end with 1990, while forecast data provide annual market size estimates for 1991 through 1995, with additional estimates for 2000. Below is a list of tables detailing the type of data, region, time period, and units of measure.

Each table gives estimates of semiconductor revenue or shipments listed by the major semiconductor device product categories. In these tables, semiconductor components are divided into three major product groups: integrated circuits, discrete devices, and optoelectronic devices. These groups are divided into a number of subgroups, some of which are segmented further.

Definitions and Conventions

Dataquest uses a common manufacturer base for all data tables. This base includes all suppliers to the merchant semiconductor market. It includes aggregate revenue estimates for North American companies that manufacture devices solely for the benefit of the parent company, such as Delco, IBM, and Unisys. Also included are companies that actively market semiconductor devices to the merchant market as well as to other divisions of their own companies. For such companies, both external and internal shipments are included. Devices that are used internally are valued at current market prices.

List of Tables

Table	Region Covered	Years	Units
0	Japan and Western Europe Exchange Rates	1970-1989	Various
1a	Worldwide Market	1985-1990	Dollars
1b	Worldwide Market	1985-1990	Percent
1c	Worldwide Market	1991-1995; 2000	Dollars
1d	Worldwide Market	1991-1995; 2000	Percent
2a	North American Market	1985-1990	Dollars
2b	North American Market	1985-1990	Percent
2c	North American Market	1991-1995; 2000	Dollars
2d	North American Market	1991-1995; 2000	Percent
3a	Japanese Market	1985-1990	Dollars
3b	Japanese Market	1985-1990	Percent
3c	Japanese Market	1991-1995; 2000	Dollars
3d	Japanese Market	1991-1995; 2000	Percent
4a	Japanese Market	1985-1990	Yen
4b	Japanese Market	1985-1990	Percent
4c	Japanese Market	1991-1995; 2000	Yen
4d	Japanese Market	1991-1995; 2000	Percent

(Continued)

List of Tables (Continued)

Consumption—Dataquest defines consumption as the purchase of a semiconductor device or devices. This definition must be differentiated from actual use of the device in a final product. A regional market size includes all devices sold to or shipped to that region, i.e., the TAM in that region.

Hybrids—In earlier consumption data, hybrid devices were included as a separate segment of integrated circuits. Hybrid devices manufactured by semiconductor companies are now included in the most appropriate product segment, usually the analog segment.

The manufacturer base, product group definitions, and guidelines for including value of output that we have used in our tables may differ from those used in other studies of this type. Our base is nearly the same as that used by the World Semiconductor Trade Statistics (WSTS) program, with the following exceptions:

- Dataquest includes all of AT&T's semiconductor revenue, both merchant and captive.
- Dataquest includes—and has included all along—nonrecurring engineering (NRE) charges associated with application-specific integrated circuit (ASIC) revenue. (This applies to both the bipolar digital and MOS digital logic categories.)
- Dataquest includes the revenue generated by sales of standalone circuit design software, sold by certain U.S. manufacturers of ASIC logic devices.
- Dataquest includes Signetics revenue with that of its parent company, Netherlands-based N.V. Philips.
- Dataquest includes revenue for Taiwanese semiconductor manufacturers.
- Dataquest includes revenue for three Japanese companies not included by WSTS until 1990: NMB Semiconductor, Seiko-Epson, and Yamaha.
- As noted herein, Dataquest includes hybrid revenue in the analog category.

Further information on the above points is available through Dataquest's Client Inquiry Center at (408) 437-8099.

Regions—North America is defined as including both the United States and Canada. Latin America, including Mexico, is considered part of the Asia/Pacific-ROW category. Asia/Pacific includes South Korea, Taiwan, Hong Kong, Singapore, and China. Western Europe includes Austria, Belgium, Germany, France, Italy, Luxembourg, the Netherlands, the Scandinavian countries (Denmark, Finland, Norway, Sweden), Spain, the United Kingdom, and the rest of Europe. Japan, the fourth region, is the only single-country region.

Data Sources

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

- World Semiconductor Trade Statistics (WSTS) data, and Dataquest's estimates of regional company sales are used to determine shipments to North America.
- Japanese trade statistics compiled and published by the Ministry of Finance (MOF) and the Ministry of International Trade and Industry (MITI), WSTS data, and Dataquest's estimates of regional company sales are used to determine shipments to Japan.
- For Western European markets, marketing statistics from WSTS data and Dataquest's estimates of regional company sales are used to determine market size.
- In Asia/Pacific-ROW, the major published sources used to estimate market size are WSTS data and Dataquest's estimates of company shipments into the region.

Dataquest believes that the estimates presented here are the most accurate and meaningful generally available today. The sources of the data and the guidelines for the forecasts presented in the tables are as follows:

- Dataquest's own forecasts of electronic equipment production and semiconductor I/O ratios
- Unit shipments or revenue (or both) published by major industry participants, both in the United States and abroad
- Estimates presented by knowledgeable and reliable industry spokespersons
- Government data or trade association data such as those from the Electronics Industry Association (EIA), MITI, WSTS, and the U.S. Department of Commerce
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant projected world economic data

Accuracy

The tables presented here represent Dataquest estimates that we believe are reasonably accurate. Where we have no reasonable estimate, none is given. A zero in a table represents an estimate.

Valuation of Consumption

Regional market size is expressed in U.S. dollars (with the Japanese market also expressed in yen). To make the tables in this study useful in comparing different regions, it is necessary to express all values in a common currency, and we chose the U.S. dollar for convenience. However, the choice of the U.S. dollar (or any single currency, for that matter) as the currency basis for the tables brings with it some problems that require the readers' careful consideration in interpreting the data.

Inflation

All countries that participate significantly in international semiconductor markets suffered from an overall price inflation in the 1980s, continuing into the 1990s. As a consequence, the dollar in a given year is not truly comparable with the dollar in any preceding year. Consumer and wholesale price indices and GNP deflators all measure price changes in various composite "market baskets" of goods. However, there is no price index that measures price changes of material, equipment, and labor inputs to the semiconductor industry. Indeed, the "mix" is changing so rapidly that what is used this year was sometimes unavailable last year, at any price. Nor is there a composite price index that measures price changes in aggregate semiconductor product. In an industry noted for its deflationary trends, this latter effect would tend to make the component purchaser's dollar worth more as time passed, in terms of purchasing ability.

We have made no adjustments in the historical data to account for these inflationary and deflationary effects. The data are expressed in current dollars (dollars that include the inflation rate and exchange rates of the given year) for all historical data; comparisons between different years must be interpreted accordingly.

Average Selling Prices

When considering the worldwide average selling prices (ASPs) for semiconductor components, one must look at the price per function of a circuit, the complexity of the circuit, and the product mix according to this increasing complexity. It is true that one characteristic of the semiconductor industry is that the price per function for integrated circuits has been dropping an average of 30 percent per year for the last 15 years. At the same time, circuits have become denser, resulting in an overall increase in the price of a device with a decreasing cost per function. Thus, Tables 7a through 7d show the worldwide ASPs increasing after many years of decreasing, due to the move toward higher-complexity devices. There are also regional differences in ASPs due to regional competition differences and the varying regional product consumption mix. The worldwide ASP is truly an aggregate measure and may differ significantly from ASPs in any specific market at any point in time.

Exchange Rates

Construction of the West European tables involves combining data from many countries, each of which has different and changing exchange rates. Dataquest uses Annual Foreign Exchange Rates for each year as published by The International Monetary Fund and the *Wall Street Journal.* As far as possible, we prepare our estimates in terms of local currencies before conversion to U.S. dollars. The exchange rates for major currencies can be found in Table 0 at the end of this introduction.

Japanese market size is originally expressed in yen. The Japanese data published in this study are expressed in both dollars (Tables 3a, 3b, 3c, and 3d) and in yen (Tables 4a, 4b, 4c, and 4d). The yen/dollar exchange rate used for each year can be found in Table 0. Because of the fluctuations in the exchange rate for the yen, the dollar values given tend to distort the growth rate of the Japanese market, but they do provide a useful basis for regional market size comparisons. However, the data in yen give a better picture of the real growth in the Japanese market.

Forecast

As mentioned previously, historical data are expressed in current dollars or dollars that include the given year's inflation rate and exchange rates. However, the revenue forecasts use constant dollars and exchange rates, with no allowance for inflation or variations in the rates of exchange between countries. All estimates for 1991 and beyond are made as if 1991 monetary conditions will continue through 2000 and, therefore, show the absolute year-to-year growth during this period.

Table 0
Foreign Exchange Rates

Year	Yrly/Qtrly	Japan (Yen per US$)	France (US$ per Franc)	Germany (US$ per Deutsche Mark)	United Kingdom (US$ per Pound Sterling)
1970	YR	358	0.18	0.27	2.38
1971	YR	343	0.18	0.29	2.44
1972	YR	302	0.20	0.31	2.50
1973	YR	269	0.22	0.37	2.44
1974	YR	292	0.21	0.39	2.33
1975	YR	297	0.23	0.41	2.22
1976	YR	296	0.21	0.40	1.82
1977	YR	269	0.20	0.43	1.75
1978	YR	210	0.22	0.50	1.92
1979	YR	219	0.24	0.55	2.13
1980	YR	227	0.24	0.55	2.33
1981	YR	221	0.18	0.44	2.04
1982	YR	248	0.15	0.41	1.75
1983	YR	235	0.13	0.39	1.52
1984	YR	237	0.11	0.35	1.33
1985	YR	238	0.11	0.34	1.30
1986	YR	167	0.14	0.46	1.47
1987	YR	144	0.17	0.56	1.64
1988	YR	130	0.17	0.57	1.79
1989	YR	138	0.16	0.53	1.50
1990	YR	144	0.18	0.62	1.79
Q191	QTR	134	0.19	0.65	1.91

Source: The International Monetary Fund Financial Times, Dataquest (May 1991)

Table 1a
Worldwide Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Including Captives	27,116	33,729	41,478	54,521	61,454	62,772
North American Captives	2,773	2,895	3,227	3,662	4,241	4,547
Total Semiconductor	24,343	30,834	38,251	50,859	57,213	58,225
Total IC	18,552	23,618	29,887	41,068	46,924	47,303
Bipolar Digital	3,684	4,325	4,760	5,200	4,510	4,440
Memory	589	606	621	689	540	459
Logic	3,095	3,719	4,139	4,511	3,970	3,981
MOS Digital	10,103	12,815	17,473	26,988	33,024	32,292
Memory	3,817	4,511	6,056	11,692	16,361	13,091
Micro	2,745	3,489	5,108	7,144	8,202	10,068
Logic	3,541	4,815	6,309	8,152	8,461	9,133
Analog	4,765	6,478	7,654	8,880	9,390	10,571
Total Discrete	4,578	5,730	6,655	7,612	7,662	8,235
Total Optoelectronic	1,213	1,486	1,709	2,179	2,627	2,687

Source: Dataquest (May 1991)

Table 1b
Worldwide Semiconductor Consumption
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR 85-90
Total Including Captives	-13.4	24.4	23.0	31.4	12.7	2.1	18.3
North American Captives	10.9	4.4	11.5	13.5	15.8	7.2	10.4
Total Semiconductor	-15.5	26.7	24.1	33.0	12.5	1.8	19.1
Total IC	-18.0	27.3	26.5	37.4	14.3	.8	20.6
Bipolar Digital	-23.0	17.4	10.1	9.2	-13.3	-1.6	3.8
Memory	-23.9	2.9	2.5	11.0	-21.6	-15.0	-4.9
Logic	-22.8	20.2	11.3	9.0	-12.0	.3	5.2
MOS Digital	-22.0	26.8	36.3	54.5	22.4	-2.2	26.2
Memory	-38.7	18.2	34.2	93.1	39.9	-20.0	28.0
Micro	-15.0	27.1	46.4	39.9	14.8	22.8	29.7
Logic	1.4	36.0	31.0	29.2	3.8	7.9	20.9
Analog	-2.5	35.9	18.2	16.0	5.7	12.6	17.3
Total Discrete	-8.2	25.2	16.1	14.4	.7	7.5	12.5
Total Optoelectronic	-.7	22.5	15.0	27.5	20.6	2.3	17.2

Source: Dataquest (May 1991)

Table 1c
Worldwide Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Including Captives	71,807	83,745	97,321	107,632	114,222	199,971
North American Captives	5,584	6,556	7,518	8,407	8,691	14,610
Total Semiconductor	66,223	77,189	89,803	99,225	105,531	185,361
Total IC	54,103	64,232	75,522	83,934	89,840	164,196
Bipolar Digital	4,624	4,679	4,683	4,480	4,256	3,272
Memory	440	434	433	402	375	248
Logic	4,184	4,245	4,250	4,078	3,881	3,024
MOS Digital	37,709	46,294	55,628	62,243	66,906	130,228
Memory	14,974	18,798	23,001	26,078	28,283	56,891
Micro	12,118	14,907	17,917	20,076	21,604	44,069
Logic	10,617	12,589	14,710	16,089	17,019	29,268
Analog	11,770	13,259	15,211	17,211	18,678	30,696
Total Discrete	9,112	9,703	10,721	11,342	11,513	15,046
Total Optoelectronic	3,008	3,254	3,560	3,949	4,178	6,119

Source: Dataquest (May 1991)

Table 1d
Worldwide Semiconductor Consumption
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	14.4	16.6	16.2	10.6	6.1	12.7	11.9
North American Captives	22.8	17.4	14.7	11.8	3.4	13.8	10.9
Total Semiconductor	13.7	16.6	16.3	10.5	6.4	12.6	11.9
Total IC	14.4	18.7	17.6	11.1	7.0	13.7	12.8
Bipolar Digital	4.1	1.2	.1	-4.3	-5.0	-.8	-5.1
Memory	-4.1	-1.4	-.2	-7.2	-6.7	-4.0	-7.9
Logic	5.1	1.5	.1	-4.0	-4.8	-.5	-4.9
MOS Digital	16.8	22.8	20.2	11.9	7.5	15.7	14.2
Memory	14.4	25.5	22.4	13.4	8.5	16.7	15.0
Micro	20.4	23.0	20.2	12.1	7.6	16.5	15.3
Logic	16.2	18.6	16.8	9.4	5.8	13.3	11.5
Analog	11.3	12.7	14.7	13.1	8.5	12.1	10.4
Total Discrete	10.6	6.5	10.4	5.8	1.5	6.9	5.5
Total Optoelectronic	11.9	8.2	9.4	10.9	5.8	9.2	7.9

Source: Dataquest (May 1991)

Table 2a
North American Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region of Consumption: North America
Distribution Channel: All
Application: All
Specification: All

	1985	1986	1987	1988	1989	1990
Total Including Captives	11,663	13,171	15,454	18,789	21,348	20,844
North American Captives	2,243	2,327	2,596	2,945	3,411	3,458
Total Semiconductor	9,420	10,844	12,858	15,844	17,937	17,386
Total IC	7,757	8,986	10,886	13,815	15,909	15,387
Bipolar Digital	1,926	2,030	2,099	2,012	1,701	1,652
Memory	288	267	271	235	203	170
Logic	1,638	1,763	1,828	1,777	1,498	1,482
MOS Digital	4,322	4,912	6,738	9,606	11,682	11,025
Memory	1,753	1,775	2,497	4,298	6,163	4,655
Micro	1,258	1,362	2,012	2,707	2,972	3,563
Logic	1,311	1,775	2,229	2,601	2,547	2,807
Analog	1,509	2,044	2,049	2,197	2,526	2,710
Total Discrete	1,295	1,542	1,642	1,676	1,683	1,669
Total Optoelectronic	368	316	330	353	345	330

Source: Dataquest (May 1991)

Table 2b
North American Semiconductor Consumption
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	North America
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR 85-90
Total Including Captives	-22.4	12.9	17.3	21.6	13.6	-2.4	12.3
North American Captives	10.7	3.7	11.6	13.4	15.8	1.4	9.0
Total Semiconductor	-27.6	15.1	18.6	23.2	13.2	-3.1	13.0
Total IC	-30.0	15.8	21.1	26.9	15.2	-3.3	14.7
Bipolar Digital	-31.7	5.4	3.4	-4.1	-15.5	-2.9	-3.0
Memory	-34.7	-7.3	1.5	-13.3	-13.6	-16.3	-10.0
Logic	-31.1	7.6	3.7	-2.8	-15.7	-1.1	-2.0
MOS Digital	-33.5	13.7	37.2	42.6	21.6	-5.6	20.6
Memory	-48.8	1.3	40.7	72.1	43.4	-24.5	21.6
Micro	-23.0	8.3	47.7	34.5	9.8	19.9	23.1
Logic	-9.1	35.4	25.6	16.7	-2.1	10.2	16.4
Analog	-14.6	35.5	.2	7.2	15.0	7.3	12.4
Total Discrete	-13.8	19.1	6.5	2.1	.4	-.8	5.2
Total Optoelectronic	-11.1	-14.1	4.4	7.0	-2.3	-4.3	-2.2

Source: Dataquest (May 1991)

Table 2c
North American Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	North America
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Including Captives	22,918	26,235	30,343	33,112	34,448	53,614
North American Captives	4,157	4,849	5,533	6,217	6,447	10,837
Total Semiconductor	18,761	21,386	24,810	26,895	28,001	42,777
Total IC	16,692	19,198	22,404	24,394	25,557	40,005
Bipolar Digital	1,621	1,588	1,649	1,509	1,381	987
Memory	149	138	134	118	104	50
Logic	1,472	1,450	1,515	1,391	1,277	937
MOS Digital	12,102	14,242	16,899	18,580	19,495	31,615
Memory	4,989	5,808	6,963	8,106	8,681	14,827
Micro	4,003	4,784	5,613	5,960	6,254	10,026
Logic	3,110	3,650	4,323	4,514	4,560	6,762
Analog	2,969	3,368	3,856	4,305	4,681	7,403
Total Discrete	1,733	1,823	2,014	2,089	2,039	2,307
Total Optoelectronic	336	365	392	412	405	465

Source: Dataquest (May 1991)

Table 2d
North American Semiconductor Consumption
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	North America
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	10.0	14.5	15.7	9.1	4.0	10.6	9.3
North American Captives	20.2	16.6	14.1	12.4	3.7	13.3	10.9
Total Semiconductor	7.9	14.0	16.0	8.4	4.1	10.0	8.8
Total IC	8.5	15.0	16.7	8.9	4.8	10.7	9.4
Bipolar Digital	-1.9	-2.0	3.8	-8.5	-8.5	-3.5	-6.5
Memory	-12.4	-7.4	-2.9	-11.9	-11.9	-9.4	-13.6
Logic	-.7	-1.5	4.5	-8.2	-8.2	-2.9	-6.0
MOS Digital	9.8	17.7	18.7	9.9	4.9	12.1	10.2
Memory	7.2	16.4	19.9	16.4	7.1	13.3	11.3
Micro	12.3	19.5	17.3	6.2	4.9	11.9	9.9
Logic	10.8	17.4	18.4	4.4	1.0	10.2	8.2
Analog	9.6	13.4	14.5	11.6	8.7	11.6	9.6
Total Discrete	3.8	5.2	10.5	3.7	-2.4	4.1	2.5
Total Optoelectronic	1.8	8.6	7.4	5.1	-1.7	4.2	2.8

Source: Dataquest (May 1991)

Table 3a
Japanese Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Including Captives	8,300	12,018	15,107	20,977	23,234	23,031
North American Captives	151	163	180	205	237	523
Total Semiconductor	8,149	11,855	14,927	20,772	22,997	22,508
Total IC	5,985	8,802	11,263	16,127	17,946	17,387
Bipolar Digital	824	1,295	1,523	1,906	1,750	1,800
Memory	136	169	227	348	246	209
Logic	688	1,126	1,296	1,558	1,504	1,591
MOS Digital	3,232	4,762	6,424	10,501	12,497	11,799
Memory	1,185	1,738	2,268	4,424	5,992	4,612
Micro	884	1,368	1,902	2,573	2,828	3,210
Logic	1,163	1,656	2,254	3,504	3,677	3,977
Analog	1,929	2,745	3,316	3,720	3,699	3,788
Total Discrete	1,621	2,242	2,693	3,282	3,321	3,392
Total Optoelectronic	543	811	971	1,363	1,730	1,729

Source: Dataquest (May 1991)

Table 3b
Japanese Semiconductor Consumption
(Millions of Dollars)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR (%) 85-90
Total Including Captives	-6.8	44.8	25.7	38.9	10.8	-.9	22.6
North American Captives	11.9	7.9	10.4	13.9	15.6	120.7	28.2
Total Semiconductor	-7.1	45.5	25.9	39.2	10.7	-2.1	22.5
Total IC	-8.2	47.1	28.0	43.2	11.3	-3.1	23.8
Bipolar Digital	-13.7	57.2	17.6	25.1	-8.2	2.9	16.9
Memory	-16.6	24.3	34.3	53.3	-29.3	-15.0	9.0
Logic	-13.1	63.7	15.1	20.2	-3.5	5.8	18.3
MOS Digital	-10.7	47.3	34.9	63.5	19.0	-5.6	29.6
Memory	-25.0	46.7	30.5	95.1	35.4	-23.0	31.2
Micro	-9.7	54.8	39.0	35.3	9.9	13.5	29.4
Logic	9.4	42.4	36.1	55.5	4.9	8.2	27.9
Analog	-.6	42.3	20.8	12.2	-.6	2.4	14.4
Total Discrete	-7.7	38.3	20.1	21.9	1.2	2.1	15.9
Total Optoelectronic	8.4	49.4	19.7	40.4	26.9	-.1	26.1

Source: Dataquest (May 1991)

Table 3c
Japanese Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Including Captives	27,025	31,580	35,586	39,208	41,787	72,290
North American Captives	671	818	931	1,008	1,025	1,723
Total Semiconductor	26,354	30,762	34,655	38,200	40,762	70,567
Total IC	20,545	24,608	28,096	31,150	33,407	60,667
Bipolar Digital	2,030	2,158	2,142	2,131	2,098	1,685
Memory	222	233	240	237	233	180
Logic	1,808	1,925	1,902	1,894	1,865	1,505
MOS Digital	14,288	17,799	20,751	23,267	25,236	50,100
Memory	5,698	7,537	9,037	10,212	11,131	24,719
Micro	3,835	4,615	5,293	5,928	6,422	11,780
Logic	4,755	5,647	6,421	7,127	7,683	13,601
Analog	4,227	4,651	5,203	5,752	6,073	8,882
Total Discrete	3,827	4,017	4,242	4,467	4,601	5,816
Total Optoelectronic	1,982	2,137	2,317	2,583	2,754	4,084

Source: Dataquest (May 1991)

Table 3d
Japanese Semiconductor Consumption
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	17.3	16.9	12.7	10.2	6.6	12.7	11.6
North American Captives	28.3	21.9	13.8	8.3	1.7	14.4	10.9
Total Semiconductor	17.1	16.7	12.7	10.2	6.7	12.6	11.6
Total IC	18.2	19.8	14.2	10.9	7.2	14.0	12.7
Bipolar Digital	12.8	6.3	-.7	-.5	-1.5	3.1	-4.3
Memory	6.2	5.0	3.0	-1.3	-1.7	2.2	-5.0
Logic	13.6	6.5	-1.2	-.4	-1.5	3.2	-4.2
MOS Digital	21.1	24.6	16.6	12.1	8.5	16.4	14.7
Memory	23.5	32.3	19.9	13.0	9.0	19.3	17.3
Micro	19.5	20.3	14.7	12.0	8.3	14.9	12.9
Logic	19.6	18.8	13.7	11.0	7.8	14.1	12.1
Analog	11.6	10.0	11.9	10.6	5.6	9.9	7.9
Total Discrete	12.8	5.0	5.6	5.3	3.0	6.3	4.8
Total Optoelectronic	14.6	7.8	8.4	11.5	6.6	9.8	8.2

Source: Dataquest (May 1991)

Table 4a
Japanese Semiconductor Consumption
(Factory Revenue in Billions of Japanese Yen)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Including Captives	1,975.3	2,006.9	2,175.4	2,727.0	3,206.3	3,316.4
North American Captives	35.9	27.2	25.9	26.7	32.7	75.3
Total Semiconductor	1,939.4	1,979.7	2,149.5	2,700.3	3,173.6	3,241.1
Total IC	1,424.4	1,469.9	1,621.9	2,096.4	2,476.6	2,503.7
Bipolar Digital	196.1	216.2	219.3	247.7	241.5	259.2
Memory	32.4	28.2	32.7	45.2	33.9	30.1
Logic	163.7	188.0	186.6	202.5	207.6	229.1
MOS Digital	769.2	795.3	925.1	1,365.1	1,724.6	1,699.0
Memory	282.0	290.2	326.6	575.1	826.9	664.1
Micro	210.4	228.5	273.9	334.5	390.3	462.2
Logic	276.8	276.6	324.6	455.5	507.4	572.7
Analog	459.1	458.4	477.5	483.6	510.5	545.5
Total Discrete	385.8	374.4	387.8	426.7	458.3	488.4
Total Optoelectronic	129.2	135.4	139.8	177.2	238.7	249.0
Exchange Rate (Yen/US$)	238	167	144	130	138	144

Source: Dataquest (May 1991)

Table 4b
Japanese Semiconductor Consumption
(Percent Change in Yen)

Company: All
Product: Each
Region of Consumption: Japan
Distribution Channel: All
Application: All
Specification: All

	1985	1986	1987	1988	1989	1990	CAGR 85-90
Total Including Captives	-6.4	1.6	8.4	25.4	17.6	3.4	10.9
North American Captives	.0	.0	.0	.0	.0	.0	.0
Total Semiconductor	-6.7	2.1	8.6	25.6	17.5	2.1	10.8
Total IC	-7.8	3.2	10.3	29.3	18.1	1.1	11.9
Bipolar Digital	-13.3	10.2	1.4	13.0	-2.5	7.3	5.7
Memory	-16.1	-13.0	16.0	38.2	-25.0	-11.2	-1.5
Logic	-12.8	14.8	-.7	8.5	2.5	10.4	7.0
MOS Digital	-10.4	3.4	16.3	47.6	26.3	-1.5	17.2
Memory	-24.6	2.9	12.5	76.1	43.8	-19.7	18.7
Micro	-9.3	8.6	19.9	22.1	16.7	18.4	17.0
Logic	9.9	-.1	17.4	40.3	11.4	12.9	15.7
Analog	-.2	-.2	4.2	1.3	5.6	6.9	3.5
Total Discrete	-7.3	-3.0	3.6	10.0	7.4	6.6	4.8
Total Optoelectronic	8.8	4.8	3.2	26.8	34.7	4.3	14.0

NA = Not available

Source: Dataquest (May 1991)

Table 4c
Japanese Semiconductor Consumption
(Factory Revenue in Billions of Japanese Yen)

Company:	All
Product:	Each
Region of Consumption:	Japan
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Including Captives	3,618.6	4,228.5	4,765.0	5,250.0	5,595.3	9,679.6
North American Captives	89.8	109.5	124.7	135.0	137.2	230.7
Total Semiconductor	3,528.8	4,119.0	4,640.3	5,115.0	5,458.1	9,448.9
Total IC	2,751.0	3,295.0	3,762.1	4,171.0	4,473.2	8,123.3
Bipolar Digital	271.8	289.0	286.8	285.3	280.9	225.6
Memory	29.7	31.2	32.1	31.7	31.2	24.1
Logic	242.1	257.8	254.7	253.6	249.7	201.5
MOS Digital	1,913.2	2,383.2	2,778.6	3,115.5	3,379.1	6,708.4
Memory	763.0	1,009.2	1,210.1	1,367.4	1,490.4	3,309.9
Micro	513.5	617.9	708.7	793.8	859.9	1,577.3
Logic	636.7	756.1	859.8	954.3	1,028.8	1,821.2
Analog	566.0	622.8	696.7	770.2	813.2	1,189.3
Total Discrete	512.4	537.9	568.0	598.1	616.1	778.8
Total Optoelectronic	265.4	286.1	310.2	345.9	368.8	546.8
Exchange Rate (Yen/US$)	133.9	133.9	133.9	133.9	133.9	133.9

Source: Dataquest (May 1991)

Table 4d
Japanese Semiconductor Consumption
(Percent Change in Yen)

Company: All
Product: Each
Region of Consumption: Japan
Distribution Channel: All
Application: All
Specification: All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	9.1	16.9	12.7	10.2	6.6	11.0	11.6
North American Captives	.0	.0	.0	.0	.0	.0	.0
Total Semiconductor	8.9	16.7	12.7	10.2	6.7	11.0	11.6
Total IC	9.9	19.8	14.2	10.9	7.2	12.3	12.7
Bipolar Digital	4.9	6.3	-.8	-.5	-1.5	1.6	-4.3
Memory	-1.3	5.1	2.9	-1.2	-1.6	.7	-5.0
Logic	5.7	6.5	-1.2	-.4	-1.5	1.7	-4.2
MOS Digital	12.6	24.6	16.6	12.1	8.5	14.7	14.7
Memory	14.9	32.3	19.9	13.0	9.0	17.5	17.3
Micro	11.1	20.3	14.7	12.0	8.3	13.2	12.9
Logic	11.2	18.8	13.7	11.0	7.8	12.4	12.1
Analog	3.8	10.0	11.9	10.5	5.6	8.3	7.9
Total Discrete	4.9	5.0	5.6	5.3	3.0	4.8	4.8
Total Optoelectronic	6.6	7.8	8.4	11.5	6.6	8.2	8.2

NA = Not available

Source: Dataquest (May 1991)

Table 5a
European Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region of Consumption: Europe
Distribution Channel: All
Application: All
Specification: All

	1985	1986	1987	1988	1989	1990
Total Including Captives	5,174	5,992	6,949	9,003	10,348	11,227
North American Captives	379	405	451	512	593	566
Total Semiconductor	4,795	5,587	6,498	8,491	9,755	10,661
Total IC	3,615	4,116	4,840	6,669	7,794	8,326
Bipolar Digital	719	719	727	772	640	577
Memory	150	147	88	74	72	58
Logic	569	572	639	698	568	519
MOS Digital	1,933	2,270	2,761	4,364	5,458	5,403
Memory	745	813	854	1,797	2,548	2,154
Micro	486	574	805	1,212	1,469	1,836
Logic	702	883	1,102	1,355	1,441	1,413
Analog	963	1,127	1,352	1,533	1,696	2,346
Total Discrete	969	1,207	1,377	1,516	1,594	1,915
Total Optoelectronic	211	264	281	306	367	420

Source: Dataquest (May 1991)

Table 5b
European Semiconductor Consumption
(Millions of Dollars)

Company:	All
Product:	Each
Region of Consumption:	Europe
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR (%) 85-90
Total Including Captives	-.5	15.8	16.0	29.6	14.9	8.5	16.8
North American Captives	12.1	6.9	11.4	13.5	15.8	-4.6	8.4
Total Semiconductor	-1.4	16.5	16.3	30.7	14.9	9.3	17.3
Total IC	-3.1	13.9	17.6	37.8	16.9	6.8	18.2
Bipolar Digital	-3.0	.0	1.1	6.2	-17.1	-9.8	-4.3
Memory	4.2	-2.0	-40.1	-15.9	-2.7	-19.4	-17.3
Logic	-4.7	.5	11.7	9.2	-18.6	-8.6	-1.8
MOS Digital	-8.9	17.4	21.6	58.1	25.1	-1.0	22.8
Memory	-24.4	9.1	5.0	110.4	41.8	-15.5	23.7
Micro	3.2	18.1	40.2	50.6	21.2	25.0	30.5
Logic	5.4	25.8	24.8	23.0	6.3	-1.9	15.0
Analog	11.1	17.0	20.0	13.4	10.6	38.3	19.5
Total Discrete	2.9	24.6	14.1	10.1	5.1	20.1	14.6
Total Optoelectronic	10.5	25.1	6.4	8.9	19.9	14.4	14.8

Source: Dataquest (May 1991)

Table 5c
European Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Europe
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Including Captives	13,030	15,305	18,367	20,508	21,983	41,690
North American Captives	756	889	1,054	1,182	1,219	2,050
Total Semiconductor	12,274	14,416	17,313	19,326	20,764	39,640
Total IC	9,634	11,542	14,002	15,818	17,138	34,417
Bipolar Digital	571	540	500	458	403	268
Memory	57	52	50	40	32	17
Logic	514	488	450	418	371	251
MOS Digital	6,462	8,155	10,264	11,703	12,757	28,000
Memory	2,570	3,346	4,293	4,667	5,140	11,269
Micro	2,225	2,873	3,706	4,447	4,847	11,762
Logic	1,667	1,936	2,265	2,589	2,770	4,969
Analog	2,601	2,847	3,238	3,657	3,978	6,149
Total Discrete	2,178	2,370	2,755	2,894	2,981	4,280
Total Optoelectronic	462	504	556	614	645	943

Source: Dataquest (May 1991)

Table 5d
European Semiconductor Consumption
(Percent Change)

Company: All
Product: Each
Region of Consumption: Europe
Distribution Channel: All
Application: All
Specification: All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	16.1	17.5	20.0	11.7	7.2	14.4	13.7
North American Captives	33.6	17.6	18.6	12.1	3.1	16.6	11.0
Total Semiconductor	15.1	17.5	20.1	11.6	7.4	14.3	13.8
Total IC	15.7	19.8	21.3	13.0	8.3	15.5	15.0
Bipolar Digital	-1.0	-5.4	-7.4	-8.4	-12.0	-6.9	-7.8
Memory	-1.7	-8.8	-3.8	-20.0	-20.0	-11.2	-11.9
Logic	-1.0	-5.1	-7.8	-7.1	-11.2	-6.5	-7.5
MOS Digital	19.6	26.2	25.9	14.0	9.0	18.7	17.0
Memory	19.3	30.2	28.3	8.7	10.1	19.0	17.0
Micro	21.2	29.1	29.0	20.0	9.0	21.4	19.4
Logic	18.0	16.1	17.0	14.3	7.0	14.4	12.4
Analog	10.9	9.5	13.7	12.9	8.8	11.1	9.1
Total Discrete	13.7	8.8	16.2	5.0	3.0	9.3	7.5
Total Optoelectronic	10.0	9.1	10.3	10.4	5.0	9.0	7.9

Source: Dataquest (May 1991)

Table 6a
Asia/Pacific-Rest of World Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Asia/ROW
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Including Captives	1,979	2,548	3,968	5,752	6,524	7,670
North American Captives	0	0	0	0	0	0
Total Semiconductor	1,979	2,548	3,968	5,752	6,524	7,670
Total IC	1,195	1,714	2,898	4,457	5,275	6,203
Bipolar Digital	215	281	411	510	419	411
Memory	15	23	35	32	19	22
Logic	200	258	376	478	400	389
MOS Digital	616	871	1,550	2,517	3,387	4,065
Memory	134	185	437	1,173	1,658	1,670
Micro	117	185	389	652	933	1,459
Logic	365	501	724	692	796	936
Analog	364	562	937	1,430	1,469	1,727
Total Discrete	693	739	943	1,138	1,064	1,259
Total Optoelectronic	91	95	127	157	185	208

Source: Dataquest (May 1991)

Table 6b
Asia/Pacific-Rest of World Semiconductor Consumption
(Millions of Dollars)

Company:	All
Product:	Each
Region of Consumption:	Asia/ROW
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR (%) 85-90
Total Including Captives	-9.3	28.8	55.7	45.0	13.4	17.6	31.1
North American Captives	NM	NM	NM	NM	NM	NM	NM
Total Semiconductor	-9.3	28.8	55.7	45.0	13.4	17.6	31.1
Total IC	-6.7	43.4	69.1	53.8	18.4	17.6	39.0
Bipolar Digital	-20.1	30.7	46.3	24.1	-17.8	-1.9	13.8
Memory	-42.3	53.3	52.2	-8.6	-40.6	15.8	8.0
Logic	-17.7	29.0	45.7	27.1	-16.3	-2.8	14.2
MOS Digital	-12.0	41.4	78.0	62.4	34.6	20.0	45.8
Memory	-42.7	38.1	136.2	168.4	41.3	.7	65.6
Micro	-19.3	58.1	110.3	67.6	43.1	56.4	65.6
Logic	13.7	37.3	44.5	-4.4	15.0	17.6	20.7
Analog	16.7	54.4	66.7	52.6	2.7	17.6	36.5
Total Discrete	-11.7	6.6	27.6	20.7	-6.5	18.3	12.7
Total Optoelectronic	-20.9	4.4	33.7	23.6	17.8	12.4	18.0

NM = Not meaningful

Source: Dataquest (May 1991)

Table 6c
Asia/Pacific-Rest of World Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region of Consumption: Asia/ROW
Distribution Channel: All
Application: All
Specification: All

	1991	1992	1993	1994	1995	2000
Total Including Captives	8,834	10,625	13,025	14,804	16,004	32,377
North American Captives	0	0	0	0	0	0
Total Semiconductor	8,834	10,625	13,025	14,804	16,004	32,377
Total IC	7,232	8,884	11,020	12,572	13,738	29,107
Bipolar Digital	402	393	392	382	374	332
Memory	12	11	9	7	6	1
Logic	390	382	383	375	368	331
MOS Digital	4,857	6,098	7,714	8,693	9,418	20,513
Memory	1,717	2,107	2,708	3,093	3,331	6,076
Micro	2,055	2,635	3,305	3,741	4,081	10,501
Logic	1,085	1,356	1,701	1,859	2,006	3,936
Analog	1,973	2,393	2,914	3,497	3,946	8,262
Total Discrete	1,374	1,493	1,710	1,892	1,892	2,643
Total Optoelectronic	228	248	295	340	374	627

Source: Dataquest (May 1991)

Table 6d
Asia/Pacific-Rest of World Semiconductor Consumption
(Percent Change)

Company: All
Product: Each
Region of Consumption: Asia/ROW
Distribution Channel: All
Application: All
Specification: All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Including Captives	15.2	20.3	22.6	13.7	8.1	15.8	15.1
North American Captives	NM	NM	NM	NM	NM	NM	NM
Total Semiconductor	15.2	20.3	22.6	13.7	8.1	15.8	15.1
Total IC	16.6	22.8	24.0	14.1	9.3	17.2	16.2
Bipolar Digital	-2.2	-2.2	-.3	-2.6	-2.1	-1.9	-2.4
Memory	-45.5	-8.3	-18.2	-22.2	-14.3	-22.9	-30.1
Logic	.3	-2.1	.3	-2.1	-1.9	-1.1	-2.1
MOS Digital	19.5	25.6	26.5	12.7	8.3	18.3	16.8
Memory	2.8	22.7	28.5	14.2	7.7	14.8	12.8
Micro	40.8	28.2	25.4	13.2	9.1	22.8	20.8
Logic	15.9	25.0	25.4	9.3	7.9	16.5	14.4
Analog	14.2	21.3	21.8	20.0	12.8	18.0	15.9
Total Discrete	9.1	8.7	14.5	10.6	.0	8.5	6.9
Total Optoelectronic	9.6	8.8	19.0	15.3	10.0	12.5	10.9

NM = Not meaningful

Source: Dataquest (May 1991)

Table 7a
Worldwide Semiconductor Average Selling Prices
(Factory ASP in U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Semiconductor	.30	.34	.33	.42	.42	.39
Total IC	1.05	1.09	1.18	1.32	1.45	1.33
Bipolar Digital	.71	.71	.69	.70	.70	.68
Memory						
Logic						
MOS Digital	1.64	1.63	1.94	2.38	2.65	2.32
Memory	2.59	2.41	3.09	4.87	5.88	4.43
Micro	3.14	3.13	3.56	4.15	3.77	4.28
Logic	.93	.99	1.12	1.13	1.13	1.06
Analog	.76	.84	.82	.72	.70	.70
Total Discrete	.08	.09	.08	.09	.08	.08
Total Optoelectronic	.22	.25	.28	.34	.27	.29

Source: Dataquest (May 1991)

Table 7b
Worldwide Semiconductor Average Selling Prices
(Percent Change in Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR 85-90
Total Semiconductor	-15.7	13.2	-2.7	24.8	-.3	-5.1	5.4
Total IC	-4.4	3.5	8.5	11.6	10.0	-8.4	4.8
Bipolar Digital	9.2	.0	-2.8	1.4	.0	-2.9	-.9
Memory							
Logic							
MOS Digital	-16.0	-.5	18.6	23.0	11.5	-12.6	7.2
Memory	-33.6	-6.9	28.2	57.6	20.7	-24.7	11.3
Micro	-11.0	-.3	13.7	16.6	-9.2	13.5	6.4
Logic	9.4	6.5	13.1	.9	.0	-6.2	2.7
Analog	1.3	10.5	-2.4	-12.2	-2.8	.0	-1.6
Total Discrete	-11.1	15.0	-13.0	12.5	-11.1	.0	.0
Total Optoelectronic	-21.4	13.6	12.0	21.4	-20.6	7.4	5.7

Source: Dataquest (May 1991)

Table 7c
Worldwide Semiconductor Average Selling Prices
(Factory ASP in U.S. Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Semiconductor	.41	.44	.47	.48	.49	.64
Total IC	1.40	1.53	1.65	1.62	1.63	2.00
Bipolar Digital	.70	.71	.72	.70	.69	.69
Memory						
Logic						
MOS Digital	2.46	2.79	3.17	3.08	3.18	4.02
Memory	4.86	6.07	7.34	8.10	9.00	17.56
Micro	4.36	4.43	4.49	4.35	4.29	4.34
Logic	1.12	1.24	1.41	1.30	1.32	1.54
Analog	.71	.71	.70	.68	.67	.68
Total Discrete	.08	.08	.08	.08	.08	.08
Total Optoelectronic	.29	.29	.29	.29	.29	.29

Source: Dataquest (May 1991)

Table 7d
Worldwide Semiconductor Average Selling Prices
(Percent Change in Dollars)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Semiconductor	3.2	8.7	5.7	2.4	3.3	4.6	5.2
Total IC	5.6	9.2	7.5	-2.0	.8	4.1	4.1
Bipolar Digital	2.9	1.4	1.4	-2.8	-1.4	.3	.0
Memory							
Logic							
MOS Digital	6.0	13.3	13.7	-2.8	3.1	6.5	4.8
Memory	9.7	24.9	20.9	10.4	11.1	15.2	14.3
Micro	1.9	1.6	1.4	-3.1	-1.4	.0	.2
Logic	5.7	10.7	13.7	-7.8	1.5	4.5	3.1
Analog	1.4	.0	-1.4	-2.9	-1.5	-.9	.3
Total Discrete	.0	.0	.0	.0	.0	.0	.0
Total Optoelectronic	.0	.0	.0	.0	.0	.0	.0

Source: Dataquest (May 1991)

Table 8a
Worldwide Semiconductor Unit Shipments
(Millions of Units)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990
Total Semiconductor	80,380	89,881	114,551	122,085	137,808	147,757
Total IC	17,607	21,654	25,260	31,098	32,303	35,553
Bipolar Digital	5,172	6,092	6,899	7,429	6,443	6,529
Memory						
Logic						
MOS Digital	6,171	7,850	9,028	11,336	12,446	13,923
Memory	1,475	1,872	1,960	2,401	2,782	2,955
Micro	875	1,115	1,435	1,721	2,176	2,352
Logic	3,820	4,864	5,633	7,214	7,488	8,616
Analog	6,264	7,712	9,334	12,333	13,414	15,101
Total Discrete	57,200	62,283	83,188	84,578	95,775	102,938
Total Optoelectronic	5,573	5,944	6,104	6,409	9,730	9,266

Source: Dataquest (May 1991)

Table 8b
Worldwide Semiconductor Unit Shipments
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1985	1986	1987	1988	1989	1990	CAGR 85-90
Total Semiconductor	.0	11.8	27.4	6.6	12.9	7.2	12.9
Total IC	-14.4	23.0	16.7	23.1	3.9	10.1	15.1
Bipolar Digital	-29.5	17.8	13.2	7.7	-13.3	1.3	4.8
Memory							
Logic							
MOS Digital	-7.1	27.2	15.0	25.6	9.8	11.9	17.7
Memory	-7.6	26.9	4.7	22.5	15.9	6.2	14.9
Micro	-4.5	27.4	28.7	20.0	26.4	8.1	21.9
Logic	-7.4	27.3	15.8	28.1	3.8	15.1	17.7
Analog	-5.0	23.1	21.0	32.1	8.8	12.6	19.2
Total Discrete	3.2	8.9	33.6	1.7	13.2	7.5	12.5
Total Optoelectronic	26.9	6.7	2.7	5.0	51.8	-4.8	10.7

Source: Dataquest (May 1991)

Table 8c
Worldwide Semiconductor Unit Shipments
(Millions of Units)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	2000
Total Semiconductor	162,794	174,510	192,080	207,313	213,438	291,457
Total IC	38,522	41,864	45,791	51,921	55,118	82,282
Bipolar Digital	6,606	6,575	6,504	6,400	6,168	4,742
Memory						
Logic						
MOS Digital	15,339	16,614	17,557	20,211	21,072	32,399
Memory	3,081	3,097	3,134	3,220	3,143	3,240
Micro	2,779	3,365	3,990	4,615	5,036	10,154
Logic	9,479	10,152	10,433	12,376	12,893	19,005
Analog	16,577	18,675	21,730	25,310	27,878	45,141
Total Discrete	113,900	121,425	134,013	141,775	143,913	188,075
Total Optoelectronic	10,372	11,221	12,276	13,617	14,407	21,100

Source: Dataquest (May 1991)

Table 8d
Worldwide Semiconductor Unit Shipments
(Percent Change)

Company:	All
Product:	Each
Region of Consumption:	Worldwide
Distribution Channel:	All
Application:	All
Specification:	All

	1991	1992	1993	1994	1995	CAGR 90-95	CAGR 95-00
Total Semiconductor	10.2	7.2	10.1	7.9	3.0	7.6	6.4
Total IC	8.4	8.7	9.4	13.4	6.2	9.2	8.3
Bipolar Digital	1.2	-.5	-1.1	-1.6	-3.6	-1.1	-5.1
Memory							
Logic							
MOS Digital	10.2	8.3	5.7	15.1	4.3	8.6	9.0
Memory	4.3	.5	1.2	2.7	-2.4	1.2	.6
Micro	18.2	21.1	18.6	15.7	9.1	16.4	15.1
Logic	10.0	7.1	2.8	18.6	4.2	8.4	8.1
Analog	9.8	12.7	16.4	16.5	10.1	13.0	10.1
Total Discrete	10.6	6.6	10.4	5.8	1.5	6.9	5.5
Total Optoelectronic	11.9	8.2	9.4	10.9	5.8	9.2	7.9

Source: Dataquest (May 1991)

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Revised

Final Worldwide Semiconductor Market Share Estimates
1990

Source: Dataquest

Semiconductor Procurement

Dataquest

Final Worldwide Semiconductor Market Share Estimates 1990

Source: Dataquest

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Chapter 1

Final Worldwide Semiconductor Market Share Estimates

These market share estimates provide our final estimates of 1990. The tables cover history for the period 1988 to 1990 for the major categories of semiconductors.

Background

An integral part of Dataquest's Semiconductor industry service database is analyzing the semiconductor markets by estimating each manufacturer's market share. These analyses provide insights into semiconductor markets and reinforce estimates of consumption, production, and company revenue that were made using other data. An index of all tables is included for easy reference. Information on further product detail may be requested through the client inquiry privilege.

The semiconductor market is divided among North American companies, Japanese companies, European companies, and Asia/Pacific companies, based on the location of their main offices. All of the major companies are included in this database.

The totals given for each company reflect worldwide production. For example, although Texas Instruments manufactures semiconductors in many parts of the world, its entire production is included under the North American companies market share section. In contrast, some, but not all, foreign-owned subsidiaries are included in the North American totals and not in the total of the parent company location. For example, Exar, a subsidiary of the Japanese company Rohm, is included as a North American company. On the other hand, revenue for Signetics is included under Philips, a European company. The total for North American companies, therefore, is not the same as for North American semiconductor production.

Merchant versus Captive Consumption

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

Hybrid Circuits

Hybrid integrated circuits, while primarily a special packaging arrangement, are included in Table 15, under Analog ICs. Only those hybrids are included that are made in the division or other organization whose primary product is semiconductors. Several major manufacturers also manufacture hybrids in other divisions; where we have identified these manufacturers, they are excluded. A split between monolithics and hybrid analog circuits is available through the client inquiry service.

Exchange Rate Conventions

Estimates of Japanese consumption or factory shipments use the exchange rate (dollar/yen) for the given year. Refer to Table 0 for the exchange rates used. In viewing the year-to-year Japanese market growth rate, one must consider the different exchange rates in effect during the year. For the European market, the value of shipments is estimated directly in dollars.

Data Sources

In both the United States and Europe, there is no official body—government organization, industry association, or trade publication—that maintains complete or even near-complete statistics on the semiconductor industry. In Japan, some statistics are kept by MITI. We believe that the estimates presented here are the most accurate and meaningful generally available today. The sources of the data presented in the tables are as follows:

- Revenue published by major industry participants

- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data such as those from WSTS, MITI, and EIA
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant projected world economic data

Need for Careful Interpretation

Construction of the tables involves combining data from many countries, each of which has different and changing exchange rates. Dataquest uses average exchange rates for each year and, as far as possible, the estimates are prepared in terms of local currencies before conversion to U.S. dollars or yen.

Despite the care taken in gathering and analyzing the available data and in attempting to categorize those data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in these tables. 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 these data and those provided by others.

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Table 0

Yen per U.S. Dollar Exchange Rates

Year	Exchange Rate
1988	130
1989	138
1990	144

Source: International Monetary Fund, Far Eastern Economic Review, Dataquest (May 1991)

Notes to Market Share Tables

1. ABB-HAFO was formerly known as ASEA Brown Boveri.
2. ABB-IXYS was formerly the West German-based power semiconductor division of ASEA Brown Boveri.
3. Allegro MicroSystems was formerly known as Sprague Technologies.
4. Appian Technology was formerly known as ZyMOS.
5. Ericsson was known as Rifa prior to March 1, 1988.
6. GEC Plessey revenue includes MEDL and Plessey revenue from 1990 onward.
7. Harris revenue includes GE Solid State revenue from 1989 onward.
8. Inmos revenue is included in SGS-Thomson revenue from 1989 onward.
9. Matra MHS was formerly known as Matra-Harris Semiconducteurs.
10. Philips revenue includes Signetics revenue.
11. Plessey revenue includes Ferranti revenue from 1987 onward.
12. SGS-Thomson revenue includes Inmos revenue from 1989 onward.
13. Thomson Composants Militaires et Spatiaux (TMS) revenue was formerly included in SGS-Thomson (30 percent) and the Other European Companies category (70 percent).
14. Vertex was formerly known as Integrated CMOS Systems.
15. VQSI was formerly known as Varo.
16. Micro Quality Semiconductor was formerly known as VQSI.
17. In 1989, AT&T revenue previously classified as MOS logic was reclassified as microcomponent.
18. In 1989, Rockwell revenue previously classified as MOS logic was reclassified as analog.
19. Prior to 1989, Sanyo revenue was understated.
20. Collection of BiCMOS revenue data began in 1987.

Table 1
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company: Each
Product: Total Semiconductor
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	50,859	57,213	58,225	100.0	100.0	100.0
North American Companies	18,586	19,978	21,537	36.5	34.9	37.0
Acrian	21	26	0	.0	.0	.0
Actel	NA	7	21	NA	.0	.0
Advanced Micro Devices	1,084	1,100	1,053	2.1	1.9	1.8
Allegro MicroSystems	120	137	116	.2	.2	.2
Altera	37	59	78	.1	.1	.1
Anadigics	NA	NA	5	NA	NA	.0
Analog Devices	360	357	381	.7	.6	.7
Appian Technology	27	37	50	.1	.1	.1
Applied Micro Circuits Corp.	28	22	28	.1	.0	.0
AT&T	859	873	861	1.7	1.5	1.5
Atmel	NA	94	123	NA	.2	.2
Bipolar Integrated Technology	6	1	1	.0	.0	.0
Brooktree	NA	52	70	NA	.1	.1
Burr-Brown	144	141	145	.3	.2	.2
California Micro Devices	28	30	27	.1	.1	.0
Catalyst	5	31	36	.0	.1	.1
Cherry Semiconductor	33	32	36	.1	.1	.1
Chips & Technologies	160	240	265	.3	.4	.5
Cirrus Logic	NA	29	130	NA	.1	.2
CID Technologies	NA	NA	4	NA	NA	.0
Comlinear	NA	10	13	NA	.0	.0
Crystal	NA	12	15	NA	.0	.0
Cypress Semiconductor	135	196	223	.3	.3	.4
Dallas Semiconductor	NA	13	17	NA	.0	.0
Dalsa Inc.	NA	NA	3	NA	NA	.0
Eastman Kodak	NA	NA	3	NA	NA	.0
Elantec	NA	12	13	NA	.0	.0
Exar	47	49	75	.1	.1	.1
Exel	0	1	0	.0	.0	.0
Fairchild-Loral	NA	NA	1	NA	NA	.0
Ford Aerospace-Loral	NA	NA	1	NA	NA	.0
General Electric	555	0	0	1.1	.0	.0
General Instrument	164	170	214	.3	.3	.4

(Continued)

Table 1 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
Gennum	NA	20	18	NA	.0	.0
Gould AMI	101	117	90	.2	.2	.2
Harris	329	830	800	.6	1.5	1.4
Hewlett-Packard	270	269	509	.5	.5	.9
Holt	9	9	10	.0	.0	.0
Honeywell	182	56	49	.4	.1	.1
Hughes	47	37	44	.1	.1	.1
IC Sensors	NA	7	6	NA	.0	.0
IMI	15	15	15	.0	.0	.0
Inova	NA	21	10	NA	.0	.0
Integrated Device Technology	171	204	199	.3	.4	.3
Intel	2,350	2,430	3,171	4.6	4.2	5.4
International CMOS Technology	NA	9	14	NA	.0	.0
Int'l. Microelectronic Prod.	47	53	56	.1	.1	.1
International Rectifier	192	190	225	.4	.3	.4
ITT	360	390	371	.7	.7	.6
Kulite	NA	25	28	NA	.0	.0
Lattice	22	31	62	.0	.1	.1
Linear Technology	59	70	83	.1	.1	.1
LSI Logic	375	512	598	.7	.9	1.0
Macronix	NA	31	7	NA	.1	.0
Maxim	35	43	65	.1	.1	.1
MCE	NA	NA	4	NA	NA	.0
Micrel	NA	NA	5	NA	NA	.0
Micro Linear	24	28	45	.0	.0	.1
Micro Power Systems	26	21	24	.1	.0	.0
Micro Quality Semiconductor	0	2	0	.0	.0	.0
Microchip Technology	111	124	85	.2	.2	.1
Micron Technology	331	395	286	.7	.7	.5
Microsemi	NA	NA	50	NA	NA	.1
Mitel	43	54	47	.1	.1	.1
MOSel	12	20	31	.0	.0	.1
Motorola	3,035	3,319	3,694	6.0	5.8	6.3
National Semiconductor	1,650	1,618	1,719	3.2	2.8	3.0
NCR	132	120	145	.3	.2	.2
Novasensor Inc.	NA	NA	12	NA	NA	.0
Optek	NA	77	66	NA	.1	.1
Pacific Monolithics	NA	NA	7	NA	NA	.0
Performance Semiconductor	NA	32	51	NA	.1	.1
Plus Logic	0	0	1	.0	.0	.0
Powerex	115	105	112	.2	.2	.2
Precision Monolithics	85	88	91	.2	.2	.2
Quality Technologies	40	38	34	.1	.1	.1
Raytheon	99	96	84	.2	.2	.1

(Continued)

Table 1 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
Rockwell	174	165	200	.3	.3	.3
Saratoga Semiconductor	10	10	0	.0	.0	.0
Seagate Micro-Electronics	NA	NA	9	NA	NA	.0
SEEQ Technology	60	53	45	.1	.1	.1
Semtech	NA	NA	18	NA	NA	.0
Sensym	NA	NA	6	NA	NA	.0
Sierra Semiconductor	47	55	61	.1	.1	.1
Signal Processing Technology	NA	NA	5	NA	NA	.0
Silicon General	35	36	36	.1	.1	.1
Silicon Systems	125	112	165	.2	.2	.3
Siliconix	131	121	116	.3	.2	.2
Sipex	NA	22	21	NA	.0	.0
Solitron	46	37	33	.1	.1	.1
Standard Microsystems	41	42	49	.1	.1	.1
Supertex	21	23	27	.0	.0	.0
Tektronix	NA	NA	40	NA	NA	.1
Teledyne	35	23	25	.1	.0	.0
Texas Instruments	2,741	2,787	2,574	5.4	4.9	4.4
TRW	61	27	28	.1	.0	.0
Unitrode	113	109	104	.2	.2	.2
Universal	10	13	14	.0	.0	.0
Vertex	NA	11	8	.0	.0	.0
Vitelic	40	66	64	.1	.1	.1
VLSI Technology	221	286	324	.4	.5	.6
VQSI	21	0	0	.0	.0	.0
VTC Inc.	46	44	40	.1	.1	.1
WaferScale Integration	35	35	33	.1	.1	.1
Weitek	35	49	58	.1	.1	.1
Western Digital	100	135	148	.2	.2	.3
Xicor	90	90	71	.2	.2	.1
Xilinx	27	44	84	.1	.1	.1
Zilog	90	99	100	.2	.2	.2
Other North American Companies	151	247	0	.3	.4	.0
Japanese Companies	25,942	29,809	28,377	51.0	52.1	48.7
Fuji Electric	346	362	385	.7	.6	.7
Fujitsu	2,607	2,963	2,880	5.1	5.2	4.9
Hitachi	3,506	3,974	3,893	6.9	6.9	6.7
Matsushita	1,883	1,882	1,942	3.7	3.3	3.3
Mitsubishi	2,312	2,579	2,319	4.5	4.5	4.0
NEC	4,543	5,015	4,898	8.9	8.8	8.4
New JRC	169	171	178	.3	.3	.3
NMB Semiconductor	199	247	201	.4	.4	.3
Oki	947	1,154	1,074	1.9	2.0	1.8

(Continued)

Table 1 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Ricoh	85	91	96	.2	.2	.2
Rohm	721	740	774	1.4	1.3	1.3
Sanken	383	387	407	.8	.7	.7
Sanyo	1,083	1,365	1,381	2.1	2.4	2.4
Seiko Epson	311	368	213	.6	.6	.4
Sharp	1,036	1,230	1,325	2.0	2.1	2.3
Shindengen Electric	NA	NA	209	NA	NA	.4
Sony	950	1,077	1,146	1.9	1.9	2.0
Toko	NA	NA	60	NA	NA	.1
Toshiba	4,395	4,930	4,843	8.6	8.6	8.3
Yamaha	151	143	153	.3	.2	.3
Other Japanese Companies	315	1,131	0	.6	2.0	.0
European Companies	4,917	5,443	6,206	9.7	9.5	10.7
ABB-HAFO	113	37	42	.2	.1	.1
ABB-IXYS	0	50	58	.0	.1	.1
Austria Mikro Systeme	44	56	59	.1	.1	.1
Ericsson	52	54	56	.1	.1	.1
Eupec	0	0	96	.0	.0	.2
European Silicon Structures	13	18	27	.0	.0	.0
Eurosil	29	30	39	.1	.1	.1
Fagor	27	29	30	.1	.1	.1
GEC Plessey	0	0	390	.0	.0	.7
Inmos	110	0	0	.2	.0	.0
Matra MHS	71	85	100	.1	.1	.2
MEDL	51	60	0	.1	.1	.0
Mietec	42	52	92	.1	.1	.2
Philips	1,738	1,716	2,011	3.4	3.0	3.5
Plessey	284	240	0	.6	.4	.0
Semikron	91	95	106	.2	.2	.2
SGS-Thomson	1,087	1,301	1,463	2.1	2.3	2.5
Siemens	784	1,194	1,224	1.5	2.1	2.1
STC	22	19	24	.0	.0	.0
TAG	23	22	25	.0	.0	.0
Telefunken Electronic	289	299	295	.6	.5	.5
TMS	0	45	45	.0	.1	.1
Zetex	0	0	24	.0	.0	.0
Other European Companies	47	41	0	.1	.1	.0
Asia/Pacific Companies	1,414	1,983	2,105	2.8	3.5	3.6
AMPi	NA	NA	7	NA	NA	.0
Daewoo	7	10	12	.0	.0	.0
ERSO	NA	NA	1	NA	NA	.0
Goldstar	137	148	163	.3	.3	.3

(Continued)

Table 1 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Asia/Pacific Companies (Continued)						
Hi-Sincerity	NA	NA	5	NA	NA	.0
Hualon Microelectronics Corp.	NA	NA	50	NA	NA	.1
Hyundai	106	210	115	.2	.4	.2
Korean Electronic Co.	95	105	114	.2	.2	.2
Kingbright	NA	NA	7	NA	NA	.0
Ledtech Electronics	NA	NA	7	NA	NA	.0
Liteon	NA	NA	6	NA	NA	.0
MOSpec	NA	NA	11	NA	NA	.0
Samsung	905	1,260	1,315	1.8	2.2	2.3
United Microelectronics	106	210	150	.2	.4	.3
Winbond	NA	NA	50	NA	NA	.1
Other Asia/Pacific Companies	58	40	58	.1	.1	.1

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 2
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company: Each
Product: Total Integrated Circuit
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	41,068	46,924	47,303	100.0	100.0	100.0
North American Companies	15,990	17,400	18,877	38.9	37.1	39.9
Actel	NA	7	21	NA	.0	.0
Advanced Micro Devices	1,084	1,100	1,053	2.6	2.3	2.2
Allegro MicroSystems	102	114	98	.2	.2	.2
Altera	37	59	78	.1	.1	.2
Anadigics	NA	NA	5	NA	NA	.0
Analog Devices	360	357	380	.9	.8	.8
Appian Technology	27	37	50	.1	.1	.1
Applied Micro Circuits Corp.	28	22	28	.1	.0	.1
AT&T	688	716	717	1.7	1.5	1.5
Atmel	NA	94	123	NA	.2	.3
Bipolar Integrated Technology	6	1	1	.0	.0	.0
Brooktree	NA	52	70	NA	.1	.1
Burr-Brown	144	141	145	.4	.3	.3
California Micro Devices	28	30	27	.1	.1	.1
Catalyst	5	31	36	.0	.1	.1
Cherry Semiconductor	33	32	36	.1	.1	.1
Chips & Technologies	160	240	265	.4	.5	.6
Cirrus Logic	NA	29	130	NA	.1	.3
Comlinear	NA	10	13	NA	.0	.0
Crystal	NA	12	15	NA	.0	.0
Cypress Semiconductor	135	196	223	.3	.4	.5
Dallas Semiconductor	NA	13	17	NA	.0	.0
Elantec	NA	12	13	NA	.0	.0
Exar	47	49	75	.1	.1	.2
Exel	0	1	0	.0	.0	.0
General Electric	389	0	0	.9	.0	.0
Gennum	NA	20	18	NA	.0	.0
Gould AMI	101	117	90	.2	.2	.2
Harris	329	692	655	.8	1.5	1.4
Hewlett-Packard	0	0	230	.0	.0	.5
Holt	9	9	10	.0	.0	.0
Honeywell	142	25	24	.3	.1	.1
Hughes	47	37	42	.1	.1	.1

(Continued)

Table 2 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
IC Sensors	NA	7	6	NA	.0	.0
IMI	15	15	15	.0	.0	.0
Inova	NA	21	10	NA	.0	.0
Integrated Device Technology	171	204	199	.4	.4	.4
Intel	2,350	2,430	3,171	5.7	5.2	6.7
International CMOS Technology	NA	9	14	NA	.0	.0
Int'l. Microelectronic Prod.	47	53	56	.1	.1	.1
International Rectifier	0	3	1	.0	.0	.0
ITT	214	235	210	.5	.5	.4
Kulite	NA	25	28	NA	.1	.1
Lattice	22	31	62	.1	.1	.1
Linear Technology	59	70	83	.1	.1	.2
LSI Logic	375	512	598	.9	1.1	1.3
Macronix	NA	31	7	NA	.1	.0
Maxim	35	43	65	.1	.1	.1
MCE	NA	NA	4	NA	NA	.0
Micrel	NA	NA	5	NA	NA	.0
Micro Linear	24	28	45	.1	.1	.1
Micro Power Systems	26	21	24	.1	.0	.1
Microchip Technology	111	124	85	.3	.3	.2
Micron Technology	331	395	286	.8	.8	.6
Mitel	43	54	47	.1	.1	.1
MOSel	12	20	31	.0	.0	.1
Motorola	2,259	2,519	2,860	5.5	5.4	6.0
National Semiconductor	1,575	1,548	1,649	3.8	3.3	3.5
NCR	132	120	145	.3	.3	.3
Novasensor Inc.	NA	NA	12	NA	NA	.0
Pacific Monolithics	NA	NA	7	NA	NA	.0
Performance Semiconductor	NA	32	51	NA	.1	.1
Plus Logic	0	0	1	.0	.0	.0
Precision Monolithics	85	88	91	.2	.2	.2
Raytheon	84	82	74	.2	.2	.2
Rockwell	174	165	200	.4	.4	.4
Saratoga Semiconductor	10	10	0	.0	.0	.0
Seagate Micro-Electronics	NA	NA	9	NA	NA	.0
SEEQ Technology	60	53	45	.1	.1	.1
Semtech	NA	NA	2	NA	NA	.0
Sensym	NA	NA	6	NA	NA	.0
Sierra Semiconductor	47	55	61	.1	.1	.1
Signal Processing Technology	NA	NA	5	NA	NA	.0
Silicon General	35	36	36	.1	.1	.1
Silicon Systems	125	112	165	.3	.2	.3
Siliconix	70	54	54	.2	.1	.1
Sipex	NA	22	21	NA	.0	.0

(Continued)

Table 2 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
Solitron	13	10	9	.0	.0	.0
Standard Microsystems	41	42	49	.1	.1	.1
Supertex	11	15	19	.0	.0	.0
Tektronix	NA	NA	35	NA	NA	.1
Teledyne	35	23	22	.1	.0	.0
Texas Instruments	2,637	2,691	2,488	6.4	5.7	5.3
TRW	25	27	28	.1	.1	.1
Unitrode	51	50	50	.1	.1	.1
Universal	10	13	14	.0	.0	.0
Vertex	NA	11	8	.0	.0	.0
Vitelic	40	66	64	.1	.1	.1
VLSI Technology	221	286	324	.5	.6	.7
VTC Inc.	46	44	40	.1	.1	.1
WaferScale Integration	35	35	33	.1	.1	.1
Weitek	35	49	57	.1	.1	.1
Western Digital	100	135	148	.2	.3	.3
Xicor	90	90	71	.2	.2	.2
Xilinx	27	44	84	.1	.1	.2
Zilog	90	99	100	.2	.2	.2
Other North American Companies	91	188	0	.2	.4	.0
Japanese Companies	20,375	23,800	22,129	49.6	50.7	46.8
Fuji Electric	64	74	80	.2	.2	.2
Fujitsu	2,420	2,738	2,639	5.9	5.8	5.6
Hitachi	2,729	3,218	3,182	6.6	6.9	6.7
Matsushita	1,328	1,244	1,243	3.2	2.7	2.6
Mitsubishi	1,975	2,185	1,940	4.8	4.7	4.1
NEC	3,884	4,321	4,207	9.5	9.2	8.9
New JRC	146	154	161	.4	.3	.3
NMB Semiconductor	199	247	201	.5	.5	.4
Oki	902	1,111	1,031	2.2	2.4	2.2
Ricoh	85	91	96	.2	.2	.2
Rohm	325	343	348	.8	.7	.7
Sanken	157	156	164	.4	.3	.3
Sanyo	811	975	979	2.0	2.1	2.1
Seiko Epson	311	368	213	.8	.8	.5
Sharp	751	902	986	1.8	1.9	2.1
Shindengen Electric	NA	NA	33	NA	NA	.1
Sony	621	732	791	1.5	1.6	1.7
Toko	NA	NA	54	NA	NA	.1
Toshiba	3,316	3,774	3,628	8.1	8.0	7.7
Yamaha	151	143	153	.4	.3	.3
Other Japanese Companies	200	1,024	0	.5	2.2	.0

(Continued)

Table 2 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue 1988	Revenue 1989	Revenue 1990	Market Share (%) 1988	Market Share (%) 1989	Market Share (%) 1990
European Companies	3,429	3,915	4,398	8.3	8.3	9.3
ABB-HAFO	28	23	24	.1	.0	.1
Austria Mikro Systeme	44	56	59	.1	.1	.1
Ericsson	52	54	56	.1	.1	.1
European Silicon Structures	13	18	27	.0	.0	.1
Eurosil	29	30	39	.1	.1	.1
GEC Plessey	0	0	354	.0	.0	.7
Inmos	110	0	0	.3	.0	.0
Matra MHS	71	85	100	.2	.2	.2
MEDL	29	39	0	.1	.1	.0
Mietec	42	52	92	.1	.1	.2
Philips	1,281	1,250	1,473	3.1	2.7	3.1
Plessey	237	240	0	.6	.5	.0
SGS-Thomson	833	1,019	1,148	2.0	2.2	2.4
Siemens	483	847	835	1.2	1.8	1.8
STC	21	17	22	.1	.0	.0
Telefunken Electronic	124	126	141	.3	.3	.3
TMS	0	33	28	.0	.1	.1
Other European Companies	32	26	0	.1	.1	.0
Asia/Pacific Companies	1,274	1,809	1,899	3.1	3.9	4.0
Daewoo	7	10	12	.0	.0	.0
ERSO	NA	NA	1	NA	NA	.0
Goldstar	136	147	163	.3	.3	.3
Hualon Microelectronics Corp.	NA	NA	50	NA	NA	.1
Hyundai	106	210	115	.3	.4	.2
Korean Electronic Co.	25	24	28	.1	.1	.1
Samsung	850	1,182	1,238	2.1	2.5	2.6
United Microelectronics	106	210	150	.3	.4	.3
Winbond	NA	NA	50	NA	NA	.1
Other Asia/Pacific Companies	44	26	58	.1	.1	.1

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 3
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Bipolar Digital
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	5,200	4,510	4,440	100.0	100.0	100.0
North American Companies	2,761	2,221	2,152	53.1	49.2	48.5
Advanced Micro Devices	536	474	407	10.3	10.5	9.2
Applied Micro Circuits Corp.	27	20	24	.5	.4	.5
AT&T	61	56	59	1.2	1.2	1.3
Atmel	NA	8	14	NA	.2	.3
Bipolar Integrated Technology	6	1	1	.1	.0	.0
Chips & Technologies	30	24	25	.6	.5	.6
Harris	62	50	60	1.2	1.1	1.4
Honeywell	27	0	0	.5	.0	.0
Intel	22	10	5	.4	.2	.1
Motorola	435	369	406	8.4	8.2	9.1
National Semiconductor	550	458	423	10.6	10.2	9.5
Raytheon	55	55	54	1.1	1.2	1.2
Teledyne	2	3	3	.0	.1	.1
Texas Instruments	940	671	663	18.1	14.9	14.9
TRW	0	7	8	.0	.2	.2
Other North American Companies	8	15	0	.2	.3	.0
Japanese Companies	1,791	1,755	1,843	34.4	38.9	41.5
Fujitsu	653	617	690	12.6	13.7	15.5
Hitachi	501	479	510	9.6	10.6	11.5
Matsushita	30	14	14	.6	.3	.3
Mitsubishi	127	125	105	2.4	2.8	2.4
NEC	292	302	295	5.6	6.7	6.6
New JRC	1	1	1	.0	.0	.0
Oki	38	48	47	.7	1.1	1.1
Rohm	0	0	1	.0	.0	.0
Sanyo	41	67	67	.8	1.5	1.5
Toshiba	108	102	113	2.1	2.3	2.5
European Companies	598	502	419	11.5	11.1	9.4
GEC Plessey	0	0	66	.0	.0	1.5
Philips	413	306	280	7.9	6.8	6.3
Plessey	94	122	0	1.8	2.7	.0

(Continued)

Table 3 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
European Companies (Continued)						
SGS-Thomson	20	7	10	.4	.2	.2
Siemens	36	54	45	.7	1.2	1.0
STC	7	4	11	.1	.1	.2
Telefunken Electronic	19	5	7	.4	.1	.2
Other European Companies	9	4	0	.2	.1	.0
Asia/Pacific Companies	50	32	26	1.0	.7	.6
Goldstar	32	32	26	.6	.7	.6
Other Asia/Pacific Companies	18	0	0	.3	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 4
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	TTL/Other
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	4,071	3,402	3,168	100.0	100.0	100.0
North American Companies	2,359	1,791	1,667	57.9	52.6	52.6
Advanced Micro Devices	524	401	306	12.9	11.8	9.7
AT&T	48	44	46	1.2	1.3	1.5
Chips & Technologies	30	24	25	.7	.7	.8
Harris	62	50	60	1.5	1.5	1.9
Intel	22	10	5	.5	.3	.2
Motorola	233	184	174	5.7	5.4	5.5
National Semiconductor	450	357	333	11.1	10.5	10.5
Raytheon	48	47	52	1.2	1.4	1.6
Teledyne	2	3	3	.0	.1	.1
Texas Instruments	940	671	663	23.1	19.7	20.9
Japanese Companies	1,208	1,176	1,159	29.7	34.6	36.6
Fujitsu	317	294	298	7.8	8.6	9.4
Hitachi	376	357	364	9.2	10.5	11.5
Matsushita	21	10	9	.5	.3	.3
Mitsubishi	127	125	105	3.1	3.7	3.3
NEC	184	195	193	4.5	5.7	6.1
New JRC	1	1	1	.0	.0	.0
NMB Semiconductor	1	0	0	.0	.0	.0
Oki	35	43	42	.9	1.3	1.3
Rohm	0	0	1	.0	.0	.0
Sanyo	41	67	67	1.0	2.0	2.1
Toshiba	105	84	79	2.6	2.5	2.5
European Companies	454	403	316	11.2	11.8	10.0
GEC Plessey	0	0	20	.0	.0	.6
Philips	393	290	266	9.7	8.5	8.4
Plessey	8	82	0	.2	2.4	.0
SGS-Thomson	20	7	10	.5	.2	.3
Siemens	8	16	13	.2	.5	.4
Telefunken Electronic	19	5	7	.5	.1	.2
Other European Companies	6	3	0	.1	.1	.0

(Continued)

Table 4 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Asia/Pacific Companies	50	32	26	1.2	.9	.8
Goldstar	32	32	26	.8	.9	.8
Other Asia/Pacific Companies	18	0	0	.4	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 5
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	ECL
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	1,130	1,108	1,272	100.0	100.0	100.0
North American Companies	402	430	485	35.6	38.8	38.1
Advanced Micro Devices	12	73	101	1.1	6.6	7.9
Applied Micro Circuits Corp.	27	20	24	2.4	1.8	1.9
AT&T	13	12	13	1.2	1.1	1.0
Atmel	NA	8	14	NA	.7	1.1
Bipolar Integrated Technology	6	1	1	.5	.1	.1
Honeywell	27	0	0	2.4	.0	.0
Motorola	202	185	232	17.9	16.7	18.2
National Semiconductor	100	101	90	8.8	9.1	7.1
Raytheon	7	8	2	.6	.7	.2
TRW	0	7	8	.0	.6	.6
Other North American Companies	8	15	0	.7	1.4	.0
Japanese Companies	584	579	684	51.7	52.3	53.8
Fujitsu	336	323	392	29.7	29.2	30.8
Hitachi	125	122	146	11.1	11.0	11.5
Matsushita	9	4	5	.8	.4	.4
NEC	108	107	102	9.6	9.7	8.0
Oki	3	5	5	.3	.5	.4
Toshiba	3	18	34	.3	1.6	2.7
European Companies	144	99	103	12.7	8.9	8.1
GEC Plessey	0	0	46	.0	.0	3.6
Philips	20	16	14	1.8	1.4	1.1
Plessey	86	40	0	7.6	3.6	.0
Siemens	28	38	32	2.5	3.4	2.5
STC	7	4	11	.6	.4	.9
Other European Companies	3	1	0	.3	.1	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 6
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Bipolar Digital Memory
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	689	540	459	100.0	100.0	100.0
North American Companies	213	167	130	30.9	30.9	28.3
Advanced Micro Devices	104	85	65	15.1	15.7	14.2
Harris	3	0	5	.4	.0	1.1
Motorola	7	4	3	1.0	.7	.7
National Semiconductor	35	56	29	5.1	10.4	6.3
Raytheon	14	12	18	2.0	2.2	3.9
Texas Instruments	50	10	10	7.3	1.9	2.2
Japanese Companies	417	326	284	60.5	60.4	61.9
Fujitsu	254	190	158	36.9	35.2	34.4
Hitachi	119	111	104	17.3	20.6	22.7
NEC	44	25	22	6.4	4.6	4.8
European Companies	59	47	45	8.6	8.7	9.8
Philips	58	47	45	8.4	8.7	9.8
Other European Companies	1	0	0	.1	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 7
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company: Each
Product: Bipolar Logic and Microcomponents
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	4,511	3,970	3,981	100.0	100.0	100.0
North American Companies	2,548	2,054	2,022	56.5	51.7	50.8
Advanced Micro Devices	432	389	342	9.6	9.8	8.6
Applied Micro Circuits Corp.	27	20	24	.6	.5	.6
AT&T	61	56	59	1.4	1.4	1.5
Atmel	NA	8	14	NA	.2	.4
Bipolar Integrated Technology	6	1	1	.1	.0	.0
Chips & Technologies	30	24	25	.7	.6	.6
Harris	59	50	55	1.3	1.3	1.4
Honeywell	27	0	0	.6	.0	.0
Intel	22	10	5	.5	.3	.1
Motorola	428	365	403	9.5	9.2	10.1
National Semiconductor	515	402	394	11.4	10.1	9.9
Raytheon	41	43	36	.9	1.1	.9
Teledyne	2	3	3	.0	.1	.1
Texas Instruments	890	661	653	19.7	16.6	16.4
TRW	0	7	8	.0	.2	.2
Other North American Companies	8	15	0	.2	.4	.0
Japanese Companies	1,374	1,429	1,559	30.5	36.0	39.2
Fujitsu	399	427	532	8.8	10.8	13.4
Hitachi	382	368	406	8.5	9.3	10.2
Matsushita	30	14	14	.7	.4	.4
Mitsubishi	127	125	105	2.8	3.1	2.6
NEC	248	277	273	5.5	7.0	6.9
New JRC	1	1	1	.0	.0	.0
Oki	38	48	47	.8	1.2	1.2
Rohm	0	0	1	.0	.0	.0
Sanyo	41	67	67	.9	1.7	1.7
Toshiba	108	102	113	2.4	2.6	2.8
European Companies	539	455	374	11.9	11.5	9.4
GEC Plessey	0	0	66	.0	.0	1.7
Philips	355	259	235	7.9	6.5	5.9
Plessey	94	122	0	2.1	3.1	.0

(Continued)

Table 7 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
European Companies (Continued)						
SGS-Thomson	20	7	10	.4	.2	.3
Siemens	36	54	45	.8	1.4	1.1
STC	7	4	11	.2	.1	.3
Telefunken Electronic	19	5	7	.4	.1	.2
Other European Companies	8	4	0	.2	.1	.0
Asia/Pacific Companies	50	32	26	1.1	.8	.7
Goldstar	32	32	26	.7	.8	.7
Other Asia/Pacific Companies	18	0	0	.4	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 8
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company: Each
Product: MOS Digital
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	26,988	33,024	32,292	100.0	100.0	100.0
North American Companies	9,754	11,277	12,388	36.1	34.1	38.4
Actel	NA	7	21	NA	.0	.1
Advanced Micro Devices	482	549	570	1.8	1.7	1.8
Allegro MicroSystems	16	16	2	.1	.0	.0
Altera	37	59	78	.1	.2	.2
Analog Devices	20	20	20	.1	.1	.1
Appian Technology	27	37	50	.1	.1	.2
Applied Micro Circuits Corp.	1	2	4	.0	.0	.0
AT&T	380	411	461	1.4	1.2	1.4
Atmel	NA	73	98	NA	.2	.3
California Micro Devices	5	8	8	.0	.0	.0
Catalyst	5	31	35	.0	.1	.1
Chips & Technologies	130	216	240	.5	.7	.7
Cirrus Logic	NA	29	129	NA	.1	.4
Cypress Semiconductor	135	196	223	.5	.6	.7
Dallas Semiconductor	NA	10	14	NA	.0	.0
Exar	7	3	0	.0	.0	.0
Exel	0	1	0	.0	.0	.0
General Electric	269	0	0	1.0	.0	.0
Gould AMI	101	101	67	.4	.3	.2
Harris	121	362	335	.4	1.1	1.0
Hewlett-Packard	0	0	230	.0	.0	.7
Holt	0	0	3	.0	.0	.0
Honeywell	88	4	4	.3	.0	.0
Hughes	47	37	34	.2	.1	.1
IMI	15	15	14	.1	.0	.0
Inova	NA	21	10	NA	.1	.0
Integrated Device Technology	171	203	196	.6	.6	.6
Intel	2,328	2,420	3,157	8.6	7.3	9.8
International CMOS Technology	NA	9	14	NA	.0	.0
Int'l. Microelectronic Prod.	47	33	38	.2	.1	.1
ITT	150	185	107	.6	.6	.3
Lattice	22	31	62	.1	.1	.2
LSI Logic	375	512	596	1.4	1.6	1.8

(Continued)

Table 8 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
Macronix	NA	31	7	NA	.1	.0
Microchip Technology	111	124	85	.4	.4	.3
Micron Technology	331	395	286	1.2	1.2	.9
MOSel	12	20	31	.0	.1	.1
Motorola	1,399	1,705	1,963	5.2	5.2	6.1
National Semiconductor	485	532	607	1.8	1.6	1.9
NCR	132	94	115	.5	.3	.4
Performance Semiconductor	NA	32	51	NA	.1	.2
Plus Logic	0	0	1	.0	.0	.0
Raytheon	2	0	0	.0	.0	.0
Rockwell	174	42	40	.6	.1	.1
Saratoga Semiconductor	10	10	0	.0	.0	.0
SEEQ Technology	60	53	45	.2	.2	.1
Sierra Semiconductor	24	27	6	.1	.1	.0
Siliconix	3	0	0	.0	.0	.0
Standard Microsystems	41	42	49	.2	.1	.2
Supertex	0	0	6	.0	.0	.0
Texas Instruments	1,271	1,603	1,367	4.7	4.9	4.2
TRW	5	5	6	.0	.0	.0
Universal	6	9	10	.0	.0	.0
Vertex	NA	11	8	.0	.0	.0
Vitelic	40	66	64	.1	.2	.2
VLSI Technology	221	286	324	.8	.9	1.0
VTC Inc.	19	17	7	.1	.1	.0
WaferScale Integration	35	35	33	.1	.1	.1
Weitek	35	49	57	.1	.1	.2
Western Digital	100	135	148	.4	.4	.5
Xicor	87	87	68	.3	.3	.2
Xilinx	27	44	84	.1	.1	.3
Zilog	90	99	100	.3	.3	.3
Other North American Companies	55	123	0	.2	.4	.0
Japanese Companies	14,494	18,006	16,123	53.7	54.5	49.9
Fuji Electric	31	31	29	.1	.1	.1
Fujitsu	1,616	1,958	1,785	6.0	5.9	5.5
Hitachi	1,885	2,407	2,325	7.0	7.3	7.2
Matsushita	875	854	819	3.2	2.6	2.5
Mitsubishi	1,453	1,676	1,394	5.4	5.1	4.3
NEC	3,123	3,604	3,495	11.6	10.9	10.8
New JRC	27	34	38	.1	.1	.1
NMB Semiconductor	199	247	201	.7	.7	.6
Oki	841	1,028	949	3.1	3.1	2.9
Ricoh	85	91	96	.3	.3	.3
Rohm	54	66	65	.2	.2	.2

(Continued)

Table 8 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Sanyo	299	378	371	1.1	1.1	1.1
Seiko Epson	296	354	201	1.1	1.1	.6
Sharp	682	837	913	2.5	2.5	2.8
Sony	235	371	392	.9	1.1	1.2
Toshiba	2,639	3,100	2,905	9.8	9.4	9.0
Yamaha	151	130	145	.6	.4	.4
Other Japanese Companies	3	840	0	.0	2.5	.0
European Companies	1,684	2,135	2,137	6.2	6.5	6.6
ABB-HAFO	28	23	24	.1	.1	.1
Austria Mikro Systeme	40	47	37	.1	.1	.1
Ericsson	6	7	8	.0	.0	.0
European Silicon Structures	13	18	27	.0	.1	.1
Eurosil	29	30	39	.1	.1	.1
GEC Plessey	0	0	115	.0	.0	.4
Inmos	110	0	0	.4	.0	.0
Matra MHS	71	85	96	.3	.3	.3
MEDL	29	35	0	.1	.1	.0
Mietec	42	52	20	.2	.2	.1
Philips	402	422	540	1.5	1.3	1.7
Plessey	76	83	0	.3	.3	.0
SGS-Thomson	461	619	584	1.7	1.9	1.8
Siemens	327	641	600	1.2	1.9	1.9
STC	10	8	5	.0	.0	.0
Telefunken Electronic	20	20	23	.1	.1	.1
TMS	0	26	19	.0	.1	.1
Other European Companies	20	19	0	.1	.1	.0
Asia/Pacific Companies	1,056	1,606	1,644	3.9	4.9	5.1
Daewoo	2	0	1	.0	.0	.0
Goldstar	63	106	117	.2	.3	.4
Hualon Microelectronics Corp.	NA	NA	49	NA	NA	.2
Hyundai	106	210	115	.4	.6	.4
Samsung	765	1,066	1,146	2.8	3.2	3.5
United Microelectronics	106	210	150	.4	.6	.5
Winbond	NA	NA	32	NA	NA	.1
Other Asia/Pacific Companies	14	14	0	.1	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 9
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	N/PMOS
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	10,196	10,843	7,007	100.0	100.0	100.0
North American Companies	3,997	3,766	2,272	39.2	34.7	32.4
Advanced Micro Devices	407	327	252	4.0	3.0	3.6
Allegro MicroSystems	7	4	0	.1	.0	.0
AT&T	52	56	67	.5	.5	1.0
Gould AMI	25	101	12	.2	.9	.2
Harris	2	13	2	.0	.1	.0
Hughes	1	1	1	.0	.0	.0
Intel	1,251	1,276	1,104	12.3	11.8	15.8
Int'l. Microelectronic Prod.	4	5	6	.0	.0	.1
ITT	80	80	43	.8	.7	.6
Macronix	NA	31	7	NA	.3	.1
Microchip Technology	68	55	24	.7	.5	.3
Micron Technology	253	298	71	2.5	2.7	1.0
Motorola	450	212	70	4.4	2.0	1.0
National Semiconductor	126	55	70	1.2	.5	1.0
NCR	57	14	9	.6	.1	.1
Rockwell	136	42	40	1.3	.4	.6
SEEQ Technology	34	11	5	.3	.1	.1
Standard Microsystems	34	10	9	.3	.1	.1
Texas Instruments	845	1,048	371	8.3	9.7	5.3
VLSI Technology	15	0	0	.1	.0	.0
Xicor	77	68	53	.8	.6	.8
Zilog	68	55	56	.7	.5	.8
Other North American Companies	5	4	0	.0	.0	.0
Japanese Companies	5,120	5,886	4,031	50.2	54.3	57.5
Fujitsu	535	606	404	5.2	5.6	5.8
Hitachi	721	800	453	7.1	7.4	6.5
Matsushita	371	333	293	3.6	3.1	4.2
Mitsubishi	808	908	677	7.9	8.4	9.7
NEC	1,140	1,202	946	11.2	11.1	13.5
Oki	304	341	234	3.0	3.1	3.3
Ricoh	40	37	35	.4	.3	.5
Rohm	1	1	2	.0	.0	.0

(Continued)

Table 9 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Sanyo	63	26	21	.6	.2	.3
Sharp	187	212	243	1.8	2.0	3.5
Sony	42	52	51	.4	.5	.7
Toshiba	875	926	672	8.6	8.5	9.6
Yamaha	31	43	0	.3	.4	.0
Other Japanese Companies	2	399	0	.0	3.7	.0
European Companies	708	666	606	6.9	6.1	8.6
Austria Mikro Systeme	8	11	11	.1	.1	.2
GEC Plessey	0	0	15	.0	.0	.2
Inmos	5	0	0	.0	.0	.0
Matra MHS	4	0	0	.0	.0	.0
Mietec	7	7	7	.1	.1	.1
Philips	175	105	101	1.7	1.0	1.4
Plessey	13	12	0	.1	.1	.0
SGS-Thomson	239	237	210	2.3	2.2	3.0
Siemens	228	260	235	2.2	2.4	3.4
STC	2	2	0	.0	.0	.0
Telefunken Electronic	20	20	23	.2	.2	.3
TMS	0	5	4	.0	.0	.1
Other European Companies	7	7	0	.1	.1	.0
Asia/Pacific Companies	371	525	98	3.6	4.8	1.4
Goldstar	7	32	6	.1	.3	.1
Hyundai	33	1	0	.3	.0	.0
Samsung	301	422	42	3.0	3.9	.6
United Microelectronics	30	70	50	.3	.6	.7

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 10
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	CMOS
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	16,584	21,449	24,824	100.0	100.0	100.0
North American Companies	5,595	7,326	9,996	33.7	34.2	40.3
Actel	NA	7	21	NA	.0	.1
Advanced Micro Devices	75	222	318	.5	1.0	1.3
Allegro MicroSystems	9	4	2	.1	.0	.0
Altera	37	59	78	.2	.3	.3
Analog Devices	20	20	20	.1	.1	.1
Appian Technology	27	37	50	.2	.2	.2
AT&T	328	355	394	2.0	1.7	1.6
Atmel	NA	73	98	NA	.3	.4
California Micro Devices	5	8	8	.0	.0	.0
Catalyst	5	31	35	.0	.1	.1
Chips & Technologies	130	216	240	.8	1.0	1.0
Cirrus Logic	NA	29	129	NA	.1	.5
Cypress Semiconductor	135	195	222	.8	.9	.9
Exar	7	3	0	.0	.0	.0
Exel	0	1	0	.0	.0	.0
General Electric	262	0	0	1.6	.0	.0
Gould AMI	76	0	55	.5	.0	.2
Harris	119	340	318	.7	1.6	1.3
Hewlett-Packard	0	0	230	.0	.0	.9
Holt	0	0	3	.0	.0	.0
Honeywell	88	4	4	.5	.0	.0
Hughes	46	36	33	.3	.2	.1
IMI	15	15	14	.1	.1	.1
Inova	NA	0	10	NA	.0	.0
Integrated Device Technology	171	202	191	1.0	.9	.8
Intel	1,077	1,144	2,053	6.5	5.3	8.3
International CMOS Technology	NA	9	14	NA	.0	.1
Int'l. Microelectronic Prod.	43	28	32	.3	.1	.1
ITT	70	105	64	.4	.5	.3
Lattice	22	31	62	.1	.1	.2
LSI Logic	374	507	591	2.3	2.4	2.4
Microchip Technology	3	3	61	.0	.0	.2
Micron Technology	0	97	215	.0	.5	.9

(Continued)

Table 10 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
MOSel	12	20	31	.1	.1	.1
Motorola	949	1,490	1,868	5.7	6.9	7.5
National Semiconductor	350	447	502	2.1	2.1	2.0
NCR	75	80	106	.5	.4	.4
Performance Semiconductor	NA	32	51	NA	.1	.2
Plus Logic	0	0	1	.0	.0	.0
Raytheon	2	0	0	.0	.0	.0
Rockwell	38	0	0	.2	.0	.0
SEEQ Technology	26	42	40	.2	.2	.2
Sierra Semiconductor	24	27	6	.1	.1	.0
Siliconix	3	0	0	.0	.0	.0
Standard Microsystems	7	32	40	.0	.1	.2
Supertex	0	0	6	.0	.0	.0
Texas Instruments	415	539	980	2.5	2.5	3.9
TRW	5	5	6	.0	.0	.0
Universal	6	9	10	.0	.0	.0
Vertex	NA	11	8	.0	.1	.0
Vitelic	40	66	64	.2	.3	.3
VLSI Technology	206	286	324	1.2	1.3	1.3
VTC Inc.	19	17	7	.1	.1	.0
WaferScale Integration	35	35	33	.2	.2	.1
Weitek	35	49	57	.2	.2	.2
Western Digital	100	135	148	.6	.6	.6
Xicor	10	19	15	.1	.1	.1
Xilinx	27	44	84	.2	.2	.3
Zilog	22	44	44	.1	.2	.2
Other North American Companies	45	116	0	.3	.5	.0
Japanese Companies	9,348	11,623	11,768	56.4	54.2	47.4
Fuji Electric	30	25	27	.2	.1	.1
Fujitsu	1,081	1,241	1,279	6.5	5.8	5.2
Hitachi	1,157	1,454	1,767	7.0	6.8	7.1
Matsushita	504	521	526	3.0	2.4	2.1
Mitsubishi	645	768	717	3.9	3.6	2.9
NEC	1,965	2,314	2,461	11.8	10.8	9.9
New JRC	27	34	38	.2	.2	.2
NMB Semiconductor	199	247	201	1.2	1.2	.8
Oki	537	623	689	3.2	2.9	2.8
Ricoh	45	53	60	.3	.2	.2
Rohm	53	65	63	.3	.3	.3
Sanyo	236	352	350	1.4	1.6	1.4
Seiko Epson	296	354	201	1.8	1.7	.8
Sharp	495	625	670	3.0	2.9	2.7
Sony	193	319	341	1.2	1.5	1.4

(Continued)

Table 10 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Toshiba	1,764	2,100	2,233	10.6	9.8	9.0
Yamaha	120	87	145	.7	.4	.6
Other Japanese Companies	1	441	0	.0	2.1	.0
European Companies	956	1,433	1,514	5.8	6.7	6.1
ABB-HAFO	28	23	24	.2	.1	.1
Austria Mikro Systeme	32	36	26	.2	.2	.1
Ericsson	6	7	8	.0	.0	.0
European Silicon Structures	13	18	27	.1	.1	.1
Eurosil	29	30	39	.2	.1	.2
GEC Plessey	0	0	100	.0	.0	.4
Inmos	105	0	0	.6	.0	.0
Matra MHS	67	85	96	.4	.4	.4
MEDL	29	35	0	.2	.2	.0
Mietec	17	22	13	.1	.1	.1
Philips	227	317	439	1.4	1.5	1.8
Plessey	63	71	0	.4	.3	.0
SGS-Thomson	222	372	362	1.3	1.7	1.5
Siemens	99	381	365	.6	1.8	1.5
STC	6	3	0	.0	.0	.0
TMS	0	21	15	.0	.1	.1
Other European Companies	13	12	0	.1	.1	.0
Asia/Pacific Companies	685	1,067	1,546	4.1	5.0	6.2
Daewoo	2	0	1	.0	.0	.0
Goldstar	56	74	111	.3	.3	.4
Hualon Microelectronics Corp.	NA	NA	49	NA	NA	.2
Hyundai	73	209	115	.4	1.0	.5
Samsung	464	644	1,104	2.8	3.0	4.4
United Microelectronics	76	140	100	.5	.7	.4
Winbond	NA	NA	32	NA	NA	.1
Other Asia/Pacific Companies	14	0	0	.1	.0	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 11
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	BiCMOS
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	208	732	461	100.0	100.0	100.0
North American Companies	162	185	120	77.9	25.3	26.0
Allegro MicroSystems	0	8	0	.0	1.1	.0
Applied Micro Circuits Corp.	1	2	4	.5	.3	.9
Cypress Semiconductor	0	1	1	.0	.1	.2
Dallas Semiconductor	NA	10	14	NA	1.4	3.0
General Electric	7	0	0	3.4	.0	.0
Harris	0	9	15	.0	1.2	3.3
Inova	NA	21	0	NA	2.9	.0
Integrated Device Technology	0	1	5	.0	.1	1.1
LSI Logic	1	5	5	.5	.7	1.1
Microchip Technology	40	66	0	19.2	9.0	.0
Micron Technology	78	0	0	37.5	.0	.0
Motorola	0	3	25	.0	.4	5.4
National Semiconductor	9	30	35	4.3	4.1	7.6
Saratoga Semiconductor	10	10	0	4.8	1.4	.0
Texas Instruments	11	16	16	5.3	2.2	3.5
Other North American Companies	5	3	0	2.4	.4	.0
Japanese Companies	26	497	324	12.5	67.9	70.3
Fuji Electric	1	6	2	.5	.8	.4
Fujitsu	0	111	102	.0	15.2	22.1
Hitachi	7	153	105	3.4	20.9	22.8
NEC	18	88	88	8.7	12.0	19.1
Oki	0	64	26	.0	8.7	5.6
Ricoh	0	1	1	.0	.1	.2
Toshiba	0	74	0	.0	10.1	.0
European Companies	20	36	17	9.6	4.9	3.7
Mietec	18	23	0	8.7	3.1	.0
SGS-Thomson	0	10	12	.0	1.4	2.6
STC	2	3	5	1.0	.4	1.1

(Continued)

Table 11 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Asia/Pacific Companies	0	14	0	.0	1.9	.0
Other Asia/Pacific Companies	0	14	0	.0	1.9	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 12
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	MOS Memory
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	11,692	16,361	13,091	100.0	100.0	100.0
North American Companies	2,836	3,688	2,990	24.3	22.5	22.8
Advanced Micro Devices	207	258	253	1.8	1.6	1.9
AT&T	24	13	13	.2	.1	.1
Atmel	NA	47	54	NA	.3	.4
Catalyst	5	31	35	.0	.2	.3
Cypress Semiconductor	94	149	166	.8	.9	1.3
Dallas Semiconductor	NA	10	14	NA	.1	.1
Exar	3	0	0	.0	.0	.0
General Electric	29	0	0	.2	.0	.0
Gould AMI	15	25	14	.1	.2	.1
Harris	26	37	24	.2	.2	.2
Honeywell	14	2	2	.1	.0	.0
Inova	NA	21	10	NA	.1	.1
Integrated Device Technology	135	158	132	1.2	1.0	1.0
Intel	392	433	371	3.4	2.6	2.8
International CMOS Technology	NA	6	8	NA	.0	.1
Int'l. Microelectronic Prod.	0	17	8	.0	.1	.1
ITT	0	10	0	.0	.1	.0
Lattice	2	0	0	.0	.0	.0
Macronix	NA	31	7	NA	.2	.1
Microchip Technology	82	94	60	.7	.6	.5
Micron Technology	331	395	286	2.8	2.4	2.2
MOSel	12	20	31	.1	.1	.2
Motorola	236	407	395	2.0	2.5	3.0
National Semiconductor	135	138	143	1.2	.8	1.1
NCR	6	8	4	.1	.0	.0
Performance Semiconductor	NA	16	19	NA	.1	.1
Saratoga Semiconductor	10	10	0	.1	.1	.0
SEEQ Technology	46	40	33	.4	.2	.3
Texas Instruments	834	1,095	741	7.1	6.7	5.7
Vitelic	40	66	64	.3	.4	.5
VLSI Technology	16	23	8	.1	.1	.1
WaferScale Integration	25	28	27	.2	.2	.2
Xicor	87	87	68	.7	.5	.5
Other North American Companies	30	13	0	.3	.1	.0

(Continued)

Table 12 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies	7,597	10,558	8,023	65.0	64.5	61.3
Fujitsu	1,067	1,265	1,006	9.1	7.7	7.7
Hitachi	1,114	1,534	1,366	9.5	9.4	10.4
Matsushita	230	370	284	2.0	2.3	2.2
Mitsubishi	966	1,161	853	8.3	7.1	6.5
NEC	1,490	1,739	1,376	12.7	10.6	10.5
NMB Semiconductor	199	247	201	1.7	1.5	1.5
Oki	353	473	392	3.0	2.9	3.0
Ricoh	26	31	29	.2	.2	.2
Rohm	8	10	7	.1	.1	.1
Sanyo	87	130	97	.7	.8	.7
Seiko Epson	94	141	62	.8	.9	.5
Sharp	344	476	497	2.9	2.9	3.8
Sony	103	228	227	.9	1.4	1.7
Toshiba	1,516	1,918	1,626	13.0	11.7	12.4
Other Japanese Companies	0	835	0	.0	5.1	.0
European Companies	464	786	760	4.0	4.8	5.8
Austria Mikro Systeme	4	0	0	.0	.0	.0
GEC Plessey	0	0	8	.0	.0	.1
Inmos	53	0	0	.5	.0	.0
Matra MHS	28	31	37	.2	.2	.3
MEDL	5	7	0	.0	.0	.0
Philips	35	60	96	.3	.4	.7
Plessey	0	3	0	.0	.0	.0
SGS-Thomson	185	269	299	1.6	1.6	2.3
Siemens	150	416	320	1.3	2.5	2.4
STC	2	0	0	.0	.0	.0
Other European Companies	2	0	0	.0	.0	.0
Asia/Pacific Companies	795	1,329	1,318	6.8	8.1	10.1
Goldstar	27	82	96	.2	.5	.7
Hualon Microelectronics Corp.	NA	NA	39	NA	NA	.3
Hyundai	106	210	115	.9	1.3	.9
Samsung	650	935	971	5.6	5.7	7.4
United Microelectronics	12	102	66	.1	.6	.5
Winbond	NA	NA	14	NA	NA	.1

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 13
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company: Each
Product: MOS Microcomponents
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	7,144	8,202	10,068	100.0	100.0	100.0
North American Companies	3,872	4,526	5,912	54.2	55.2	58.7
Advanced Micro Devices	183	172	178	2.6	2.1	1.8
Analog Devices	20	20	20	.3	.2	.2
Appian Technology	17	30	38	.2	.4	.4
AT&T	39	141	145	.5	1.7	1.4
California Micro Devices	1	8	8	.0	.1	.1
Chips & Technologies	130	216	240	1.8	2.6	2.4
Cirrus Logic	NA	29	129	NA	.4	1.3
Cypress Semiconductor	7	11	15	.1	.1	.1
General Electric	48	0	0	.7	.0	.0
Harris	62	115	110	.9	1.4	1.1
Holt	0	0	1	.0	.0	.0
Hughes	2	2	2	.0	.0	.0
IMI	1	0	0	.0	.0	.0
Integrated Device Technology	15	13	20	.2	.2	.2
Intel	1,835	1,929	2,726	25.7	23.5	27.1
ITT	15	25	28	.2	.3	.3
LSI Logic	18	67	93	.3	.8	.9
Microchip Technology	18	18	16	.3	.2	.2
Motorola	699	803	1,009	9.8	9.8	10.0
National Semiconductor	150	172	248	2.1	2.1	2.5
NCR	6	22	31	.1	.3	.3
Performance Semiconductor	NA	13	24	NA	.2	.2
Rockwell	51	42	40	.7	.5	.4
SEEQ Technology	0	0	12	.0	.0	.1
Sierra Semiconductor	1	1	1	.0	.0	.0
Standard Microsystems	34	34	40	.5	.4	.4
Texas Instruments	234	252	320	3.3	3.1	3.2
TRW	0	5	6	.0	.1	.1
VLSI Technology	54	94	105	.8	1.1	1.0
WaferScale Integration	0	2	2	.0	.0	.0
Weitek	35	49	57	.5	.6	.6
Western Digital	100	135	148	1.4	1.6	1.5
Zilog	90	99	100	1.3	1.2	1.0
Other North American Companies	7	7	0	.1	.1	.0

(Continued)

Table 13 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies	2,817	3,190	3,551	39.4	38.9	35.3
Fuji Electric	0	0	1	.0	.0	.0
Fujitsu	202	211	239	2.8	2.6	2.4
Hitachi	525	554	607	7.3	6.8	6.0
Matsushita	230	217	250	3.2	2.6	2.5
Mitsubishi	381	435	464	5.3	5.3	4.6
NEC	790	937	1,083	11.1	11.4	10.8
Oki	134	149	147	1.9	1.8	1.5
Ricoh	19	22	23	.3	.3	.2
Rohm	16	16	18	.2	.2	.2
Sanyo	70	70	80	1.0	.9	.8
Seiko Epson	12	12	11	.2	.1	.1
Sharp	54	112	138	.8	1.4	1.4
Sony	37	47	49	.5	.6	.5
Toshiba	346	407	441	4.8	5.0	4.4
Other Japanese Companies	1	1	0	.0	.0	.0
European Companies	401	433	538	5.6	5.3	5.3
Eurosil	2	2	4	.0	.0	.0
GEC Plessey	0	0	8	.0	.0	.1
Inmos	57	0	0	.8	.0	.0
Matra MHS	21	28	33	.3	.3	.3
MEDL	1	3	0	.0	.0	.0
Philips	114	131	192	1.6	1.6	1.9
Plessey	0	3	0	.0	.0	.0
SGS-Thomson	118	161	175	1.7	2.0	1.7
Siemens	88	92	116	1.2	1.1	1.2
TMS	0	13	10	.0	.2	.1
Asia/Pacific Companies	54	53	67	.8	.6	.7
Goldstar	4	2	3	.1	.0	.0
Samsung	15	8	22	.2	.1	.2
United Microelectronics	35	43	39	.5	.5	.4

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 14
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	MOS Logic
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	8,152	8,461	9,133	100.0	100.0	100.0
North American Companies	3,046	3,063	3,486	37.4	36.2	38.2
Actel	NA	7	21	NA	.1	.2
Advanced Micro Devices	92	119	139	1.1	1.4	1.5
Allegro MicroSystems	16	16	2	.2	.2	.0
Altera	37	59	78	.5	.7	.9
Appian Technology	10	7	12	.1	.1	.1
Applied Micro Circuits Corp.	1	2	4	.0	.0	.0
AT&T	317	257	303	3.9	3.0	3.3
Atmel	NA	26	44	NA	.3	.5
California Micro Devices	4	0	0	.0	.0	.0
Cypress Semiconductor	34	36	42	.4	.4	.5
Exar	4	3	0	.0	.0	.0
Exel	0	1	0	.0	.0	.0
General Electric	192	0	0	2.4	.0	.0
Gould AMI	86	76	53	1.1	.9	.6
Harris	33	210	201	.4	2.5	2.2
Hewlett-Packard	0	0	230	.0	.0	2.5
Holt	0	0	2	.0	.0	.0
Honeywell	74	2	2	.9	.0	.0
Hughes	45	35	32	.6	.4	.4
IMI	14	15	14	.2	.2	.2
Integrated Device Technology	21	32	44	.3	.4	.5
Intel	101	58	60	1.2	.7	.7
International CMOS Technology	NA	3	6	NA	.0	.1
Int'l. Microelectronic Prod.	47	16	30	.6	.2	.3
ITT	135	150	79	1.7	1.8	.9
Lattice	20	31	62	.2	.4	.7
LSI Logic	357	445	503	4.4	5.3	5.5
Microchip Technology	11	12	9	.1	.1	.1
Motorola	464	495	559	5.7	5.9	6.1
National Semiconductor	200	222	216	2.5	2.6	2.4
NCR	120	64	80	1.5	.8	.9
Performance Semiconductor	NA	3	8	NA	.0	.1
Plus Logic	0	0	1	.0	.0	.0

(Continued)

Table 14 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
Raytheon	2	0	0	.0	.0	.0
Rockwell	123	0	0	1.5	.0	.0
SEEQ Technology	14	13	0	.2	.2	.0
Sierra Semiconductor	23	26	5	.3	.3	.1
Siliconix	3	0	0	.0	.0	.0
Standard Microsystems	7	8	9	.1	.1	.1
Supertex	0	0	6	.0	.0	.1
Texas Instruments	203	256	306	2.5	3.0	3.4
TRW	5	0	0	.1	.0	.0
Universal	6	9	10	.1	.1	.1
Vertex	NA	11	8	.0	.1	.1
VLSI Technology	151	169	211	1.9	2.0	2.3
VTC Inc.	19	17	7	.2	.2	.1
WaferScale Integration	10	5	4	.1	.1	.0
Xilinx	27	44	84	.3	.5	.9
Other North American Companies	18	103	0	.2	1.2	.0
Japanese Companies	4,080	4,258	4,549	50.0	50.3	49.8
Fuji Electric	31	31	28	.4	.4	.3
Fujitsu	347	482	540	4.3	5.7	5.9
Hitachi	246	319	352	3.0	3.8	3.9
Matsushita	415	267	285	5.1	3.2	3.1
Mitsubishi	106	80	77	1.3	.9	.8
NEC	843	928	1,036	10.3	11.0	11.3
New JRC	27	34	38	.3	.4	.4
Oki	354	406	410	4.3	4.8	4.5
Ricoh	40	38	44	.5	.4	.5
Rohm	30	40	40	.4	.5	.4
Sanyo	142	178	194	1.7	2.1	2.1
Seiko Epson	190	201	128	2.3	2.4	1.4
Sharp	284	249	278	3.5	2.9	3.0
Sony	95	96	116	1.2	1.1	1.3
Toshiba	777	775	838	9.5	9.2	9.2
Yamaha	151	130	145	1.9	1.5	1.6
Other Japanese Companies	2	4	0	.0	.0	.0
European Companies	819	916	839	10.0	10.8	9.2
ABB-HAFO	28	23	24	.3	.3	.3
Austria Mikro Systeme	36	47	37	.4	.6	.4
Ericsson	6	7	8	.1	.1	.1
European Silicon Structures	13	18	27	.2	.2	.3
Eurosil	27	28	35	.3	.3	.4
GEC Plessey	0	0	99	.0	.0	1.1
Matra MHS	22	26	26	.3	.3	.3

(Continued)

Table 14 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
European Companies (Continued)						
MEDL	23	25	0	.3	.3	.0
Mietec	42	52	20	.5	.6	.2
Philips	253	231	252	3.1	2.7	2.8
Plessey	76	77	0	.9	.9	.0
SGS-Thomson	158	189	110	1.9	2.2	1.2
Siemens	89	133	164	1.1	1.6	1.8
STC	8	8	5	.1	.1	.1
Telefunken Electronic	20	20	23	.2	.2	.3
TMS	0	13	9	.0	.2	.1
Other European Companies	18	19	0	.2	.2	.0
Asia/Pacific Companies	207	224	259	2.5	2.6	2.8
Daewoo	2	0	1	.0	.0	.0
Goldstar	32	22	18	.4	.3	.2
Hualon Microelectronics Corp.	NA	NA	10	NA	NA	.1
Samsung	100	123	153	1.2	1.5	1.7
United Microelectronics	59	65	45	.7	.8	.5
Winbond	NA	NA	18	NA	NA	.2
Other Asia/Pacific Companies	14	14	0	.2	.2	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 15
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Analog
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	8,880	9,390	10,571	100.0	100.0	100.0
North American Companies	3,475	3,902	4,337	39.1	41.6	41.0
Advanced Micro Devices	66	77	76	.7	.8	.7
Allegro MicroSystems	86	98	96	1.0	1.0	.9
Anadigics	NA	NA	5	NA	NA	.0
Analog Devices	340	337	360	3.8	3.6	3.4
AT&T	247	249	197	2.8	2.7	1.9
Atmel	NA	13	11	NA	.1	.1
Brooktree	NA	52	70	NA	.6	.7
Burr-Brown	144	141	145	1.6	1.5	1.4
California Micro Devices	23	22	19	.3	.2	.2
Catalyst	0	0	1	.0	.0	.0
Cherry Semiconductor	33	32	36	.4	.3	.3
Cirrus Logic	NA	0	1	NA	.0	.0
Comlinear	NA	10	13	NA	.1	.1
Crystal	NA	12	15	NA	.1	.1
Dallas Semiconductor	NA	3	3	NA	.0	.0
Elantec	NA	12	13	NA	.1	.1
Exar	40	46	75	.5	.5	.7
General Electric	120	0	0	1.4	.0	.0
Gennum	NA	20	18	NA	.2	.2
Gould AMI	0	16	23	.0	.2	.2
Harris	146	280	260	1.6	3.0	2.5
Holt	9	9	7	.1	.1	.1
Honeywell	27	21	20	.3	.2	.2
Hughes	0	0	8	.0	.0	.1
IC Sensors	NA	7	6	NA	.1	.1
IMI	0	0	1	.0	.0	.0
Integrated Device Technology	0	1	3	.0	.0	.0
Intel	0	0	9	.0	.0	.1
Int'l. Microelectronic Prod.	0	20	18	.0	.2	.2
International Rectifier	0	3	1	.0	.0	.0
ITT	64	50	103	.7	.5	1.0
Kulite	NA	25	28	NA	.3	.3
Linear Technology	59	70	83	.7	.7	.8

(Continued)

Table 15 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
North American Companies (Continued)						
LSI Logic	0	0	2	.0	.0	.0
Maxim	35	43	65	.4	.5	.6
MCE	NA	NA	4	NA	NA	.0
Micrel	NA	NA	5	NA	NA	.0
Micro Linear	24	28	45	.3	.3	.4
Micro Power Systems	26	21	24	.3	.2	.2
Mitel	43	54	47	.5	.6	.4
Motorola	425	445	491	4.8	4.7	4.6
National Semiconductor	540	558	619	6.1	5.9	5.9
NCR	0	26	30	.0	.3	.3
Novasensor Inc.	NA	NA	12	NA	NA	.1
Pacific Monolithics	NA	NA	7	NA	NA	.1
Precision Monolithics	85	88	91	1.0	.9	.9
Raytheon	27	27	20	.3	.3	.2
Rockwell	0	123	160	.0	1.3	1.5
Seagate Micro-Electronics	NA	NA	9	NA	NA	.1
Semtech	NA	NA	2	NA	NA	.0
Sensym	NA	NA	6	NA	NA	.1
Sierra Semiconductor	23	28	55	.3	.3	.5
Signal Processing Technology	NA	NA	5	NA	NA	.0
Silicon General	35	36	36	.4	.4	.3
Silicon Systems	125	112	165	1.4	1.2	1.6
Siliconix	67	54	54	.8	.6	.5
Sipex	NA	22	21	NA	.2	.2
Solitron	13	10	9	.1	.1	.1
Supertex	11	15	13	.1	.2	.1
Tektronix	NA	NA	35	NA	NA	.3
Teledyne	33	20	19	.4	.2	.2
Texas Instruments	426	417	458	4.8	4.4	4.3
TRW	20	15	14	.2	.2	.1
Unitrode	51	50	50	.6	.5	.5
Universal	4	4	4	.0	.0	.0
VTC Inc.	27	27	33	.3	.3	.3
Xicor	3	3	3	.0	.0	.0
Other North American Companies	28	50	0	.3	.5	.0
Japanese Companies	4,090	4,039	4,163	46.1	43.0	39.4
Fuji Electric	33	43	51	.4	.5	.5
Fujitsu	151	163	164	1.7	1.7	1.6
Hitachi	343	332	347	3.9	3.5	3.3
Matsushita	423	376	410	4.8	4.0	3.9
Mitsubishi	395	384	441	4.4	4.1	4.2
NEC	469	415	417	5.3	4.4	3.9
New JRC	118	119	122	1.3	1.3	1.2

(Continued)

Table 15 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Oki	23	35	35	.3	.4	.3
Rohm	271	277	282	3.1	2.9	2.7
Sanken	157	156	164	1.8	1.7	1.6
Sanyo	471	530	541	5.3	5.6	5.1
Seiko Epson	15	14	12	.2	.1	.1
Sharp	69	65	73	.8	.7	.7
Shindengen Electric	NA	NA	33	NA	NA	.3
Sony	386	361	399	4.3	3.8	3.8
Toko	NA	NA	54	NA	NA	.5
Toshiba	569	572	610	6.4	6.1	5.8
Yamaha	0	13	8	.0	.1	.1
Other Japanese Companies	197	184	0	2.2	2.0	.0
European Companies	1,147	1,278	1,842	12.9	13.6	17.4
Austria Mikro Systeme	4	9	22	.0	.1	.2
Ericsson	46	47	48	.5	.5	.5
GEC Plessey	0	0	173	.0	.0	1.6
Matra MHS	0	0	4	.0	.0	.0
MEDL	0	4	0	.0	.0	.0
Mietec	0	0	72	.0	.0	.7
Philips	466	522	653	5.2	5.6	6.2
Plessey	67	35	0	.8	.4	.0
SGS-Thomson	352	393	554	4.0	4.2	5.2
Siemens	120	152	190	1.4	1.6	1.8
STC	4	5	6	.0	.1	.1
Telefunken Electronic	85	101	111	1.0	1.1	1.1
TMS	0	7	9	.0	.1	.1
Other European Companies	3	3	0	.0	.0	.0
Asia/Pacific Companies	168	171	229	1.9	1.8	2.2
Daewoo	5	10	11	.1	.1	.1
ERSO	NA	NA	1	NA	NA	.0
Goldstar	41	9	20	.5	.1	.2
Hualon Microelectronics Corp.	NA	NA	1	NA	NA	.0
Korean Electronic Co.	25	24	28	.3	.3	.3
Samsung	85	116	92	1.0	1.2	.9
Winbond	NA	NA	18	NA	NA	.2
Other Asia/Pacific Companies	12	12	58	.1	.1	.5

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 16
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Total Discrete
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	7,612	7,662	8,235	100.0	100.0	100.0
North American Companies	2,171	2,120	2,203	28.5	27.7	26.8
Acrian	21	26	0	.3	.3	.0
Allegro MicroSystems	18	23	17	.2	.3	.2
Analog Devices	0	0	1	.0	.0	.0
AT&T	161	147	130	2.1	1.9	1.6
General Electric	145	0	0	1.9	.0	.0
General Instrument	164	170	214	2.2	2.2	2.6
Harris	0	120	130	.0	1.6	1.6
Hewlett-Packard	57	56	56	.7	.7	.7
Honeywell	10	0	0	.1	.0	.0
International Rectifier	192	187	224	2.5	2.4	2.7
ITT	146	155	161	1.9	2.0	2.0
Micro Quality Semiconductor	0	2	0	.0	.0	.0
Microsemi	NA	NA	50	NA	NA	.6
Motorola	752	775	808	9.9	10.1	9.8
National Semiconductor	75	70	70	1.0	.9	.9
Powerex	115	105	112	1.5	1.4	1.4
Raytheon	15	14	10	.2	.2	.1
Semtech	NA	NA	16	NA	NA	.2
Siliconix	61	67	62	.8	.9	.8
Solitron	33	27	24	.4	.4	.3
Supertex	10	8	8	.1	.1	.1
Teledyne	0	0	3	.0	.0	.0
Texas Instruments	63	60	53	.8	.8	.6
Unitrode	62	59	54	.8	.8	.7
VQSI	21	0	0	.3	.0	.0
Other North American Companies	50	49	0	.7	.6	.0
Japanese Companies	4,056	4,091	4,313	53.3	53.4	52.4
Fuji Electric	279	287	304	3.7	3.7	3.7
Fujitsu	82	109	117	1.1	1.4	1.4
Hitachi	707	690	641	9.3	9.0	7.8
Matsushita	377	332	374	5.0	4.3	4.5
Mitsubishi	310	364	348	4.1	4.8	4.2

(Continued)

Table 16 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
NEC	571	574	567	7.5	7.5	6.9
New JRC	8	4	4	.1	.1	.0
Oki	9	10	10	.1	.1	.1
Rohm	287	301	321	3.8	3.9	3.9
Sanken	207	213	224	2.7	2.8	2.7
Sanyo	210	230	232	2.8	3.0	2.8
Shindengen Electric	NA	NA	176	NA	NA	2.1
Sony	112	96	85	1.5	1.3	1.0
Toko	NA	NA	6	NA	NA	.1
Toshiba	864	848	904	11.4	11.1	11.0
Other Japanese Companies	33	33	0	.4	.4	.0
European Companies	1,250	1,284	1,541	16.4	16.8	18.7
ABB-HAFO	76	5	8	1.0	.1	.1
ABB-IXYS	0	50	58	.0	.7	.7
Eupec	0	0	96	.0	.0	1.2
Fagor	27	29	30	.4	.4	.4
GEC Plessey	0	0	36	.0	.0	.4
MEDL	22	21	0	.3	.3	.0
Philips	432	442	507	5.7	5.8	6.2
Plessey	25	0	0	.3	.0	.0
Semikron	91	95	106	1.2	1.2	1.3
SGS-Thomson	254	282	315	3.3	3.7	3.8
Siemens	201	232	258	2.6	3.0	3.1
STC	1	2	2	.0	.0	.0
TAG	23	22	25	.3	.3	.3
Telefunken Electronic	91	95	76	1.2	1.2	.9
TMS	0	2	1	.0	.0	.0
Zetex	0	0	23	.0	.0	.3
Other European Companies	7	7	0	.1	.1	.0
Asia/Pacific Companies	135	167	178	1.8	2.2	2.2
AMPi	NA	NA	6	NA	NA	.1
Goldstar	1	1	0	.0	.0	.0
Hi-Sincerity	NA	NA	5	NA	NA	.1
Korean Electronic Co.	65	74	79	.9	1.0	1.0
MOSpec	NA	NA	11	NA	NA	.1
Samsung	55	78	77	.7	1.0	.9
Other Asia/Pacific Companies	14	14	0	.2	.2	.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 17
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Total Optoelectronic
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Total Market	2,179	2,627	2,687	100.0	100.0	100.0
North American Companies	425	458	457	19.5	17.4	17.0
Allegro MicroSystems	0	0	1	.0	.0	.0
AT&T	10	10	14	.5	.4	.5
CID Technologies	NA	NA	4	NA	NA	.1
Dalsa Inc.	NA	NA	3	NA	NA	.1
Eastman Kodak	NA	NA	3	NA	NA	.1
Fairchild-Loral	NA	NA	1	NA	NA	.0
Ford Aerospace-Loral	NA	NA	1	NA	NA	.0
General Electric	21	0	0	1.0	.0	.0
Harris	0	18	15	.0	.7	.6
Hewlett-Packard	213	213	223	9.8	8.1	8.3
Honeywell	30	31	25	1.4	1.2	.9
Hughes	0	0	2	.0	.0	.1
Motorola	24	25	26	1.1	1.0	1.0
Optek	NA	77	66	NA	2.9	2.5
Quality Technologies	40	38	34	1.8	1.4	1.3
Tektronix	NA	NA	5	NA	NA	.2
Texas Instruments	41	36	33	1.9	1.4	1.2
TRW	36	0	0	1.7	.0	.0
Weitek	0	0	1	.0	.0	.0
Other North American Companies	10	10	0	.5	.4	.0
Japanese Companies	1,511	1,918	1,935	69.3	73.0	72.0
Fuji Electric	3	1	1	.1	.0	.0
Fujitsu	105	116	124	4.8	4.4	4.6
Hitachi	70	66	70	3.2	2.5	2.6
Matsushita	178	306	325	8.2	11.6	12.1
Mitsubishi	27	30	31	1.2	1.1	1.2
NEC	88	120	124	4.0	4.6	4.6
New JRC	15	13	13	.7	.5	.5
Oki	36	33	33	1.7	1.3	1.2
Rohm	109	96	105	5.0	3.7	3.9
Sanken	19	18	19	.9	.7	.7
Sanyo	62	160	170	2.8	6.1	6.3

(Continued)

Table 17 (Continued)
Worldwide Semiconductor Market Share Estimates
(Factory Revenue in Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1988	1989	1990	1988	1989	1990
Japanese Companies (Continued)						
Sharp	285	328	339	13.1	12.5	12.6
Sony	217	249	270	10.0	9.5	10.0
Toshiba	215	308	311	9.9	11.7	11.6
Other Japanese Companies	82	74	0	3.8	2.8	.0
European Companies	238	244	267	10.9	9.3	9.9
ABB-HAFO	9	9	10	.4	.3	.4
Philips	25	24	31	1.1	.9	1.2
Plessey	22	0	0	1.0	.0	.0
Siemens	100	115	131	4.6	4.4	4.9
Telefunken Electronic	74	78	78	3.4	3.0	2.9
TMS	0	10	16	.0	.4	.6
Zetex	0	0	1	.0	.0	.0
Other European Companies	8	8	0	.4	.3	.0
Asia/Pacific Companies	5	7	28	.2	.3	1.0
AMPi	NA	NA	1	NA	NA	.0
Korean Electronic Co.	5	7	7	.2	.3	.3
Kingbright	NA	NA	7	NA	NA	.3
Ledtech Electronics	NA	NA	7	NA	NA	.3
Liteon	NA	NA	6	NA	NA	.2

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Chapter 2

Final Worldwide Semiconductor Market Share Rankings

These market share rankings provide our final estimates for 1990. The tables rank the major companies in 12 semiconductor categories for 1989 and 1990.

Index of Tables

Table 1
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40
Product:	Total Semiconductor
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
1	1	NEC	5,015	4,898	-2	8.4
2	2	Toshiba	4,930	4,843	-2	8.3
3	3	Hitachi	3,974	3,893	-2	6.7
4	4	Motorola	3,319	3,694	11	6.3
5	8	Intel	2,430	3,171	30	5.4
6	5	Fujitsu	2,963	2,880	-3	4.9
7	6	Texas Instruments	2,787	2,574	-8	4.4
8	7	Mitsubishi	2,579	2,319	-10	4.0
9	10	Philips	1,716	2,011	17	3.5
10	9	Matsushita	1,882	1,942	3	3.3
11	11	National Semiconductor	1,618	1,719	6	3.0
12	13	SGS-Thomson	1,301	1,463	12	2.5
13	12	Sanyo	1,365	1,381	1	2.4
14	15	Sharp	1,230	1,325	8	2.3
15	14	Samsung	1,260	1,315	4	2.3
16	16	Siemens	1,194	1,224	3	2.1
17	19	Sony	1,077	1,146	6	2.0
18	17	Oki	1,154	1,074	-7	1.8
19	18	Advanced Micro Devices	1,100	1,053	-4	1.8
20	20	AT&T	873	861	-1	1.5
21	21	Harris	830	800	-4	1.4
22	22	Rohm	740	774	5	1.3
23	23	LSI Logic	512	598	17	1.0
24	32	Hewlett-Packard	269	509	89	.9
25	26	Sanken	387	407	5	.7
26	NM	GEC Plessey	0	390	NM	.7
27	28	Fuji Electric	362	385	6	.7
28	29	Analog Devices	357	381	7	.7
29	25	ITT	390	371	-5	.6
30	31	VLSI Technology	286	324	13	.6
31	30	Telefunken Electronic	299	295	-1	.5
32	24	Micron Technology	395	286	-28	.5
33	35	Chips & Technologies	240	265	10	.5
34	40	International Rectifier	190	225	18	.4
35	39	Cypress Semiconductor	196	223	14	.4
36	42	General Instrument	170	214	26	.4

(Continued)

Table 1 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
37	27	Seiko Epson	368	213	-42	.4
38	NA	Shindengen Electric	NA	209	NA	.4
39	33	NMB Semiconductor	247	201	-19	.3
40	43	Rockwell	165	200	21	.3
		All Others	7,043	6,169	-12	10.6
		North American Companies	19,978	21,537	8	37.0
		Japanese Companies	29,809	28,377	-5	48.7
		European Companies	5,443	6,206	14	10.7
		Asia/Pacific Companies	1,983	2,105	6	3.6
		Total Market	57,213	58,225	2	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 2
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40
Product:	Total Integrated Circuit
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
1	1	NEC	4,321	4,207	-3	8.9
2	2	Toshiba	3,774	3,628	-4	7.7
3	3	Hitachi	3,218	3,182	-1	6.7
4	7	Intel	2,430	3,171	30	6.7
5	6	Motorola	2,519	2,860	14	6.0
6	4	Fujitsu	2,738	2,639	-4	5.6
7	5	Texas Instruments	2,691	2,488	-8	5.3
8	8	Mitsubishi	2,185	1,940	-11	4.1
9	9	National Semiconductor	1,548	1,649	7	3.5
10	10	Philips	1,250	1,473	18	3.1
11	11	Matsushita	1,244	1,243	-0	2.6
12	12	Samsung	1,182	1,238	5	2.6
13	15	SGS-Thomson	1,019	1,148	13	2.4
14	14	Advanced Micro Devices	1,100	1,053	-4	2.2
15	13	Oki	1,111	1,031	-7	2.2
16	17	Sharp	902	986	9	2.1
17	16	Sanyo	975	979	0	2.1
18	18	Siemens	847	835	-1	1.8
19	19	Sony	732	791	8	1.7
20	20	AT&T	716	717	0	1.5
21	21	Harris	692	655	-5	1.4
22	22	LSI Logic	512	598	17	1.3
23	25	Analog Devices	357	380	6	.8
24	NM	GEC Plessey	0	354	NM	.7
25	26	Rohm	343	348	1	.7
26	27	VLSI Technology	286	324	13	.7
27	23	Micron Technology	395	286	-28	.6
28	30	Chips & Technologies	240	265	10	.6
29	NM	Hewlett-Packard	0	230	NM	.5
30	35	Cypress Semiconductor	196	223	14	.5
31	24	Seiko Epson	368	213	-42	.5
32	31	ITT	235	210	-11	.4
33	28	NMB Semiconductor	247	201	-19	.4
34	36	Rockwell	165	200	21	.4
35	34	Integrated Device Technology	204	199	-2	.4
36	48	Silicon Systems	112	165	47	.3

(Continued)

Table 2 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
37	37	Sanken	156	164	5	.3
38	39	Goldstar	147	163	11	.3
39	38	New JRC	154	161	5	.3
40	40	Yamaha	143	153	7	.3
		All Others	5,470	4,553	-17	9.6
		North American Companies	17,400	18,877	8	39.9
		Japanese Companies	23,800	22,129	-7	46.8
		European Companies	3,915	4,398	12	9.3
		Asia/Pacific Companies	1,809	1,899	5	4.0
		Total Market	46,924	47,303	1	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 3
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 20
Product:	Bipolar Digital
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	2	Fujitsu	617	690	12	15.5
2	1	Texas Instruments	671	663	-1	14.9
3	3	Hitachi	479	510	6	11.5
4	5	National Semiconductor	458	423	-8	9.5
5	4	Advanced Micro Devices	474	407	-14	9.2
6	6	Motorola	369	406	10	9.1
7	8	NEC	302	295	-2	6.6
8	7	Philips	306	280	-8	6.3
9	11	Toshiba	102	113	11	2.5
10	9	Mitsubishi	125	105	-16	2.4
11	12	Sanyo	67	67	0	1.5
12	NM	GEC Plessey	0	66	NM	1.5
13	16	Harris	50	60	20	1.4
14	13	AT&T	56	59	5	1.3
15	14	Raytheon	55	54	-2	1.2
16	17	Oki	48	47	-2	1.1
17	15	Siemens	54	45	-17	1.0
18	18	Goldstar	32	26	-19	.6
19	19	Chips & Technologies	24	25	4	.6
20	20	Applied Micro Circuits Corp.	20	24	20	.5
		All Others	201	75	-63	1.7
		North American Companies	2,221	2,152	-3	48.5
		Japanese Companies	1,755	1,843	5	41.5
		European Companies	502	419	-17	9.4
		Asia/Pacific Companies	32	26	-19	.6
		Total Market	4,510	4,440	-2	100.0

NM = Not meaningful

Source: Dataquest (May 1991)

Table 4
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 10
Product:	Bipolar Digital Memory
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Fujitsu	190	158	-17	34.4
2	2	Hitachi	111	104	-6	22.7
3	3	Advanced Micro Devices	85	65	-24	14.2
4	5	Philips	47	45	-4	9.8
5	4	National Semiconductor	56	29	-48	6.3
6	6	NEC	25	22	-12	4.8
7	7	Raytheon	12	18	50	3.9
8	8	Texas Instruments	10	10	0	2.2
9	NM	Harris	0	5	NM	1.1
10	9	Motorola	4	3	-25	.7
		All Others	0	0	NM	.0
		North American Companies	167	130	-22	28.3
		Japanese Companies	326	284	-13	61.9
		European Companies	47	45	-4	9.8
		Asia/Pacific Companies	0	0	NM	.0
		Total Market	540	459	-15	100.0

NM = Not meaningful

Source: Dataquest (May 1991)

Table 5
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 20
Product:	Bipolar Logic & Microcomponent
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Texas Instruments	661	653	-1	16.4
2	2	Fujitsu	427	532	25	13.4
3	5	Hitachi	368	406	10	10.2
4	6	Motorola	365	403	10	10.1
5	3	National Semiconductor	402	394	-2	9.9
6	4	Advanced Micro Devices	389	342	-12	8.6
7	7	NEC	277	273	-1	6.9
8	8	Philips	259	235	-9	5.9
9	11	Toshiba	102	113	11	2.8
10	9	Mitsubishi	125	105	-16	2.6
11	12	Sanyo	67	67	0	1.7
12	NM	GEC Plessey	0	66	NM	1.7
13	13	AT&T	56	59	5	1.5
14	15	Harris	50	55	10	1.4
15	16	Oki	48	47	-2	1.2
16	14	Siemens	54	45	-17	1.1
17	17	Raytheon	43	36	-16	.9
18	18	Goldstar	32	26	-19	.7
19	19	Chips & Technologies	24	25	4	.6
20	20	Applied Micro Circuits Corp.	20	24	20	.6
		All Others	201	75	-63	1.9
		North American Companies	2,054	2,022	-2	50.8
		Japanese Companies	1,429	1,559	9	39.2
		European Companies	455	374	-18	9.4
		Asia/Pacific Companies	32	26	-19	.7
		Total Market	3,970	3,981	0	100.0

NM = Not meaningful

Source: Dataquest (May 1991)

Table 6
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company: Top 40
Product: MOS Digital
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
1	1	NEC	3,604	3,495	-3	10.8
2	3	Intel	2,420	3,157	30	9.8
3	2	Toshiba	3,100	2,905	-6	9.0
4	4	Hitachi	2,407	2,325	-3	7.2
5	6	Motorola	1,705	1,963	15	6.1
6	5	Fujitsu	1,958	1,785	-9	5.5
7	7	Mitsubishi	1,676	1,394	-17	4.3
8	8	Texas Instruments	1,603	1,367	-15	4.2
9	9	Samsung	1,066	1,146	8	3.5
10	10	Oki	1,028	949	-8	2.9
11	12	Sharp	837	913	9	2.8
12	11	Matsushita	854	819	-4	2.5
13	16	National Semiconductor	532	607	14	1.9
14	13	Siemens	641	600	-6	1.9
15	17	LSI Logic	512	596	16	1.8
16	14	SGS-Thomson	619	584	-6	1.8
17	15	Advanced Micro Devices	549	570	4	1.8
18	18	Philips	422	540	28	1.7
19	19	AT&T	411	461	12	1.4
20	22	Sony	371	392	6	1.2
21	21	Sanyo	378	371	-2	1.1
22	23	Harris	362	335	-7	1.0
23	25	VLSI Technology	286	324	13	1.0
24	20	Micron Technology	395	286	-28	.9
25	27	Chips & Technologies	216	240	11	.7
26	NM	Hewlett-Packard	0	230	NM	.7
27	31	Cypress Semiconductor	196	223	14	.7
28	24	Seiko Epson	354	201	-43	.6
29	26	NMB Semiconductor	247	201	-19	.6
30	30	Integrated Device Technology	203	196	-3	.6
31	28	United Microelectronics	210	150	-29	.5
32	33	Western Digital	135	148	10	.5
33	34	Yamaha	130	145	12	.4
34	67	Cirrus Logic	29	129	345	.4
35	36	Goldstar	106	117	10	.4
36	29	Hyundai	210	115	-45	.4

(Continued)

Table 6 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
36	39	NCR	94	115	22	.4
36	NM	GEC Plessey	0	115	NM	.4
39	32	ITT	185	107	-42	.3
40	38	Zilog	99	100	1	.3
		All Others	2,874	1,876	-35	5.8
		North American Companies	11,277	12,388	10	38.4
		Japanese Companies	18,006	16,123	-10	49.9
		European Companies	2,135	2,137	0	6.6
		Asia/Pacific Companies	1,606	1,644	2	5.1
		Total Market	33,024	32,292	-2	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 7
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40
Product:	MOS Memory
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Toshiba	1,918	1,626	-15	12.4
2	2	NEC	1,739	1,376	-21	10.5
3	3	Hitachi	1,534	1,366	-11	10.4
4	4	Fujitsu	1,265	1,006	-20	7.7
5	7	Samsung	935	971	4	7.4
6	5	Mitsubishi	1,161	853	-27	6.5
7	6	Texas Instruments	1,095	741	-32	5.7
8	8	Sharp	476	497	4	3.8
9	12	Motorola	407	395	-3	3.0
10	9	Oki	473	392	-17	3.0
11	10	Intel	433	371	-14	2.8
12	11	Siemens	416	320	-23	2.4
13	15	SGS-Thomson	269	299	11	2.3
14	13	Micron Technology	395	286	-28	2.2
15	14	Matsushita	370	284	-23	2.2
16	16	Advanced Micro Devices	258	253	-2	1.9
17	18	Sony	228	227	-0	1.7
18	17	NMB Semiconductor	247	201	-19	1.5
19	21	Cypress Semiconductor	149	166	11	1.3
20	23	National Semiconductor	138	143	4	1.1
21	20	Integrated Device Technology	158	132	-16	1.0
22	19	Hyundai	210	115	-45	.9
23	24	Sanyo	130	97	-25	.7
24	28	Goldstar	82	96	17	.7
24	30	Philips	60	96	60	.7
26	27	Xicor	87	68	-22	.5
27	25	United Microelectronics	102	66	-35	.5
28	29	Vitelic	66	64	-3	.5
29	22	Seiko Epson	141	62	-56	.5
30	26	Microchip Technology	94	60	-36	.5
31	31	Atmel	47	54	15	.4
32	NA	Hualon Microelectronic Corp.	NA	39	NA	.3
33	35	Matra MHS	31	37	19	.3
34	37	Catalyst	31	35	13	.3
35	32	SEEQ Technology	40	33	-18	.3
36	42	MOSel	20	31	55	.2

(Continued)

Table 7 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
37	34	Ricoh	31	29	-6	.2
38	38	Waferscale Integration	28	27	-4	.2
39	33	Harris	37	24	-35	.2
40	44	Performance Semiconductor	16	19	19	.1
		All Others	1,044	134	-87	1.0
		North American Companies	3,688	2,990	-19	22.8
		Japanese Companies	10,558	8,023	-24	61.3
		European Companies	786	760	-3	5.8
		Asia/Pacific Companies	1,329	1,318	-1	10.1
		Total Market	16,361	13,091	-20	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 8
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company: Top 40
Product: MOS Microcomponents
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Intel	1,929	2,726	41	27.1
2	2	NEC	937	1,083	16	10.8
3	3	Motorola	803	1,009	26	10.0
4	4	Hitachi	554	607	10	6.0
5	5	Mitsubishi	435	464	7	4.6
6	6	Toshiba	407	441	8	4.4
7	7	Texas Instruments	252	320	27	3.2
8	8	Matsushita	217	250	15	2.5
9	11	National Semiconductor	172	248	44	2.5
10	9	Chips & Technologies	216	240	11	2.4
11	10	Fujitsu	211	239	13	2.4
12	17	Philips	131	192	47	1.9
13	12	Advanced Micro Devices	172	178	3	1.8
14	13	SGS-Thomson	161	175	9	1.7
15	16	Western Digital	135	148	10	1.5
16	14	Oki	149	147	-1	1.5
17	15	AT&T	141	145	3	1.4
18	19	Sharp	112	138	23	1.4
19	31	Cirrus Logic	29	129	345	1.3
20	22	Siemens	92	116	26	1.2
21	18	Harris	115	110	-4	1.1
22	21	VLSI Technology	94	105	12	1.0
23	20	Zilog	99	100	1	1.0
24	24	LSI Logic	67	93	39	.9
25	23	Sanyo	70	80	14	.8
26	25	Weitek	49	57	16	.6
27	26	Sony	47	49	4	.5
28	28	Rockwell	42	40	-5	.4
28	29	Standard Microsystems	34	40	18	.4
30	27	United Microelectronics	43	39	-9	.4
31	30	Appian Technology	30	38	27	.4
32	32	Matra MHS	28	33	18	.3
33	35	NCR	22	31	41	.3
34	33	ITT	25	28	12	.3
35	40	Performance Semiconductor	13	24	85	.2
36	34	Ricoh	22	23	5	.2

(Continued)

Table 8 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
37	44	Samsung	8	22	175	.2
38	36	Analog Devices	20	20	0	.2
38	41	Integrated Device Technology	13	20	54	.2
40	38	Rohm	16	18	13	.2
		All Others	90	103	14	1.0
		North American Companies	4,526	5,912	31	58.7
		Japanese Companies	3,190	3,551	11	35.3
		European Companies	433	538	24	5.3
		Asia/Pacific Companies	53	67	26	.7
		Total Market	8,202	10,068	23	100.0

NM = Not meaningful

Source: Dataquest (May 1991)

Table 9
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company: Top 40
Product: MOS Logic
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
1	1	NEC	928	1,036	12	11.3
2	2	Toshiba	775	838	8	9.2
3	3	Motorola	495	559	13	6.1
4	4	Fujitsu	482	540	12	5.9
5	5	LSI Logic	445	503	13	5.5
6	6	Oki	406	410	1	4.5
7	7	Hitachi	319	352	10	3.9
8	10	Texas Instruments	256	306	20	3.4
9	9	AT&T	257	303	18	3.3
10	8	Matsushita	267	285	7	3.1
11	11	Sharp	249	278	12	3.0
12	12	Philips	231	252	9	2.8
13	NM	Hewlett-Packard	0	230	NM	2.5
14	13	National Semiconductor	222	216	-3	2.4
15	18	VLSI Technology	169	211	25	2.3
16	14	Harris	210	201	-4	2.2
17	17	Sanyo	178	194	9	2.1
18	20	Siemens	133	164	23	1.8
19	22	Samsung	123	153	24	1.7
20	21	Yamaha	130	145	12	1.6
21	23	Advanced Micro Devices	119	139	17	1.5
22	15	Seiko Epson	201	128	-36	1.4
23	24	Sony	96	116	21	1.3
24	16	SGS-Thomson	189	110	-42	1.2
25	NM	GEC Plessey	0	99	NM	1.1
26	34	Xilinx	44	84	91	.9
27	29	NCR	64	80	25	.9
28	19	ITT	150	79	-47	.9
29	30	Altera	59	78	32	.9
30	25	Mitsubishi	80	77	-4	.8
31	41	Lattice	31	62	100	.7
32	31	Intel	58	60	3	.7
33	27	Gould AMI	76	53	-30	.6
34	28	United Microelectronics	65	45	-31	.5
35	36	Ricoh	38	44	16	.5
35	40	Integrated Device Technology	32	44	38	.5

(Continued)

Table 9 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
35	46	Atmel	26	44	69	.5
38	37	Cypress Semiconductor	36	42	17	.5
39	35	Rohm	40	40	0	.4
40	39	New JRC	34	38	12	.4
		All Others	748	495	-34	5.4
		North American Companies	3,063	3,486	14	38.2
		Japanese Companies	4,258	4,549	7	49.8
		European Companies	916	839	-8	9.2
		Asia/Pacific Companies	224	259	16	2.8
		Total Market	8,461	9,133	8	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 10
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company: Top 40
Product: Analog
Region of Consumption: Worldwide
Distribution Channel: NM
Application: All
Specification: All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	4	Philips	522	653	25	6.2
2	2	National Semiconductor	558	619	11	5.9
3	1	Toshiba	572	610	7	5.8
4	8	SGS-Thomson	393	554	41	5.2
5	3	Sanyo	530	541	2	5.1
6	5	Motorola	445	491	10	4.6
7	6	Texas Instruments	417	458	10	4.3
8	9	Mitsubishi	384	441	15	4.2
9	7	NEC	415	417	0	3.9
10	10	Matsushita	376	410	9	3.9
11	11	Sony	361	399	11	3.8
12	12	Analog Devices	337	360	7	3.4
13	13	Hitachi	332	347	5	3.3
14	15	Rohm	277	282	2	2.7
15	14	Harris	280	260	-7	2.5
16	16	AT&T	249	197	-21	1.9
17	19	Siemens	152	190	25	1.8
18	NM	GEC Plessey	0	173	NM	1.6
19	24	Silicon Systems	112	165	47	1.6
20	17	Fujitsu	163	164	1	1.6
20	18	Sanken	156	164	5	1.6
22	21	Rockwell	123	160	30	1.5
23	20	Burr-Brown	141	145	3	1.4
24	22	New JRC	119	122	3	1.2
25	25	Telefunken Electronic	101	111	10	1.1
26	35	ITT	50	103	106	1.0
27	26	Allegro MicroSystems	98	96	-2	.9
28	23	Samsung	116	92	-21	.9
29	27	Precision Monolithics	88	91	3	.9
30	29	Linear Technology	70	83	19	.8
31	28	Advanced Micro Devices	77	76	-1	.7
32	37	Exar	46	75	63	.7
33	30	Sharp	65	73	12	.7
34	NM	Mietec	0	72	NM	.7
35	33	Brooktree	52	70	35	.7
36	38	Maxim	43	65	51	.6

(Continued)

Table 10 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
37	44	Sierra Semiconductor	28	55	96	.5
38	31	Siliconix	54	54	0	.5
38	NA	Toko	NA	54	NA	.5
40	39	Fuji Electric	43	51	19	.5
		All Others	1,045	1,028	-2	9.7
		North American Companies	3,902	4,337	11	41.0
		Japanese Companies	4,039	4,163	3	39.4
		European Companies	1,278	1,842	44	17.4
		Asia/Pacific Companies	171	229	34	2.2
		Total Market	9,390	10,571	13	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 11
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40
Product:	Total Discrete
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Toshiba	848	904	7	11.0
2	2	Motorola	775	808	4	9.8
3	3	Hitachi	690	641	-7	7.8
4	4	NEC	574	567	-1	6.9
5	5	Philips	442	507	15	6.2
6	7	Matsushita	332	374	13	4.5
7	6	Mitsubishi	364	348	-4	4.2
8	8	Rohm	301	321	7	3.9
9	10	SGS-Thomson	282	315	12	3.8
10	9	Fuji Electric	287	304	6	3.7
11	11	Siemens	232	258	11	3.1
12	12	Sanyo	230	232	1	2.8
13	13	Sanken	213	224	5	2.7
13	14	International Rectifier	187	224	20	2.7
15	15	General Instrument	170	214	26	2.6
16	NA	Shindengen Electric	NA	176	NA	2.1
17	16	ITT	155	161	4	2.0
18	17	AT&T	147	130	-12	1.6
18	18	Harris	120	130	8	1.6
20	19	Fujitsu	109	117	7	1.4
21	20	Powerex	105	112	7	1.4
22	23	Semikron	95	106	12	1.3
23	NM	Eupec	0	96	NM	1.2
24	21	Sony	96	85	-11	1.0
25	25	Korean Electronic Co.	74	79	7	1.0
26	24	Samsung	78	77	-1	.9
27	22	Telefunken Electronic	95	76	-20	.9
28	26	National Semiconductor	70	70	0	.9
29	27	Siliconix	67	62	-7	.8
30	31	ABB-IXYS	50	58	16	.7
31	30	Hewlett-Packard	56	56	0	.7
32	29	Unitrode	59	54	-8	.7
33	28	Texas Instruments	60	53	-12	.6
34	NA	Microsemi	NA	50	NA	.6
35	NM	GEC Plessey	0	36	NM	.4
36	32	Fagor	29	30	3	.4

(Continued)

Table 11 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
37	36	TAG	22	25	14	.3
38	33	Solitron	27	24	-11	.3
39	NM	Zetex	0	23	NM	.3
40	35	Allegro MicroSystems	23	17	-26	.2
		All Others	198	91	-54	1.1
		North American Companies	2,120	2,203	4	26.8
		Japanese Companies	4,091	4,313	5	52.4
		European Companies	1,284	1,541	20	18.7
		Asia/Pacific Companies	167	178	7	2.2
		Total Market	7,662	8,235	7	100.0

NA = Not available

NM = Not meaningful

Source: Dataquest (May 1991)

Table 12
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 20
Product:	Total Optoelectronic
Region of Consumption:	Worldwide
Distribution Channel:	NM
Application:	All
Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change (%)	1990 Market Share (%)
1	1	Sharp	328	339	3	12.6
2	3	Matsushita	306	325	6	12.1
3	2	Toshiba	308	311	1	11.6
4	4	Sony	249	270	8	10.0
5	5	Hewlett-Packard	213	223	5	8.3
6	6	Sanyo	160	170	6	6.3
7	9	Siemens	115	131	14	4.9
8	7	NEC	120	124	3	4.6
8	8	Fujitsu	116	124	7	4.6
10	10	Rohm	96	105	9	3.9
11	11	Telefunken Electronic	78	78	0	2.9
12	13	Hitachi	66	70	6	2.6
13	12	Optek	77	66	-14	2.5
14	14	Quality Technologies	38	34	-11	1.3
15	15	Texas Instruments	36	33	-8	1.2
15	16	Oki	33	33	0	1.2
17	18	Mitsubishi	30	31	3	1.2
17	20	Philips	24	31	29	1.2
19	19	Motorola	25	26	4	1.0
20	17	Honeywell	31	25	-19	.9
		All Others	178	138	-22	5.1
		North American Companies	458	457	-0	17.0
		Japanese Companies	1,918	1,935	1	72.0
		European Companies	244	267	9	9.9
		Asia/Pacific Companies	7	28	300	1.0
		Total Market	2,627	2,687	2	100.0

NM = Not meaningful

Source: Dataquest (May 1991)

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North American Semiconductor Price Outlook

Fourth Quarter 1991

Source: Dataquest

Semiconductor Procurement

Dataquest

North American Semiconductor Price Outlook

Fourth Quarter 1991

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Semiconductor Procurement

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North American Semiconductor Price Outlook: Fourth Quarter 1991

Methodology and Sources

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

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

Price Variations

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

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74LS TTL												1-6
74LS00	.098	.100	.100	.100	.100	.100	.105	.105	.110	.110	.108	
74LS74	.115	.115	.115	.115	.115	.115	.117	.117	.117	.117	.117	
74LS138	.156	.150	.150	.150	.150	.150	.155	.155	.155	.155	.155	
74LS244	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	
74LS373	.216	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	
74S TTL												1-6
74S00	.141	.140	.140	.140	.140	.140	.140	.140	.140	.140	.140	
74S74	.174	.174	.174	.174	.174	.174	.170	.170	.170	.170	.170	
74S138	.258	.259	.259	.259	.259	.259	.259	.259	.259	.259	.259	
74S244	.528	.515	.505	.500	.500	.505	.500	.500	.500	.500	.500	
74S373	.529	.515	.500	.500	.500	.504	.500	.500	.500	.500	.500	
74F TTL												1-6
74FOO	.100	.100	.100	.100	.100	.100	.100	.100	.100	.100	.100	
74F74	.118	.118	.118	.117	.117	.118	.116	.116	.116	.116	.116	
74F138	.172	.168	.168	.163	.160	.165	.157	.155	.153	.152	.154	
74F244	.244	.230	.230	.228	.227	.229	.223	.220	.217	.214	.219	
74F373	.241	.230	.230	.228	.227	.229	.223	.220	.217	.214	.219	
74HC CMOS												1-8
74HC00	.100	.105	.105	.105	.105	.105	.105	.105	.110	.110	.108	
74HC74	.119	.120	.120	.120	.120	.120	.120	.120	.125	.125	.123	
74HC138	.154	.155	.155	.157	.158	.156	.158	.158	.158	.158	.158	
74HC244	.236	.230	.230	.230	.230	.230	.235	.235	.235	.235	.235	
74HC373	.235	.230	.230	.230	.230	.230	.235	.235	.235	.235	.235	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Family	1990	1991	1992	1993	1994	1995
74LS TTL						
74LS00	.098	.100	.108	.110	.110	.110
74LS74	.115	.115	.117	.117	.117	.117
74LS138	.156	.150	.155	.152	.152	.152
74LS244	.215	.215	.215	.205	.199	.195
74LS373	.216	.215	.215	.206	.199	.195
74S TTL						
74S00	.141	.140	.140	.140	.140	.142
74S74	.174	.174	.170	.174	.174	.174
74S138	.258	.259	.259	.259	.259	.259
74S244	.528	.505	.500	.500	.500	.500
74S373	.529	.504	.500	.500	.500	.500
74F TTL						
74FOO	.100	.100	.100	.102	.107	.107
74F74	.118	.118	.116	.114	.108	.105
74F138	.172	.165	.154	.150	.149	.147
74F244	.244	.229	.219	.216	.214	.213
74F373	.241	.229	.219	.215	.214	.214
74HC CMOS						
74HC00	.100	.105	.108	.110	.110	.110
74HC74	.119	.120	.123	.128	.128	.128
74HC138	.154	.156	.158	.160	.160	.162
74HC244	.236	.230	.235	.238	.240	.242
74HC373	.235	.230	.235	.238	.240	.241

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74AC CMOS												1-6
74AC00	.218	.200	.193	.190	.187	.193	.183	.182	.181	.180	.181	
74AC74	.282	.267	.264	.260	.260	.263	.255	.254	.253	.253	.254	
74AC138	.359	.345	.340	.330	.315	.333	.305	.300	.295	.290	.298	
74AC244	.516	.497	.495	.480	.467	.485	.455	.445	.435	.425	.440	
74AC373	.538	.525	.515	.500	.495	.509	.490	.488	.485	.483	.486	
74ALS TTL												1-6
74ALS00	.136	.136	.130	.125	.123	.128	.120	.118	.115	.115	.117	
74ALS74	.168	.165	.155	.150	.145	.154	.140	.135	.130	.130	.134	
74ALS138	.285	.286	.280	.275	.270	.278	.260	.260	.260	.260	.260	
74ALS244	.393	.385	.383	.381	.380	.382	.373	.371	.367	.364	.369	
74ALS373	.393	.385	.383	.381	.380	.382	.373	.371	.367	.364	.369	
74AS TTL												1-6
74AS00	.172	.172	.172	.169	.165	.170	.160	.160	.160	.160	.160	
74AS74	.179	.180	.180	.180	.180	.180	.180	.180	.180	.180	.180	
74AS138	.444	.460	.460	.460	.460	.460	.430	.430	.430	.430	.430	
74AS244	.770	.760	.760	.750	.750	.755	.740	.740	.740	.740	.740	
74AS373	.776	.750	.740	.735	.730	.739	.730	.730	.730	.730	.730	
74BC*												4-6
74BC00	.398	.344	.333	.323	.314	.328	.297	.286	.279	.272	.284	
74BC244	.906	.846	.809	.779	.752	.796	.725	.698	.672	.648	.686	
74BC373	.909	.849	.811	.781	.754	.799	.726	.700	.674	.649	.687	
10KH ECL												6
10H102	.494	.490	.490	.490	.490	.490	.490	.490	.490	.490	.490	
10H131	NA	1.200	1.200	1.200	1.200	1.200	1.100	1.100	1.100	1.100	1.100	
10H173	1.200	1.200	1.200	1.200	1.200	1.200	1.100	1.100	1.100	1.100	1.100	

NA = Not available
*Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Family	1990	1991	1992	1993	1994	1995
74AC CMOS						
74AC00	.218	.193	.181	.176	.173	.170
74AC74	.282	.263	.254	.240	.225	.220
74AC138	.359	.333	.298	.280	.276	.270
74AC244	.516	.485	.440	.412	.403	.395
74AC373	.538	.509	.486	.447	.418	.399
74ALS TTL						
74ALS00	.136	.128	.117	.115	.115	.115
74ALS74	.168	.154	.134	.130	.130	.135
74ALS138	.285	.278	.260	.257	.252	.249
74ALS244	.393	.382	.369	.363	.359	.356
74ALS373	.393	.382	.369	.363	.360	.357
74AS TTL						
74AS00	.172	.170	.160	.160	.160	.160
74AS74	.179	.180	.180	.179	.179	.179
74AS138	.444	.460	.430	.410	.405	.398
74AS244	.770	.755	.740	.720	.690	.669
74AS373	.776	.739	.730	.720	.680	.659
74BC*						
74BC00	.398	.328	.284	.267	.260	.242
74BC244	.906	.796	.686	.640	.611	.587
74BC373	.909	.799	.687	.610	.612	.588
10KH ECL						
10H102	.494	.490	.490	.490	.490	.490
10H131	NA	1.200	1.100	1.100	1.100	1.100
10H173	1.200	1.200	1.100	1.100	1.100	1.100

NA = Not available
*Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8-Bit MPUs												
Z84C00-6	1.04	.99	.98	.98	.98	.98	.94	.94	.92	.92	.93	5-8
16-Bit MPUs												
68000-8	3.32	4.00	4.00	3.75	3.75	3.88	3.50	3.50	3.50	3.50	3.50	2-4
68000-12	5.98	5.65	5.60	5.55	5.50	5.58	5.50	5.50	5.50	5.50	5.50	2-4
68EC000-8	NA	NA	NA	3.00	3.00	NA	3.00	2.95	2.85	2.85	2.91	4-8
68302-16	NA	NA	NA	NA	30.00	NA	28.00	26.00	22.00	21.00	24.25	4-8
80186-8 PLCC	7.91	6.70	6.37	6.15	5.94	6.29	5.76	5.59	5.47	5.40	5.55	6-8
80C186-10 PLCC	NA	NA	NA	13.95	13.95	NA	13.90	13.85	13.75	13.70	13.80	NA
80286-10 PLCC	9.37	6.92	6.57	6.37	6.15	6.50	5.95	5.76	5.59	5.40	5.68	1-10
80286-12 PLCC	12.00	7.50	6.99	6.75	6.54	6.95	6.35	6.14	5.93	5.80	6.06	1-10
80286-16 PLCC	NA	15.88	13.89	12.75	11.50	13.50	9.75	8.24	7.25	6.50	7.94	1-10
80287-12	NA	NA	111.30	105.74	85.00	75.51	78.00	70.00	63.00	59.00	67.50	1-10
CISC 32-Bit MPUs/Peripherals												
68020-16 PQFP	NA	37.73	36.92	36.11	32.00	35.69	30.00	30.00	30.00	30.00	30.00	2-4
68881-16 PLCC	NA	26.00	23.50	20.00	18.00	21.88	15.00	15.00	14.25	14.00	14.56	2-4
68EC020-16 PQFP	NA	NA	NA	NA	25.00	NA	24.50	24.25	24.00	24.00	24.19	4-8
68020-25 PQFP[1]	131.20	NA	NA	NA	40.00	NA	36.00	36.00	34.50	34.00	35.13	2-4
68030-16 CQFP[1]	138.00	NA	85.00	82.00	78.50	NA	77.00	76.00	75.00	75.00	75.75	2-4
68882-16	87.51	65.00	55.00	45.00	35.00	50.00	31.00	30.50	29.50	29.00	30.00	2-4
68030-25 CQFP[2]	189.28	167.00	163.00	159.00	155.00	161.00	120.00	119.00	116.00	115.00	117.50	5-10
68EC030-25 PQFP	NA	NA	NA	NA	40.00	NA	37.00	36.50	35.25	35.00	35.94	4-8
68040-25	730.38	593.25	554.09	517.16	490.91	538.85	455.08	430.10	413.90	400.90	425.00	4-8
68330-16	NA	NA	NA	NA	19.00	NA	18.00	18.00	17.50	17.50	17.75	4-8
68340-16	NA	NA	NA	NA	25.00	NA	24.00	23.25	22.50	22.25	23.00	2-4
80386SX-16 PQFP	62.73	60.50	58.88	57.42	56.35	58.29	55.75	55.35	54.37	54.03	54.87	6-12
80386SX-20 PQFP	NA	94.00	91.18	88.00	84.90	89.52	82.91	80.96	78.51	76.53	79.73	6-12

(Continued)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
CISC 32-Bit MPUs/Peripherals (Continued)												
AM386-40	NA	NA	231.00	199.00	190.00	NA	180.50	171.48	163.00	154.00	167.25	6
80386-25	184.21	162.20	159.00	157.50	153.50	158.05	149.00	145.00	142.00	138.50	143.63	6-8
80387-25[3]	326.78	308.00	277.00	249.30	239.50	268.45	234.00	229.00	224.00	220.00	226.75	4-8
80486-25	790.39	690.00	585.00	445.00	425.00	536.25	415.00	405.00	396.00	388.00	401.00	6-8
80486-33	NA	756.86	627.00	445.00	425.00	563.46	415.00	405.00	396.00	388.00	401.00	6-8
80486SX-20[3]	NA	NA	258.00	247.68	230.34	NA	218.83	210.07	205.87	203.81	209.65	12
RISC 32-Bit MPUs												
29000-25	NA	135.00	112.00	102.00	98.00	111.75	93.50	89.00	85.00	81.00	87.13	8
88100-25	NA	82.25	77.00	74.00	71.00	76.06	69.50	68.05	67.45	67.00	68.00	4-8
R3000-25	NA	150.00	135.00	127.00	119.00	132.75	112.00	106.00	100.00	95.00	103.25	6-9
SPARC-25	NA	100.35	90.72	84.70	79.21	88.74	75.62	72.30	69.51	66.55	71.00	NA

NA = Not available
[1] CPGA for 1990.
[2] CPGA for 1990-1991.
[3] Volume of <1000 pieces for 80387-25 and 80486SX-20.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Family	1990	1991	1992	1993	1994	1995
8-Bit MPUs						
Z84C00-6	1.04	.98	.93	.92	.89	.88
16-Bit MPUs						
68000-8	3.32	3.88	3.50	3.50	3.50	3.53
68000-12	5.98	5.58	5.50	5.45	5.45	5.45
80186-8 PLCC	7.91	6.29	5.55	5.35	5.30	5.30
80286-10 PLCC	9.37	6.50	5.68	5.34	5.34	5.34
80286-12 PLCC	12.00	6.95	6.06	5.60	5.40	5.35
80286-16 PLCC	NA	13.50	7.94	6.25	5.75	5.50
80287-12	NA	75.51	67.50	59.00	NA	NA
CISC 32-Bit MPUs/Peripherals						
68020-16 PQFP	NA	35.69	30.00	30.00	29.97	29.97
68881-16 PLCC	NA	21.88	14.56	14.00	14.00	14.00
68020-25 PQFP[1]	131.20	NA	35.13	33.00	32.00	31.00
68030-16 PQFP[1]	138.00	NA	75.75	74.00	73.00	73.03
68882-16	87.51	50.00	30.00	28.50	28.00	27.75
68030-25 PQFP[2]	189.28	161.00	117.50	113.00	110.00	110.00
68040-25	730.38	538.85	425.00	370.00	350.00	340.00
80386SX-16 PQFP	62.73	58.29	54.87	51.75	NA	NA
80386SX-20 PQFP	NA	89.52	79.73	74.00	71.50	71.50
AM386-40	NA	NA	167.25	146.00	140.00	134.00
80386-25	184.21	158.05	143.63	135.00	133.00	133.00
80387-25[3]	326.78	268.45	226.75	204.00	199.00	199.00
80486-25	790.39	536.25	401.00	355.00	355.00	355.00
80486-33	NA	563.46	401.00	355.00	355.00	355.00
80486SX-20[3]	NA	NA	209.65	199.72	194.74	194.74

(Continued)

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

Family	1990	1991	1992	1993	1994	1995
RISC 32-Bit MPUs						
29000-25	NA	111.75	87.13	77.50	74.50	70.00
88100-25	NA	76.06	68.00	61.25	56.00	51.00
R3000-25	NA	132.75	103.25	88.00	84.50	79.90
SPARC-25	NA	88.74	71.00	62.40	59.00	53.66

NA = Not available
[1]CPGA for 1990.
[2]CPGA for 1990-1991.
[3]Volume of <1000 pieces for 80387-25 and 80486SX-20.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
256Kx1 DRAM 100-120ns (DIP)	1.93	1.77	1.77	1.77	1.77	1.77	1.81	1.81	1.81	1.81	1.81	1-8
64Kx4 DRAM 100ns (DIP)	1.98	1.80	1.80	1.80	1.80	1.80	1.86	1.86	1.86	1.86	1.86	1-12
64Kx4 VRAM 120ns (ZIP)[2]	4.06	3.28	3.25	3.16	3.10	3.20	3.06	3.03	2.99	2.96	3.01	2-12
1Mbx1 DRAM 80ns (DIP/SOJ)	6.06	4.55	4.50	4.33	4.18	4.39	4.08	4.01	3.95	3.88	3.98	1-8
256Kx4 DRAM 80-100ns (SOJ)	6.09	4.57	4.53	4.34	4.19	4.41	4.09	4.02	3.96	3.89	3.99	1-8
64Kx16 DRAM 80ns (SOJ)	NA	7.70	7.30	6.76	6.29	7.01	5.95	5.75	5.58	5.42	5.68	4-8
256Kx4 VRAM 120ns (ZIP)[2]	13.91	10.06	9.42	9.05	8.72	9.31	8.43	8.20	8.00	7.88	8.13	4-12
128Kx8 VRAM 100ns (SOJ)[2]	NA	11.35	10.20	9.55	9.10	10.05	8.85	8.60	8.34	8.10	8.47	4-14
4Mbx1 DRAM 80ns (SOJ, 300 mil)	36.36	19.99	17.55	16.00	14.75	17.07	13.75	13.05	12.27	11.70	12.69	1-12
1Mbx8 SIMM 100ns	54.71	39.49	39.24	38.30	37.20	38.56	36.12	35.25	34.51	33.68	34.89	4-10
1Mbx9 SIMM 80ns[3]	61.14	44.43	44.55	43.67	42.80	43.86	36.80	34.50	33.28	31.00	33.90	3-9
256Kx9 SIMM 100ns	17.10	14.20	13.99	13.88	13.34	13.85	12.87	12.85	12.85	12.89	12.87	1-8
256Kx36 SIMM 80ns	66.37	50.96	51.44	49.79	48.24	50.11	47.75	47.40	47.20	47.10	47.36	5-8

NA = Not available
[1] Contract volume = at least 100,000 per order except as specified
[2] Contract volume may be less than 100,000 per order
[3] 3-piece solution for 1992
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
256Kx1 DRAM 100-120ns (DIP)	1.93	1.77	1.81	2.00	2.00	2.10
64Kx4 DRAM 100ns (DIP)	1.98	1.80	1.86	2.00	2.00	2.10
64Kx4 VRAM 120ns (ZIP)[2]	4.06	3.20	3.01	2.90	2.88	2.87
1Mbx1 DRAM 80ns (DIP/SOJ)	6.06	4.39	3.98	3.85	3.85	3.90
256Kx4 DRAM 80-100ns (SOJ)	6.09	4.41	3.99	3.89	3.88	3.91
64Kx16 DRAM 80ns (SOJ)	NA	7.01	5.68	4.54	4.29	4.20
256Kx4 VRAM 120ns (ZIP)[2]	13.91	9.31	8.13	7.45	7.05	6.75
128Kx8 VRAM 100ns (SOJ)[2]	NA	10.05	8.47	7.88	7.52	7.11
4Mbx1 DRAM 80ns (SOJ, 300 mil)	36.36	17.07	12.69	10.75	8.90	8.00
1Mbx8 SIMM 100ns	54.71	38.56	34.89	33.38	32.96	33.38
1Mbx9 SIMM 80ns[3]	61.14	43.86	33.90	NA	NA	NA
256Kx9 SIMM 100ns	17.10	13.85	12.87	12.00	12.00	12.00
256Kx36 SIMM 80ns	66.37	50.11	47.36	38.71	38.41	36.48

NA - Not available
[1] Contract volume - at least 100,000 per order except as specified
[2] Contract volume may be less than 100,000 per order
[3] 3-piece solution for 1992
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
Fast 4Kx4 (25ns)	2.88	2.40	2.40	2.40	2.40	2.40	2.30	2.30	2.30	2.30	2.30	2-12
Fast 2Kx8 (25ns)	3.49	2.60	2.56	2.40	2.40	2.49	2.45	2.45	2.50	2.50	2.48	2-13
Fast 64Kx1 (25ns)	4.27	3.59	3.53	3.53	3.60	3.56	3.65	3.65	3.65	3.65	3.65	2-12
Fast 16Kx4 (25ns)	4.54	3.64	3.58	3.50	3.45	3.54	3.40	3.35	3.30	3.30	3.34	7-14
Fast 8Kx8 (25ns)	5.14	3.95	3.85	3.64	3.46	3.73	3.35	3.30	3.25	3.25	3.29	1-Alloccation
Fast 16Kx4 (35ns)	3.97	3.22	3.18	3.08	3.03	3.13	3.01	3.01	3.00	3.00	3.01	6-11
Fast 8Kx8 (45ns)	3.98	3.25	3.20	3.15	3.13	3.18	3.10	3.10	3.08	3.08	3.09	7-Allocation
Slow 8Kx8 (120-150ns)	1.96	2.00	2.00	2.00	2.00	2.00	2.15	2.15	2.15	2.15	2.15	1-10
Fast 64Kx4 (25ns)	15.71	11.00	10.25	9.30	9.08	9.91	8.75	8.63	8.57	8.52	8.62	1-10
Fast 32Kx8 (35ns)	14.74	9.97	8.78	8.00	7.63	8.59	7.30	6.95	6.80	6.65	6.93	5-10
Slow 32Kx8 (100ns)	5.37	4.35	4.22	4.12	4.10	4.20	4.13	4.13	4.13	4.13	4.13	4-9
Slow 128Kx8 (100ns)	30.79	19.27	15.99	15.27	14.50	16.26	13.92	13.45	12.98	12.53	13.22	2-10
Fast 128Kx8 (25ns)	NA	85.00	70.00	62.50	55.10	68.15	52.06	48.00	43.00	38.00	45.27	8-12

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
Fast 4Kx4 (25ns)	2.88	2.40	2.30	2.30	2.50	2.55
Fast 2Kx8 (25ns)	3.49	2.49	2.48	2.65	2.67	2.67
Fast 64Kx1 (25ns)	4.27	3.56	3.65	3.65	3.67	3.67
Fast 16Kx4 (25ns)	4.54	3.54	3.34	3.50	3.60	3.73
Fast 8Kx8 (25ns)	5.14	3.73	3.29	3.30	3.55	4.00
Fast 16Kx4 (35ns)	3.97	3.13	3.01	3.12	3.14	3.15
Fast 8Kx8 (45ns)	3.98	3.18	3.09	3.15	3.20	3.20
Slow 8Kx8 (120-150ns)	1.96	2.00	2.15	2.35	2.40	2.40
Fast 64Kx4 (25ns)	15.71	9.91	8.62	7.52	6.75	5.99
Fast 32Kx8 (35ns)	14.74	8.59	6.93	5.95	5.55	5.50
Slow 32Kx8 (100ns)	5.37	4.20	4.13	4.20	4.25	4.25
Slow 128Kx8 (100ns)	30.79	16.26	13.22	9.90	7.75	7.50
Fast 128Kx8 (25ns)	NA	68.15	45.27	31.30	24.32	23.10

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (September 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
CMOS												
32Kx8 ROM	1.75	1.60	1.60	1.60	1.60	1.60	1.63	1.63	1.63	1.63	1.63	4-10
64Kx8 ROM	2.40	2.15	2.10	2.05	2.02	2.08	2.00	1.95	1.90	1.90	1.94	5-10
128Kx8 ROM	3.06	2.38	2.33	2.24	2.21	2.29	2.16	2.11	2.06	2.01	2.09	4-10
64Kx16 ROM	NA	3.18	3.02	2.75	2.55	2.87	2.40	2.28	2.19	2.09	2.24	5-9
256Kx8 ROM	3.90	3.45	3.29	3.18	3.13	3.26	3.09	3.05	3.01	2.96	3.03	4-10
512Kx8 ROM	5.43	4.05	4.02	3.97	3.90	3.99	3.85	3.70	3.65	3.60	3.70	4-12
256Kx16 ROM*	NA	5.52	5.21	4.98	4.79	5.12	4.59	4.45	4.35	4.27	4.42	5-12

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
CMOS						
32Kx8 ROM	1.75	1.60	1.63	2.00	NA	NA
64Kx8 ROM	2.40	2.08	1.94	2.35	2.55	2.55
128Kx8 ROM	3.06	2.29	2.09	2.01	2.01	2.01
64Kx16 ROM	NA	2.87	2.24	2.07	2.05	2.04
256Kx8 ROM	3.90	3.26	3.03	2.90	2.79	2.73
512Kx8 ROM	5.43	3.99	3.70	3.46	3.30	3.22
256Kx16 ROM*	NA	5.12	4.42	4.11	3.98	3.92

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
TTL												
4K PROM PDIP	.94	.95	.97	.98	.99	.97	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM PDIP	2.14	2.15	2.20	2.30	2.40	2.26	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM PDIP	6.38	5.57	5.12	4.71	4.80	5.05	4.70	4.60	4.50	4.50	4.58	6-8
64K PROM PDIP	7.89	7.18	7.00	6.86	6.75	6.95	6.62	6.47	6.36	6.23	6.42	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
TTL						
4K PROM PDIP	.94	.97	1.00	NA	NA	NA
16K PROM PDIP	2.14	2.26	2.40	2.40	NA	NA
32K PROM PDIP	6.38	5.05	4.58	4.50	4.50	NA
64K PROM PDIP	7.89	6.95	6.42	5.92	5.54	5.45

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
8Kx8 EPROM	1.75	1.65	1.69	1.77	1.79	1.73	1.81	1.83	1.84	1.85	1.83	2-8
16Kx8 EPROM	2.19	1.81	1.81	1.81	1.81	1.81	1.99	1.99	2.01	2.01	2.00	2-8
32Kx8 EPROM	2.02	1.92	1.92	1.92	1.93	1.92	2.01	2.02	2.02	2.03	2.02	2-10
64Kx8 EPROM	3.10	2.80	2.75	2.65	2.65	2.71	2.63	2.60	2.60	2.60	2.61	3-12
128Kx8 EPROM	5.96	4.80	4.46	4.31	4.22	4.45	3.99	3.90	3.82	3.74	3.86	4-10
256Kx8 EPROM	NA	12.00	10.00	9.20	8.32	9.88	7.67	7.05	6.51	6.12	6.84	4-14
512Kx8 EPROM*	NA	NA	NA	NA	16.98	NA	16.00	14.83	13.72	12.78	14.33	NA

NA = Not available
*Estimated and not by survey
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
8Kx8 EPROM	1.75	1.73	1.83	2.65	2.90	2.99
16Kx8 EPROM	2.19	1.81	2.00	2.74	3.00	3.05
32Kx8 EPROM	2.02	1.92	2.02	2.35	3.00	3.00
64Kx8 EPROM	3.10	2.71	2.61	2.60	3.00	3.05
128Kx8 EPROM	5.96	4.45	3.86	3.74	3.74	4.01
256Kx8 EPROM	NA	9.88	6.84	6.00	5.60	5.40
512Kx8 EPROM*	NA	NA	14.33	NA	NA	NA

NA = Not available
*Estimated and not by survey
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.68	1.40	1.40	1.48	1.53	1.45	1.53	1.53	1.53	1.53	1.53	1-12
32Kx8	1.77	1.44	1.47	1.55	1.56	1.51	1.56	1.56	1.56	1.56	1.56	2-12
64Kx8	3.08	2.51	2.51	2.51	2.50	2.51	2.43	2.42	2.41	2.40	2.42	2-12
128Kx8	NA	4.55	4.31	4.10	3.97	4.23	3.86	3.76	3.67	3.57	3.72	6-12

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
16Kx8	1.68	1.45	1.53	NA	NA	NA
32Kx8	1.77	1.51	1.56	NA	NA	NA
64Kx8	3.08	2.51	2.42	2.40	2.65	2.75
128Kx8	NA	4.23	3.72	3.51	3.44	3.40

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K EEPROM	3.28	3.25	3.20	3.00	2.95	3.10	2.95	2.90	2.90	2.90	2.91	1-7
8Kx8 EEPROM	5.26	4.90	4.70	4.55	4.40	4.64	4.20	4.14	3.99	3.95	4.07	1-8
32Kx8 EEPROM	40.08	23.00	20.60	18.60	17.00	19.80	14.00	12.40	11.00	9.78	11.80	1-8
64Kx8 EEPROM	NA	99.00	60.00	40.00	25.00	56.00	21.25	19.13	17.21	15.84	18.36	1-8
128Kx8 EEPROM	NA	150.0	132.0	118.0	110.0	127.5	100.00	87.00	75.00	65.0	81.8	1-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

Table 20

Estimated Long-Range EEPROM Price Trends—North American Bookings

(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and Above; Dollars)

Product	1990	1991	1992	1993	1994	1995
16K EEPROM	3.28	3.10	2.91	2.85	2.80	2.80
8Kx8 EEPROM	5.26	4.64	4.07	3.74	3.58	3.46
32Kx8 EEPROM	40.08	19.80	11.80	9.30	8.95	8.55
64Kx8 EEPROM	NA	56.00	18.36	13.46	11.20	10.86
128Kx8 EEPROM	NA	127.50	81.75	52.00	41.60	33.77

NA = Not available

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

Source: Dataquest (September 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
32Kx8, PDIP	NA	6.45	6.00	5.80	5.65	5.98	5.35	5.15	4.97	4.80	5.07	5-10
128Kx8, TSOP	NA	16.00	13.90	13.00	12.00	13.73	10.75	10.10	9.25	8.50	9.65	5-9
256Kx8, TSOP	NA	30.00	25.50	23.00	19.50	24.50	16.75	15.10	13.50	11.75	14.28	6-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Product	1990	1991	1992	1993	1994	1995
32Kx8, PDIP	NA	5.98	5.07	4.70	4.50	NA
128Kx8, TSOP	NA	13.73	9.65	7.99	6.35	NA
256Kx8, TSOP	NA	24.50	14.28	11.25	8.99	NA

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
1.5 Micron	123	110	105	95	94	87	87	82	72	10-12
1.2 Micron	111	102	95	85	81	74	87	78	70	7-10
1.0 Micron	162	100	90	89	82	71	89	78	70	9-12
ECL	6,017	5,360	4,850	4,750	4,588	3,823	4,250	3,500	3,000	11-14
NRE Charges ($K)										
CMOS										
1.5 Micron	16.50	16.00	16.00	23.50	21.00	21.00	26.60	26.00	26.00	3-5
1.2 Micron	13.50	13.00	13.00	19.40	18.00	17.00	NA	23.00	21.00	3-7
1.0 Micron	NA	23.00	19.00	NA	24.00	24.00	NA	29.00	28.50	3-8
ECL	39.00	32.00	30.00	54.00	50.00	45.00	75.00	55.00	50.00	12-14

Gate Count	10-19.99K Gates			20-29.99 Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
1.5 Micron	88	81	71	92	83	73	NA	98	88	10-12
1.2 Micron	94	77	69	115	79	71	NA	98	85	7-12
1.0 Micron	78	77	69	115	79	71	NA	94	78	8-12
ECL	5,250	4,550	4,000	4,600	3,838	3,200	NA	3,600	3,050	10-14
NRE Charges ($K)										
CMOS										Prototypes:
1.5 Micron	42	40	40	60	60	60	NA	100	100	3-6
1.2 Micron	NA	40	40	NA	58	58	NA	102	102	4-8
1.0 Micron	49	43	42	69	61	60	NA	98	96	3-8
ECL	86	70	65	118	105	100	NA	170	147	6-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	107	99	89	107	94	88	116	93	87	10-13
1.5 Micron	151	115	110	110	110	90	95	92	82	10-14
1.2 Micron	125	103	96	95	85	80	85	80	72	8-15
1.0 Micron	134	101	91	110	97	80	102	80	72	10-15
NRE Charges ($K)										Prototypes:
2.0 Micron	45.00	44.00	43.00	55.00	50.00	49.00	65.00	60.00	60.00	4-8
1.5 Micron	36.44	35.00	35.00	38.50	38.00	38.00	48.00	48.00	47.00	5-8
1.2 Micron	34.50	33.00	32.00	38.00	35.50	35.00	48.00	45.00	43.50	5-8
1.0 Micron	45.00	35.00	34.00	48.33	40.00	39.00	59.00	51.00	49.00	4-8

Gate Count	10-19.99K Gates			20-29.99 Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	128	100	90	132	124	102	NA	128	110	10-13
1.5 Micron	95	84	74	100	86	79	NA	99	88	10-14
1.2 Micron	89	79	71	123	82	74	NA	100	87	9-15
1.0 Micron	109	79	70	103	81	74	NA	96	81	10-15
NRE Charges ($K)										Prototypes:
2.0 Micron	75.00	74.00	73.00	90.00	89.00	88.00	NA	120.00	120.00	4-8
1.5 Micron	70.45	66.00	65.00	100.00	89.00	85.00	NA	112.00	110.00	5-8
1.2 Micron	69.00	62.00	58.50	90.00	80.00	75.00	NA	110.00	100.00	5-8
1.0 Micron	76.50	69.00	66.50	105.00	88.00	83.00	NA	114.00	112.50	4-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataqutst (September 1991)

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

Pin Count	Speed (ns)*	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤20	≤6	8.15	7.35	6.73	6.23	2-9
	6.1-7.5	3.45	3.18	2.93	2.75	2-8
	7.6-10.0	1.80	1.73	1.60	1.56	2-8
	10.1-14.99	1.41	1.32	1.27	1.23	2-8
	15-24.99	.74	.70	.66	.62	2-4
	25-34.99	.54	.52	.50	.48	2-4
	≥35	.54	.52	.50	.48	2-6
24	≤6	10.85	10.70	9.82	9.19	3-8
	6.1-7.5	6.00	5.80	5.08	4.93	2-6
	7.6-10.0	3.80	3.45	3.15	2.85	2-4
	10.1-14.99	3.28	3.12	3.00	2.88	3-6
	15-24.99	1.25	1.20	1.14	1.10	2-4
	≥25	.84	.80	.75	.74	2-4
24						
22V10	15-24.99	6.25	5.70	5.32	5.00	3-8
	25-34.99	2.88	2.74	2.55	2.43	2-8

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Pin Count	Speed (ns)*	1990	1991	1992	1993	1994	1995
≤ 20	≤6	9.00	7.75	6.48	6.02	5.75	5.50
	6.1-7.5	4.14	3.32	2.84	2.60	2.51	2.40
	7.6-10.0	2.11	1.77	1.58	1.42	1.39	1.32
	10.1-14.99	1.63	1.37	1.25	1.12	1.08	1.00
	15-24.99	.98	.72	.64	.61	.60	.60
	25-34.99	.60	.53	.49	.48	.48	.48
	≥35	.62	.53	.49	.48	.48	.48
24	≤6	12.18	10.78	9.50	8.50	7.36	6.60
	6.1-7.5	6.92	5.90	5.00	4.67	4.40	4.22
	7.6-10.0	4.64	3.63	3.00	2.78	2.69	2.60
	10.1-14.99	3.71	3.20	2.94	2.72	2.54	2.44
	15-24.99	1.58	1.23	1.12	1.09	1.08	1.08
	≥25	1.00	.82	.75	.72	.70	.70
24							
22V10	15-24.99	NA	5.97	5.16	4.85	4.65	4.49
	25-34.99	NA	2.81	2.49	2.19	2.07	1.98

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Pin Count	Speed (ns)*	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤ 20	6.1-7.5	6.73	6.28	5.75	5.31	4-14
	7.6-10.0	4.10	3.70	3.32	3.16	1-14
	10.1-14.99	2.88	2.63	2.28	2.12	2-4
	15-24.99	.94	.88	.80	.77	1-4
	≥ 25	.76	.73	.68	.65	4-6
24	6.1-7.5	NA	10.00	9.70	8.90	10-14
	7.6-10.0	7.25	6.56	6.23	5.80	1-14
	10.1-14.99	3.80	3.62	3.43	3.28	1-6
	15-24.99	1.59	1.46	1.34	1.25	1-8
	≥ 25	1.20	1.05	.99	.94	1-6
24						
22V10	7.6-10.0	24.00	20.00	18.00	16.25	2-10
	15-24.99	7.45	6.57	5.99	5.47	1-8
	25-34.99	3.29	2.79	2.47	2.01	1-4

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended as guidelines.
Source: Dataquest (September 1991)

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

Pin Count	Speed (ns)*	1990	1991	1992	1992	1994	1995
≤ 20	6.1-7.5	NA	6.50	5.53	5.15	4.80	4.45
	7.6-10.0	4.36	3.90	3.24	2.70	2.48	2.30
	10.1-14.99	3.33	2.76	2.20	1.89	1.70	1.60
	15-24.99	1.30	.91	.79	.76	.74	.73
	≥ 25	.93	.75	.67	.64	.62	.59
24	6.1-7.5	NA	NA	9.30	8.10	7.45	7.00
	7.6-10.0	8.22	6.91	6.02	5.40	4.90	4.55
	10.1-14.99	4.35	3.71	3.36	3.09	2.82	2.64
	15-24.99	2.05	1.53	1.30	1.24	1.22	1.22
	≥ 25	1.64	1.13	.97	.94	.94	.94
24							
22V10	7.6-10.0	NA	22.00	17.13	14.10	12.82	11.92
	15-24.99	NA	7.01	5.73	5.40	5.10	4.91
	25-34.99	NA	3.04	2.24	2.01	2.01	2.00

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended as guidelines.
Source: Dataquest (September 1991)

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

Pin Count	Speed (ns)*	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
24	≤2.0	40.00	35.00	33.75	32.75	6-8
	2.01-4.0	33.00	30.00	27.90	26.40	8-10
	4.1-6.0	8.00	7.00	6.83	6.71	4
	6.1-15.0	6.50	6.00	5.80	5.71	4

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Pin Count	Speed (ns)*	1990	1991	1992	1993	1994	1995
24	≤2.0	42.50	37.50	33.25	30.00	27.40	25.07
	2.01-4.0	35.00	31.50	27.15	24.46	21.99	20.24
	4.1-6.0	9.50	7.50	6.77	6.27	5.86	5.68
	6.1-15.0	7.00	6.25	5.76	5.54	5.32	5.32

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

	1991		1992		Current Lead
Device Family	H1	H2	H1	H2	Time (Weeks)
Voltage Regulators					
7800CT	.890	.880	.875	.865	3-6
78L00CP	.123	.121	.120	.118	
7805-TO92	.140	.140	.138	.137	
Comparators					
LM339	.139	.138	.137	.137	4-6
LM393	.130	.130	.129	.127	
Op Amps					
741	.133	.130	.130	.125	4-6
3403P	.187	.184	.182	.178	
1741CP1	.125	.125	.124	.120	
Interface ICs					
1488P	.160	.150	.150	.150	4-6
3486P	.935	.900	.895	.885	
Telecom ICs					4-7
CODEC/FILTER 1*	2.100	2.060	2.030	2.000	
34017P	.357	.334	.330	.320	

*Estimated and not by survey
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Voltage Regulators						
7800CT (TO-220)	.900	.885	.870	.860	.856	.852
78L00CP	.126	.122	.119	1.170	.116	.116
7805-TO92	NA	.140	.138	.137	.137	.137
Comparators						
LM339	.135	.139	.137	.131	.130	.130
LM393	.133	.130	.128	.127	.126	.126
Op Amps						
741	NA	.132	.128	.128	.128	.128
3403P	.193	.186	.180	.175	.173	.171
1741CP1	.128	.125	.122	.118	.117	.116
Interface ICs						
1488P	.175	.155	.150	.145	.140	.137
3486P	.995	.918	.890	.870	.850	.840
Telecom ICs						
CODEC/FILTER 1*	NA	2.080	2.015	NA	NA	NA
34017P	.400	.346	.325	.310	.298	.290

NA = Not available
*Estimated and not by survey
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Small Signal Transistors					3-8
2N2222A	.140	.140	.138	.138	
2N3904	.032	.030	.029	.028	
2N2907A	.072	.068	.066	.062	
MPSA 43	.059	.055	.052	.049	
2N2222	.051	.047	.046	.045	
Bipolar Power Transistors					4-8
2N3772	1.040	1.040	1.040	1.040	
2N3055A	.700	.670	.650	.640	
2N6107	.235	.235	.235	.235	
Power MOSFET					5-8
IRF530	.420	.410	.400	.390	
IRF540	1.050	1.000	.990	.970	
IRF9531	1.064	1.052	1.040	1.030	
IRF9520	.430	.420	.416	.414	
Small Signal Diodes					4-6
1N4002	.020	.020	.020	.020	
1N645	.047	.047	.047	.046	
Power Diodes					4-7
1N3891	.900	.900	.888	.878	
1N3737	7.162	7.160	7.120	7.090	
1N4936	.097	.095	.095	.094	

(Continued)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Zener Diodes					4-8
1N829	1.165	1.165	1.165	1.165	
1N752A	.027	.026	.026	.025	
1N963B	.026	.026	.026	.025	
1N4735A	.040	.040	.040	.039	
1.5KE62A	.670	.647	.625	.610	
1.5KE30CA	1.330	1.277	1.230	1.200	
P6KE30CA	.763	.734	.708	.690	
Thyristors					3-8
2N6400	.650	.650	.620	.620	
2N4186	2.295	2.285	2.275	2.265	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Small Signal Transistors						
2N2222A	.113	.140	.138	.138	.138	.138
2N3904	.040	.031	.029	.028	.028	.028
2N2907A	.100	.070	.064	.062	.062	.062
MPSA 43	NA	.057	.050	.048	.046	.046
2N2222	NA	.049	.046	.045	.045	.045
Bipolar Power Transistors						
12N3772	1.050	1.040	1.040	1.040	1.040	1.040
2N3055	NA	.685	.645	.589	.574	.574
12N6107	.235	.235	.235	.235	.235	.235
Power MOSFET						
IRF530	.600	.415	.395	.390	.390	.390
IRF540	NA	1.025	.980	.965	.960	.955
IRF9531	1.088	1.058	1.035	1.028	1.022	1.022
IRF9520	.443	.425	.415	.410	.408	.408
Small Signal Diodes						
1N4002	.020	.020	.020	.020	.020	.020
1N645	.049	.047	.046	.045	.045	.045
Power Diodes						
1N3891	.923	.900	.883	.873	.864	.864
1N3737	7.233	7.161	7.105	7.040	6.990	6.990
1N4936	.098	.096	.094	.093	.092	.092
Zener Diodes						
1N829	1.165	1.165	1.165	1.165	1.165	1.165
1N752A	NA	.027	.026	.025	.025	.025
1N963B	.032	.026	.026	.025	.025	.025
1N4735A	NA	.040	.040	.039	.039	.039
1.5KE62A	NA	.659	.617	.604	.595	.595

(Continued)

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

Device Family	1990	1991	1992	1993	1994	1995
Zener Diodes (Continued)						
1.5KE30CA	NA	1.304	1.215	1.186	1.167	1.167
P6KE30CA	NA	.748	.699	.690	.681	.681
Thyristors						
2N6400	NA	.650	.620	.583	.562	.562
2N4186	2.315	2.290	2.270	2.260	2.250	2.250

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Optoelectronic Round LED Lamps					6
T1 STD RED	.054	.054	.054	.054	
T1 3/4 STD RED	.054	.054	.054	.054	
T1 3/4 H.EF.RED	.074	.073	.073	.072	
Mold Frame LED					6
0.3" Digital Display	.500	.500	.500	.490	
0.6" Digital Display	.550	.550	.540	.530	
Optical Couplers					6-8
4N25	.200	.190	.190	.195	
4N36	.230	.225	.225	.225	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 11991)

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

Device Family	1990	1991	1992	1993	1994	1995
Optoelectronic Round LED Lamps						
T1 STD RED	.055	.054	.054	.053	.051	.051
T1 3/4 STD RED	.056	.054	.054	.053	.051	.051
T1 3/4 H.EF.RED	.079	.074	.073	.071	.070	.070
Mold Frame LED						
0.3" Digital Display	.528	.500	.495	.485	.480	.480
0.6" Digital Display	.615	.550	.535	.522	.512	.512
Optical Couplers						
4N25	.205	.195	.193	.193	.193	.193
4N36	.238	.228	.225	.225	.225	.225

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (September 1991)

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North American Semiconductor Price Outlook

Third Quarter 1991

Source: Dataquest

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Semiconductor Procurement

North American Semiconductor Price Outlook
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Source: Dataquest

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North American Semiconductor Price Outlook: Third Quarter 1991

Methodology and Sources

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

This document includes associated long-range forecasts, which are generated by Semiconductor Group analysts.

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

Price Variations

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

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

Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
74LS TTL												1-8
74LS00	.098	.100	.100	.100	.100	.100	.105	.105	.110	.110	.108	
74LS74	.115	.115	.115	.115	.117	.115	.117	.117	.117	.117	.117	
74LS138	.156	.150	.150	.150	.152	.150	.155	.155	.155	.155	.155	
74LS244	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	
74LS373	.216	.215	.215	.215	.215	.215	.215	.215	.215	.215	.215	
74S TTL												1-6
74S00	.141	.140	.140	.140	.140	.140	.140	.140	.140	.140	.140	
74S74	.174	.174	.174	.174	.174	.174	.170	.170	.170	.170	.170	
74S138	.258	.259	.259	.259	.259	.259	.259	.259	.259	.259	.259	
74S244	.528	.515	.505	.500	.500	.505	.500	.500	.500	.500	.500	
74S373	.529	.515	.500	.500	.500	.504	.500	.500	.500	.500	.500	
74F TTL												1-6
74F00	.100	.100	.100	.103	.103	.102	.107	.107	.107	.107	.107	
74F74	.118	.118	.118	.117	.117	.118	.116	.116	.116	.116	.116	
74F138	.172	.168	.168	.163	.163	.165	.158	.158	.158	.158	.158	
74F244	.244	.230	.230	.229	.229	.229	.223	.220	.220	.220	.221	
74F373	.241	.230	.230	.229	.229	.229	.223	.220	.220	.220	.221	
74HC CMOS												1-8
74HC00	.100	.105	.105	.105	.105	.105	.105	.105	.110	.110	.108	
74HC74	.119	.120	.120	.120	.120	.120	.125	.125	.128	.128	.126	
74HC138	.154	.155	.155	.155	.158	.156	.160	.160	.160	.160	.160	
74HC244	.236	.230	.230	.230	.230	.230	.238	.238	.238	.238	.238	
74HC373	.235	.230	.230	.230	.230	.230	.238	.238	.238	.238	.238	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Family	1990	1991	1992	1993	1994	1995
74LS TTL						
74LS00	.098	.100	.108	.110	.110	.110
74LS74	.115	.115	.117	.117	.117	.117
74LS138	.156	.150	.155	.152	.152	.152
74LS244	.215	.215	.215	.205	.199	.195
74LS373	.216	.215	.215	.206	.199	.195
74S TTL						
74S00	.141	.140	.140	.140	.140	.142
74S74	.174	.174	.170	.174	.174	.174
74S138	.258	.259	.259	.259	.259	.259
74S244	.528	.505	.500	.500	.500	.500
74S373	.529	.504	.500	.500	.500	.500
74F TTL						
74F00	.100	.102	.107	.107	.107	.107
74F74	.118	.118	.116	.112	.108	.105
74F138	.172	.165	.158	.151	.149	.147
74F244	.244	.229	.221	.217	.215	.213
74F373	.241	.229	.221	.215	.215	.214
74HC CMOS						
74HC00	.100	.105	.108	.110	.110	.110
74HC74	.119	.120	.126	.128	.128	.128
74HC138	.154	.156	.160	.160	.160	.162
74HC244	.236	.230	.238	.238	.240	.242
74HC373	.235	.230	.238	.238	.240	.241

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74AC CMOS												1-6
74AC00	.218	.200	.193	.190	.190	.193	.183	.183	.183	.183	.183	
74AC74	.282	.267	.267	.265	.263	.266	.255	.254	.253	.253	.254	
74AC138	.359	.345	.345	.344	.343	.344	.336	.336	.336	.336	.336	
74AC244	.516	.497	.495	.480	.467	.485	.465	.465	.465	.465	.465	
74AC373	.538	.525	.515	.505	.495	.510	.490	.488	.485	.483	.486	
74ALS TTL												1-6
74ALS00	.136	.136	.136	.134	.134	.135	.128	.128	.128	.128	.128	
74ALS74	.168	.165	.164	.163	.155	.162	.155	.155	.155	.155	.155	
74ALS138	.285	.286	.286	.286	.286	.286	.285	.285	.285	.285	.285	
74ALS244	.393	.385	.383	.381	.380	.382	.373	.371	.367	.364	.369	
74ALS373	.393	.385	.383	.381	.380	.382	.373	.371	.367	.364	.369	
74AS TTL												1-8
74AS00	.172	.172	.172	.169	.165	.170	.160	.160	.160	.160	.160	
74AS74	.179	.180	.180	.180	.180	.180	.180	.180	.180	.180	.180	
74AS138	.444	.460	.460	.460	.460	.460	.430	.430	.430	.430	.430	
74AS244	.770	.760	.760	.750	.750	.755	.740	.740	.740	.740	.740	
74AS373	.776	.750	.750	.750	.750	.750	.735	.735	.735	.735	.735	
74BC*												4-6
74BC00	.398	.344	.333	.323	.314	.328	.297	.286	.279	.272	.284	
74BC244	.906	.846	.809	.779	.752	.796	.725	.698	.672	.648	.686	
74BC373	.909	.849	.811	.781	.754	.799	.726	.700	.674	.649	.687	
10KH ECL												6
10H102	.494	.490	.490	.490	.490	.490	.490	.490	.490	.490	.490	
10H131	NA	1.200	1.200	1.200	1.200	1.200	1.100	1.100	1.100	1.100	1.100	
10H173	1.200	1.200	1.200	1.200	1.200	1.200	1.100	1.100	1.100	1.100	1.100	

NA = Not available
*Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Family	1990	1991	1992	1993	1994	1995
74AC CMOS						
74AC00	.218	.193	.183	.177	.173	.170
74AC74	.282	.266	.254	.240	.225	.220
74AC138	.359	.344	.336	.319	.294	.280
74AC244	.516	.485	.465	.442	.418	.399
74AC373	.538	.510	.486	.447	.418	.399
74ALS TTL						
74ALS00	.136	.135	.128	.128	.128	.128
74ALS74	.168	.162	.155	.147	.140	.140
74ALS138	.285	.286	.285	.261	.253	.249
74ALS244	.393	.382	.369	.363	.359	.356
74ALS373	.393	.382	.369	.363	.360	.357
74AS TTL						
74AS00	.172	.170	.160	.160	.160	.160
74AS74	.179	.180	.180	.179	.179	.179
74AS138	.444	.460	.430	.410	.405	.398
74AS244	.770	.755	.740	.7200	.690	.669
74AS373	.776	.750	.735	.720	.680	.659
74BC*						
74BC00	.398	.328	.284	.267	.260	.242
74BC244	.906	.796	.686	.640	.611	.587
74BC373	.909	.799	.687	.610	.612	.588
10KH ECL						
10H102	.494	.490	.490	.490	.490	.490
10H131	NA	1.200	1.100	1.10	1.100	1.100
10H173	1.200	1.200	1.100	1.100	1.100	1.100

NA = Not available
*Prices for 74BC excludes 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
8-Bit MPUs												
Z84C00-6	1.04	.99	.98	.98	.98	.98	.96	.94	.92	.92	.94	5-8
16-Bit MPUs												
68000-8	3.32	4.00	4.00	3.75	3.75	3.88	3.50	3.50	3.50	3.50	3.50	4-9
68000-12	5.98	5.65	5.60	5.55	5.50	5.58	5.50	5.50	5.50	5.50	5.50	5-9
80186-8 PLCC	7.91	6.70	6.37	6.05	5.74	6.21	5.57	5.43	5.32	5.30	5.41	6-8
80286-10 PLCC	9.37	6.92	6.57	6.37	5.97	6.46	5.81	5.65	5.48	5.34	5.57	2-14
80286-12 PLCC	12.00	7.50	6.99	6.63	6.38	6.87	6.03	5.83	5.64	5.46	5.74	2-14
80286-16 PLCC	NA	15.88	13.89	11.81	10.04	12.90	8.73	7.68	6.76	5.95	7.28	2-4
80287-12	NA	NA	111.30	105.74	100.45	79.37	96.43	92.57	90.26	88.90	92.04	NA
CISC 32-Bit MPUs/Peripherals												
68020-16 PQFP	NA	37.73	36.92	36.11	35.67	36.61	34.62	33.70	32.89	32.55	33.44	5-10
68881-16 PLCC	NA	26.00	23.50	20.00	19.00	22.13	18.50	18.00	18.00	18.00	18.13	5-10
68020-25 PQFP[1]	131.20	NA	NA	65.00	60.00	NA	60.00	55.00	55.00	55.00	56.25	5-10
68030-16 PQFP[1]	138.00	NA	NA	100.00	90.00	NA	87.00	83.00	83.00	83.00	84.00	5-9
68882-16	87.51	65.00	55.00	45.00	40.00	51.25	36.00	33.00	33.00	33.00	33.75	5-10
68030-25 PQFP[2]	189.28	167.00	163.00	159.00	155.00	161.00	140.00	136.00	136.00	136.00	137.00	5-10
68040-25	730.38	593.25	554.09	517.16	490.91	538.85	455.08	430.10	413.90	400.90	425.00	14-20
80386SX-16 PQFP	62.73	60.50	58.88	57.42	56.35	58.29	55.25	54.50	53.42	53.03	54.05	8-14
80386SX-20 PQFP	NA	94.00	91.18	88.44	85.79	89.85	83.91	81.96	79.51	77.53	80.73	9-14
AM386-40	NA	NA	231.00	218.00	203.00	NA	184.00	175.00	169.00	160.00	172.00	3
80386-25	184.21	162.20	159.95	154.00	150.55	156.68	148.50	144.50	142.50	138.50	143.50	6-8
80387-25[3]	326.78	308.00	277.00	249.30	239.50	268.45	234.00	229.00	224.00	220.00	226.75	4-8
80486-25	790.39	690.00	585.00	495.00	425.00	548.75	396.00	388.00	381.00	375.00	385.00	6-8
80486-33	NA	756.86	667.00	517.75	436.02	594.41	415.80	401.58	394.34	380.63	398.09	NA
80486SX-20[3]	NA	NA	258.00	247.68	230.34	NA	218.83	210.07	205.87	203.81	209.65	12

(Continued)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
RISC 32-Bit MPUs												
29000-25[4]	NA	135.00	128.42	121.28	117.52	125.55	112.90	107.00	102.00	98.10	105.00	NA
88100-25[4]	NA	82.25	77.00	74.00	71.00	76.06	69.50	68.05	67.45	67.00	68.00	4-8
R3000-25[4]	NA	150.00	135.00	125.00	118.00	132.00	111.00	105.00	99.50	94.50	102.50	6-9
SPARC-25[4]	NA	100.35	90.72	84.70	79.21	88.74	75.62	72.30	69.51	66.55	71.00	NA

NA = Not available
[1]CPGA for 1990.
[2]CPGA for 1990-1991.
[3]Volume of <1,000 pieces for 80387-25 and 80486SX-20.
[4]Prices exclude floating point/memory management units.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Family	1990	1991	1992	1993	1994	1995
8-Bit MPUs						
Z84C00-6	1.04	.98	.94	.91	.89	.88
16-Bit MPUs						
68000-8	3.32	3.88	3.50	3.50	3.53	3.56
68000-12	5.98	5.58	5.50	5.35	5.20	5.10
80186-8 PLCC	7.91	6.21	5.41	5.30	5.30	5.30
80286-10 PLCC	9.37	6.46	5.57	5.34	5.34	5.34
80286-12 PLCC	12.00	6.87	5.74	5.39	5.34	5.34
80286-16 PLCC	NA	12.90	7.28	5.75	5.51	5.45
80287-12	NA	79.37	92.04	85.50	NA	NA
CISC 32-Bit MPUs/Peripherals						
68020-16 PQFP	NA	36.61	33.44	31.42	29.97	29.97
68881-16 PLCC	NA	22.13	18.13	18.00	18.00	18.00
68020-25 PQFP[1]	131.20	NA	56.25	52.25	50.16	49.16
68030-16 PQFP[1]	138.00	NA	84.00	78.85	74.91	73.03
68882-16	87.51	51.25	33.75	32.01	31.21	30.59
68030-25 PQFP[2]	189.28	161.00	137.00	132.00	130.00	130.00
68040-25	730.38	538.85	425.00	380.00	360.00	345.00
80386SX-16 PQFP	62.73	58.29	54.05	51.00	NA	NA
80386SX-20 PQFP	NA	89.85	80.73	76.56	75.15	75.15
AM386-40	NA	NA	172.00	150.40	141.38	135.72
80386-25	184.21	156.68	143.50	135.00	133.00	133.00
80387-25[3]	326.78	268.45	226.75	204.00	199.00	199.00
80486-25	790.39	548.75	385.00	360.00	355.00	355.00
80486-33	NA	594.41	398.09	371.11	360.00	356.81
80486SX-20[3]	NA	NA	209.65	199.72	194.74	194.74

(Continued)

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

Family	1990	1991	1992	1993	1994	1995
RISC 32-Bit MPUs						
29000-25[4]	NA	125.55	105.00	92.00	87.00	82.50
88100-25[4]	NA	76.06	68.00	62.35	57.80	54.00
R3000-25[4]	NA	132.00	102.50	89.00	84.50	79.90
SPARC-25[4]	NA	88.74	71.00	62.40	59.00	53.66

NA = Not available
[1]CPGA for 1990.
[2]CPGA for 1990-1991.
[3]Volume of <1,000 pieces for 80387-25 and 80486SX-20.
[4]Prices exclude floating point/memory management units.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
256Kx1 DRAM 100-120ns (DIP)	1.93	1.77	1.77	1.77	1.77	1.77	1.81	1.81	1.81	1.81	1.81	1-12
64Kx4 DRAM 100ns (DIP)	1.98	1.80	1.80	1.80	1.80	1.80	1.86	1.86	1.86	1.86	1.86	1-12
64Kx4 VRAM 120ns (ZIP)[2]	4.06	3.28	3.25	3.15	3.10	3.20	3.05	3.00	2.95	2.92	2.98	2-12
1Mbx1 DRAM 80ns (DIP/SOJ)	6.06	4.55	4.60	4.49	4.39	4.51	4.29	4.15	4.10	3.99	4.13	1-20
256Kx4 DRAM 80-100ns (SOJ)	6.09	4.57	4.62	4.51	4.41	4.53	4.30	4.16	4.11	4.00	4.14	2-12
64Kx16 DRAM 80ns (SOJ)	NA	7.70	7.35	6.76	6.44	7.06	6.25	6.07	5.84	5.64	5.95	2-8
256Kx4 VRAM 120ns (ZIP)[2]	13.91	10.06	9.42	9.25	8.92	9.41	8.63	8.36	8.16	7.90	8.26	2-12
128Kx8 VRAM 100ns (SOJ)[2]	NA	11.35	10.34	10.23	9.83	10.44	9.37	9.05	8.73	8.46	8.90	4-14
4Mbx1 DRAM 80ns (SOJ, 300 mil)	36.36	19.99	17.51	16.00	14.95	17.11	13.94	13.35	12.75	12.30	13.09	2-12
1Mbx8 SIMM 100ns	54.71	39.49	39.43	38.63	37.40	38.74	36.12	34.86	34.44	33.68	34.77	4-10
1Mbx9 SIMM 80ns	61.14	44.43	44.44	43.84	42.20	43.73	40.93	39.78	38.93	38.06	39.42	4-12
256Kx9 SIMM 100ns	17.10	14.20	13.99	13.80	13.40	13.85	12.82	12.34	12.16	12.09	12.35	2-12
256Kx36 SIMM 80ns	66.37	50.96	51.44	49.79	48.24	50.11	47.75	47.40	47.05	46.50	47.18	4-10

NA = Not available
[1]Contract volume = at least 100,000 per order except as specified
[2]Contract volume may be less than 100,000 per order
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
256Kx1 DRAM 100-120ns	1.93	1.77	1.81	2.00	2.00	2.10
64Kx4 DRAM 100ns	1.98	1.80	1.86	2.00	2.00	2.10
64Kx4 VRAM 120ns	4.06	3.20	2.98	2.90	2.88	2.87
1Mbx1 DRAM 80ns[2]	6.06	4.51	4.13	3.90	3.85	3.90
256Kx4 DRAM 80-100ns (SOJ)[3]	6.09	4.53	4.14	3.91	3.88	3.91
64Kx16 DRAM 80ns (SOJ)	NA	7.06	5.95	4.54	4.29	4.20
256Kx4 VRAM 120ns (ZIP)	13.91	9.41	8.26	7.60	7.05	6.75
128Kx8 VRAM 100ns (SOJ)	NA	10.44	8.90	8.28	7.72	7.40
4Mbx1 DRAM 80ns + (SOJ, 300 mil)[4]	36.36	17.11	13.09	11.00	9.00	8.00
1Mbx8 SIMM 100ns	54.71	38.74	34.77	33.38	32.96	33.38
1Mbx9 SIMM 80ns	61.14	43.73	39.42	37.83	37.36	37.48
256Kx9 SIMM 100ns	17.10	13.85	12.35	11.00	11.00	11.11
256Kx36 SIMM 80ns	66.37	50.11	47.18	38.71	38.41	36.48

NA = Not available
[1]Contract volume = at least 100,000 per order
[2]80-100ns for 1990
[3]100ns for 1990
[4]300-350 mil for 1990
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
Fast 4Kx4 (25ns)	2.88	2.35	2.40	2.40	2.40	2.39	2.45	2.45	2.45	2.45	2.45	2-13
Fast 2Kx8 (25ns)	3.49	2.60	2.56	2.51	2.51	2.55	2.55	2.57	2.59	2.60	2.58	2-13
Fast 64Kx1 (25ns)	4.27	3.59	3.53	3.53	3.60	3.56	3.65	3.65	3.65	3.65	3.65	2-12
Fast 16Kx4 (25ns)	4.54	3.64	3.58	3.58	3.65	3.61	3.70	3.70	3.70	3.70	3.70	7-18
Fast 8Kx8 (25ns)	5.14	3.95	3.95	4.05	4.15	4.03	4.15	4.15	4.15	4.15	4.15	6-Allocation
Fast 16Kx4 (35ns)	3.97	3.22	3.18	3.15	3.11	3.16	3.10	3.10	3.10	3.10	3.10	6-14
Fast 8Kx8 (45ns)	3.98	3.25	3.20	3.15	3.10	3.18	3.10	3.10	3.15	3.15	3.12	7-Allocation
Slow 8Kx8 (120-150ns)	1.96	2.00	2.00	2.00	2.00	2.00	2.20	2.20	2.20	2.20	2.20	4-10
Fast 64Kx4 (25ns)	15.71	11.00	10.25	9.60	9.20	10.01	8.75	8.68	8.60	8.52	8.64	5-12
Fast 32Kx8 (35ns)	14.74	9.97	8.78	8.00	7.63	8.59	7.30	6.95	6.80	6.65	6.93	5-Allocation
Slow 32Kx8 (100ns)	5.37	4.35	4.22	4.19	4.15	4.23	4.15	4.15	4.15	4.15	4.15	4-10
Slow 128Kx8 (100ns)	30.79	19.27	15.99	15.27	14.50	16.26	13.71	13.03	12.70	12.24	12.92	2-10
Fast 128Kx8 (25ns)	NA	85.00	70.00	62.50	58.73	69.06	53.95	47.95	43.00	38.00	45.73	8-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
Fast 4Kx4 (25ns)	2.88	2.39	2.45	2.50	2.55	2.55
Fast 2Kx8 (25ns)	3.49	2.55	2.58	2.65	2.67	2.67
Fast 64Kx1 (25ns)	4.27	3.56	3.65	3.65	3.67	3.67
Fast 16Kx4 (25ns)	4.54	3.61	3.70	3.70	3.72	3.73
Fast 8Kx8 (25ns)	5.14	4.03	4.15	4.15	4.15	4.15
Fast 16Kx4 (35ns)	3.97	3.16	3.10	3.10	3.12	3.15
Fast 8Kx8 (45ns)	3.98	3.18	3.12	3.15	3.20	3.20
Slow 8Kx8 (120-150ns)	1.96	2.00	2.20	2.35	2.40	2.40
Fast 64Kx4 (25ns)	15.71	10.01	8.64	7.55	6.75	5.99
Fast 32Kx8 (35ns)	14.74	8.59	6.93	5.95	5.55	5.50
Slow 32Kx8 (100ns)	5.37	4.23	4.15	4.20	4.25	4.25
Slow 128Kx8 (100ns)	30.79	16.26	12.92	9.90	7.75	7.50
Fast 128Kx8 (25ns)	NA	69.06	45.73	31.30	24.32	23.10

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
CMOS												
32Kx8 ROM	1.75	1.60	1.60	1.60	1.60	1.60	1.63	1.63	1.63	1.63	1.63	5-10
64Kx8 ROM	2.40	2.15	2.10	2.05	2.02	2.08	2.00	1.95	1.90	1.90	1.94	5-10
128Kx8 ROM	3.06	2.38	2.33	2.24	2.21	2.29	2.16	2.11	2.06	2.01	2.09	4-10
64Kx16 ROM	NA	3.18	3.02	2.87	2.73	2.95	2.61	2.51	2.41	2.35	2.47	5-9
256Kx8 ROM	3.90	3.45	3.29	3.18	3.13	3.26	3.09	3.05	3.01	2.96	3.03	4-10
512Kx8 ROM	5.43	4.05	3.92	3.86	3.80	3.91	3.70	3.63	3.54	3.51	3.60	4-12
256Kx16 ROM*	NA	5.52	5.21	5.04	4.91	5.17	4.69	4.48	4.35	4.27	4.45	5-12

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
CMOS						
32Kx8 ROM	1.75	1.60	1.63	2.00	NA	NA
64Kx8 ROM	2.40	2.08	1.94	2.55	2.55	2.55
128Kx8 ROM	3.06	2.29	2.09	2.05	2.05	2.05
64Kx16 ROM	NA	2.95	2.47	2.32	2.28	2.24
256Kx8 ROM	3.90	3.26	3.03	2.92	2.79	2.73
512Kx8 ROM	5.43	3.91	3.60	3.45	3.30	3.22
256Kx16 ROM*	NA	5.17	4.45	4.13	3.98	3.92

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
TTL												
4K PROM	.94	.95	.97	.98	.99	.97	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM	2.14	2.15	2.20	2.30	2.40	2.26	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM	6.38	5.57	5.12	4.71	4.80	5.05	4.70	4.60	4.50	4.50	4.58	6-8
64K PROM	7.89	7.18	7.00	6.86	6.75	6.95	6.62	6.47	6.36	6.23	6.42	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
TTL						
4K PROM	.94	.97	1.00	NA	NA	NA
16K PROM	2.14	2.26	2.40	2.40	NA	NA
32K PROM	6.38	5.05	4.58	4.50	4.50	NA
64K PROM	7.89	6.95	6.42	5.92	5.54	5.45

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This price forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	Q2	Q3	Q4	1991 Year	1992 Q1	Q2	Q3	Q4	1992 Year	Current Lead Time (Weeks)
8Kx8 EPROM	1.75	1.65	1.65	1.78	1.80	1.72	1.81	1.84	1.85	1.87	1.84	2-8
16Kx8 EPROM	2.19	1.80	1.80	1.80	1.80	1.80	2.03	2.03	2.06	2.06	2.04	2-8
32Kx8 EPROM	2.02	1.98	1.99	2.00	2.03	2.00	2.09	2.10	2.11	2.13	2.11	2-10
64Kx8 EPROM	3.10	2.80	2.75	2.65	2.68	2.72	2.65	2.65	2.65	2.65	2.65	3-12
128Kx8 EPROM	5.96	4.80	4.58	4.44	4.30	4.53	4.20	4.08	3.97	3.86	4.03	4-10
256Kx8 EPROM	NA	12.00	1.77	9.68	8.75	10.0	7.86	7.23	6.67	6.23	7.00	4-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
8Kx8 EPROM	1.75	1.72	1.84	2.80	2.90	2.99
16Kx8 EPROM	2.19	1.80	2.04	2.94	3.00	3.05
32Kx8 EPROM	2.02	2.00	2.11	2.50	3.00	3.00
64Kx8 EPROM	3.10	2.72	2.65	2.60	3.05	3.05
128Kx8 EPROM	5.96	4.53	4.03	4.02	4.01	4.01
256Kx8 EPROM	NA	10.30	7.00	6.10	5.60	5.40

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.68	1.40	1.40	1.48	1.53	1.45	1.53	1.53	1.53	1.53	1.53	1-12
32Kx8	1.77	1.44	1.47	1.57	1.59	1.52	1.59	1.59	1.59	1.59	1.59	2-12
64Kx8	3.08	2.51	2.50	2.49	2.48	2.49	2.47	2.45	2.44	2.43	2.45	2-12
128Kx8	NA	4.55	4.31	4.10	3.97	4.23	3.86	3.76	3.67	3.57	3.72	6-12

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
16Kx8	1.68	1.45	1.53	NA	NA	NA
32Kx8	1.77	1.52	1.59	NA	NA	NA
64Kx8	3.08	2.49	2.45	2.43	2.75	2.75
128Kx8	NA	4.23	3.72	3.53	3.44	3.40

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K EEPROM	3.28	3.25	3.20	3.00	2.95	3.10	2.95	2.90	2.90	2.90	2.91	1-7
8Kx8 EEPROM	5.26	4.90	4.70	4.55	4.40	4.64	4.20	4.14	3.99	3.95	4.07	1-8
32Kx8 EEPROM	40.08	23.00	20.60	18.60	17.00	19.80	14.00	12.40	11.00	9.78	11.80	1-8
64Kx8 EEPROM	NA	99.00	60.00	40.00	25.00	56.00	21.25	19.13	17.21	15.84	18.36	1-8
128Kx8 EEPROM	NA	150.0	132.0	118.0	110.0	127.5	100.00	87.00	75.00	65.00	81.75	1-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
16K EEPROM	3.28	3.10	2.91	2.85	2.80	2.80
8Kx8 EEPROM	5.26	4.64	4.07	3.74	3.58	3.46
32Kx8 EEPROM	40.08	19.80	11.80	9.30	8.95	8.55
64Kx8 EEPROM	NA	56.00	18.36	13.46	11.20	10.86
128Kx8 EEPROM	NA	127.50	81.75	52.00	41.60	33.77

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
32Kx8, PDIP	NA	6.45	6.00	5.80	5.65	5.98	5.35	5.15	4.97	4.80	5.07	5-10
128Kx8, TSOP	NA	16.00	13.90	13.00	12.00	13.73	10.75	10.10	9.25	8.50	9.65	5-9
256Kx8, TSOP	NA	30.00	25.50	23.00	19.50	24.50	16.75	15.10	13.50	11.75	14.28	6-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Product	1990	1991	1992	1993	1994	1995
32Kx8, PDIP	NA	5.98	5.07	4.70	4.50	NA
128Kx8, TSOP	NA	13.73	9.65	7.99	6.35	NA
256Kx8, TSOP	NA	24.50	14.28	11.25	8.99	NA

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	127.0	97.0	87.0	95.0	92.5	87.0	90.0	85.8	79.8	9-13
1.5 Micron	123.0	97.5	85.6	95.0	89.5	83.3	80.7	82.3	72.0	10-12
1.25 Micron	111.0	97.5	84.7	85.0	81.0	73.7	87.0	79.0	71.6	9-11
1.0 Micron	161.6	100.4	84.0	88.5	80.8	71.0	88.5	78.1	70.0	10-13
ECL	6017	5360	4850	4750	4588	3823	4250	3875	3210	11-14
NRE Charges ($K)										
CMOS										
2.0 Micron	15.50	14.50	14.25	20.20	19.50	19.25	21.47	21.40	21.40	3-5
1.5 Micron	16.50	15.50	15.46	23.50	19.45	19.00	26.60	25.50	24.00	3-5
1.25 Micron	13.50	13.00	13.00	19.40	18.00	17.90	NA	23.00	23.00	3-6
1.0 Micron	NA	23.00	16.50	NA	24.00	21.00	NA	27.00	23.00	3-7
ECL	39.00	32.00	30.00	54.00	50.00	45.00	75.00	57.60	51.00	12-14

(Continued)

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

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	96.7	90.5	81.5	NA	94.1	83.8	NA	103.1	99.0	10-14
1.5 Micron	87.5	80.0	69.6	92.0	81.5	73.0	NA	100.0	90.0	10-12
1.25 Micron	94.0	79.0	69.1	115.0	80.0	72.0	NA	99.9	87.0	9-12
1.0 Micron	77.9	78.0	67.0	115.0	79.0	67.0	NA	95.7	80.0	10-13
ECL	5250	4550	4000	4600	3838	3200	NA	3600	3050	10-14
NRE Charges ($K)										
CMOS										Prototypes:
2.0 Micron	34.70	34.70	34.70	NA	58.00	58.00	NA	105.00	102.00	4-7
1.5 Micron	41.88	40.00	40.00	60.00	60.00	60.00	NA	100.00	100.00	3-6
1.25 Micron	NA	40.00	40.00	NA	58.00	58.00	NA	102.00	102.00	4-7
1.0 Micron	49.00	43.75	43.25	68.50	62.50	60.00	NA	105.00	102.00	4-7
ECL	85.67	71.45	69.00	117.50	105.00	100.00	NA	170.00	146.67	6-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	107.1	100.0	90.0	107.1	94.5	90.0	116.0	92.6	87.0	10-13
1.5 Micron	150.5	110.5	105.0	110.0	105.0	90.0	95.0	92.5	80.0	10-14
1.25 Micron	125.0	99.0	90.0	95.0	95.0	85.0	85.0	83.0	75.0	8-15
1.0 Micron	134.0	97.0	90.0	109.9	95.0	80.3	102.0	82.5	74.3	10-15
NRE Charges ($K)										Prototypes:
2.0 Micron	45.00	44.00	43.00	55.00	50.00	47.00	65.00	60.00	56.00	4-8
1.5 Micron	36.44	34.50	34.00	38.50	37.00	37.00	48.00	46.00	45.50	5-8
1.25 Micron	34.50	33.90	33.90	38.00	37.00	37.00	48.00	46.00	45.00	5-8
1.0 Micron	45.00	36.00	35.00	48.33	39.00	38.00	59.00	49.00	47.00	4-8

(Continued)

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

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production:
2.0 Micron	128.0	105.0	90.0	132.0	123.6	111.7	NA	127.6	105.9	10-13
1.5 Micron	95.0	84.0	69.2	100.0	88.0	77.0	NA	90.1	77.0	10-14
1.25 Micron	88.8	83.0	69.0	123.0	93.0	88.3	NA	102.9	87.4	9-15
1.0 Micron	109.3	82.5	71.4	102.6	88.0	77.0	NA	88.0	77.0	10-15
NRE Charges ($K)										Prototypes:
2.0 Micron	75.00	74.00	72.50	90.00	89.00	88.00	NA	120.00	120.00	4-8
1.5 Micron	70.45	67.00	66.00	100.00	90.00	89.00	NA	114.00	110.0	5-8
1.25 Micron	69.00	67.00	66.00	90.00	89.00	89.00	NA	125.00	119.50	5-8
1.0 Micron	76.50	72.00	70.00	105.00	89.00	88.00	NA	125.00	119.50	4-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤20	≤6	8.15	7.35	6.73	6.23	3-9
	6.1-7.5	3.54	3.28	2.98	2.85	2-8
	7.6-10.0	1.80	1.73	1.59	1.52	2-8
	10.1-14.99	1.41	1.32	1.27	1.23	3-8
	15-<25	.76	.70	.67	.62	2-12
	25-<35	.54	.53	.52	.50	2-12
	≥35	.54	.53	.52	.51	2-12
24	≤6	10.85	10.70	9.82	9.19	3-9
	6.1-7.5	6.05	5.55	5.23	5.01	2-12
	7.6-10.0	3.99	3.81	3.58	3.36	2-8
	10.1-14.99	3.28	3.12	3.00	2.88	3-8
	15-<25	1.30	1.24	1.15	1.12	2-8
	≥25	.84	.80	.75	.74	2-12
24						
22V10						
	15-<25	6.25	6.01	5.78	5.56	3-8
	25-<35	2.88	2.74	2.55	2.43	2-8

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
≤20							
	≤6	9.00	7.75	6.48	6.02	5.75	5.50
	6.1-7.5	4.14	3.41	2.91	2.70	2.51	2.40
	7.6-10.0	2.11	1.77	1.56	1.40	1.39	1.32
	10.1-14.99	1.63	1.37	1.25	1.12	1.08	1.00
	15-<25	.98	.73	.65	.62	.61	.60
	25-<35	.60	.54	.51	.49	.48	.48
	≥35	.62	.54	.52	.50	.49	.49
24							
	≤6	12.18	10.78	9.50	8.50	7.36	6.60
	6.1-7.5	6.92	5.80	5.12	4.75	4.40	4.22
	7.6-10.0	4.64	3.90	3.47	3.20	3.03	2.90
	10.1-14.99	3.71	3.20	2.94	2.72	2.54	2.40
	15-<25	1.58	1.27	1.14	1.11	1.10	1.08
	≥25	1.00	.82	.75	.72	.70	.70
24							
22V10							
	15-<25	NA	6.13	5.67	4.98	4.68	4.49
	25-<35	NA	2.81	2.49	2.19	2.07	1.98

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤20	6.1-7.5	6.73	6.28	5.75	5.31	4-10
	7.6-10.0	4.10	3.75	3.37	3.16	2-12
	10.1-14.99	2.88	2.63	2.18	2.12	2-6
	15-<25	.96	.93	.83	.80	1-5
	≥25	.76	.73	.68	.66	2-5
24						
	7.6-10.0	7.35	6.65	6.23	5.87	2-10
	10.1-14.99	3.80	3.60	3.40	3.24	1-8
	15-<25	1.70	1.57	1.45	1.41	2-8
	≥25	1.22	1.15	1.05	.99	2-6
24						
22V10						
	7.6-10.0	25.00	21.00	18.00	16.00	2-4
	15-<25	7.75	6.87	6.32	5.70	1-12
	25-<35	3.45	2.99	2.59	2.05	1-5

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended as guidelines.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
≤20	6.1-7.5	NA	6.50	5.53	5.15	4.80	4.45
	7.6-10.0	4.36	3.93	3.27	2.70	2.48	2.30
	10.1-14.99	3.33	2.76	2.15	1.84	1.69	1.59
	15-<25	1.30	.94	.82	.78	.75	.73
	≥25	.93	.75	.67	.64	.62	.59
24							
	7.6-10.0	8.22	7.00	6.05	5.40	4.90	4.55
	10.1-14.99	4.35	3.70	3.32	3.05	2.82	2.64
	15-<25	2.05	1.64	1.43	1.40	1.36	1.33
	≥25	1.64	1.19	1.02	.98	.98	.98
24							
22V10	7.6-10.0	NA	23.00	17.00	14.10	12.82	11.92
	15-<25	NA	7.31	6.01	5.45	5.15	4.91
	25-<35	NA	3.22	2.32	2.02	2.01	2.00

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
24						
	≤2.0	40.00	35.00	33.75	32.75	6-8
	2.01-4.0	33.00	30.00	27.90	26.40	8-10
	4.1-6.0	8.00	7.00	6.83	6.71	4
	6.1-15.0	6.50	6.00	5.80	5.71	4

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
24							
	≤2.0	42.50	37.50	33.25	30.00	27.40	25.07
	2.01-4.0	35.00	31.50	27.15	24.46	21.99	20.24
	4.1-6.0	9.50	7.50	6.77	6.27	5.86	5.68
	6.1-15.0	7.00	6.25	5.76	5.54	5.32	5.32

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead (Times (Weeks)
Voltage Regulators					
7800CT	.890	.880	.875	.865	3-5
78L00CP	.123	.121	120	.118	
7805-TO92	.140	.140	140	140	
Comparators					
LM339	.139	.138	.137	.137	4-6
LM393	.130	.130	.129	.127	
Op Amps					
741	.133	.130	.130	.130	4-6
3403P	.187	.184	.182	.178	
1741CP1	.125	.125	.124	.120	
Interface ICs					
1488P	.160	.150	.150	.150	4-6
3486P	.935	.900	.895	.885	
Telecom IC					
34017P	.357	.334	.330	.320	5-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Voltage Regulators						
7800CT (TO-220)	.900	.885	.870	.860	.856	.852
78L00CP	.126	.122	.119	1.170	.116	.116
7805-TO92	NA	.140	.140	1.400	1.400	1.400
Comparators						
LM339	.135	.139	.137	.131	.130	.130
LM393	.133	.130	.128	.127	.126	.126
Op Amps						
741	NA	.132	.130	.130	.130	.130
3403P	.193	.186	.180	.175	.173	.171
1741CP1	.128	.125	.122	.118	.117	.116
Interface ICs						
1488P	.175	.155	.150	.145	.140	.137
3486P	.995	.918	.890	.870	.850	.840
Telecom IC						
34017P	.400	.346	.325	.310	.298	.290

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Small Signal Transistors					4-8
2N2222A	.140	.140	.140	.140	
2N3904	.034	.032	.300	.300	
2N2907A	.750	.700	.068	.065	
MPSA 43	.059	.055	.052	.049	
2N2222	.051	.047	.046	.045	
Bipolar Power Transistors					5-8
2N3772	1.040	1.040	1.040	1.040	
2N3055	.690	.670	.650	.640	
2N6107	.235	.235	.235	.235	
Power MOSFETs					5-8
IRF530	.450	.420	.400	.400	
IRF540	1.150	1.050	1.000	1.000	
IRF9531	1.064	1.052	1.040	1.030	
IRF9520	.430	.420	.416	.414	
Small Signal Diodes					4-6
1N4002	.020	.020	.020	.020	
1N645	.047	.047	.047	.046	
Power Diodes					4-7
1N3891	.900	.900	.888	.878	
1N3737	7.162	7.160	7.120	7.090	
1N4936	.097	.095	.095	.094	

(Continued)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Zener Diodes					4-8
1N829	1.165	1.165	1.165	1.165	
1N752A	.027	.026	.026	.025	
1N963B	.026	.026	.026	.025	
1N4735A	.040	.040	.040	.039	
1.5KE62A	.670	.647	.625	.610	
1.5KE30CA	1.330	1.277	1.230	1.200	
P6KE30CA	.763	.734	.708	.690	
Thyristors					4-8
2N6400	.650	.650	.620	.620	
2N4186	2.295	2.285	2.275	2.265	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Small Signal Transistors						
2N2222A	.113	.140	.140	.140	.140	.140
2N3904	.040	.033	.300	.300	.300	.300
2N2907A	.100	.725	.067	.065	.062	.062
MPSA 43	NA	.057	.050	.048	.046	.046
2N2222	NA	.049	.046	.045	.045	.045
Bipolar Power Transistors						
2N3772	1.050	1.040	1.040	1.040	1.040	1.040
2N3055	NA	.680	.645	.589	.574	.574
2N6107	.235	.235	.235	.235	.235	.235
Power MOSFETs						
IRF530	.600	.435	.400	.400	.400	.400
IRF540	NA	1.100	1.000	1.000	1.000	1.000
IRF9531	1.088	1.058	1.035	1.028	1.022	1.022
IRF9520	.443	.425	.415	.410	.408	.408
Small Signal Diodes						
1N4002	.020	.020	.020	.020	.020	.020
1N645	.049	.047	.046	.045	.045	.045
Power Diodes						
1N3891	.923	.900	.883	.873	.864	.864
1N3737	7.233	7.161	7.105	7.040	6.990	6.990
1N4936	.098	.096	.094	.093	.092	.092

(Continued)

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

Device Family	1990	1991	1992	1993	1994	1995
Zener Diodes						
1N829	1.165	1.165	1.165	1.165	1.165	1.165
1N752A	NA	.027	.026	.025	.025	.025
1N963B	.032	.026	.026	.025	.025	.025
1N4735A	NA	.040	.040	.039	.039	.039
1.5KE62A	NA	.659	.617	.604	.595	.595
1.5KE30CA	NA	1.304	1.215	1.186	1.167	1.167
P6KE30CA	NA	.748	.699	.690	.681	.681
Thyristors						
2N6400	NA	.650	.620	.583	.562	.562
2N4186	2.315	2.290	2.270	2.260	2.250	2.250

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Optoelectronic Round LED Lamps					6
T1 STD RED	.054	.054	.054	.053	
T1 3/4 STD RED	.054	.054	.053	.053	
T1 3/4 H.EF.RED	.074	.073	.072	.072	
Mold Frame LED					6
0.3" Digital Display	.500	.500	.490	.490	
0.6" Digital Display	.550	.550	.530	.520	
Optical Couplers					6-8
4N25	.200	.200	.200	.200	
4N36	.230	.230	.229	.229	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (June 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Optoelectronic Round LED Lamps						
T1 STD RED	.055	.054	.053	.052	.051	.051
T1 3/4 STD RED	.056	.054	.053	.052	.051	.051
T1 3/4 H.EF.RED	.079	.074	.072	.071	.070	.070
Mold Frame LED						
0.3" Digital Display	.528	.500	.490	.485	.480	.476
0.6" Digital Display	.615	.550	.525	.517	.512	.512
Optical Couplers						
4N25	.205	.200	.200	.200	.200	.200
4N36	.238	.230	.229	.229	.229	.229

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

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North American Semiconductor Price Outlook:

Second Quarter 1991

Source: Dataquest

Semiconductor Procurement

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North American Semiconductor Price Outlook:

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Methodology and Sources

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

This document includes associated long-range forecasts, which are generated by Semiconductor Group analysts.

For SPS binderholders, the price analysis presented here correlates with the quarterly and long-range price tables mailed on March 20, 1991. For SPS clients that use the SPS on-line service, the prices presented here correlate with the quarterly and long-range price tables dated March 1991 in the SPS on-line service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

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

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74LS TTL												0-7
74LS00	0.098	0.100	0.100	0.100	0.100	0.100	0.110	0.110	0.110	0.110	0.110	
74LS74	0.115	0.115	0.115	0.115	0.115	0.115	0.117	0.117	0.117	0.117	0.117	
74LS138	0.156	0.150	0.150	0.150	0.152	0.150	0.152	0.152	0.152	0.152	0.152	
74LS244	0.215	0.215	0.215	0.215	0.215	0.215	0.215	0.215	0.215	0.214	0.215	
74LS373	0.216	0.215	0.215	0.215	0.215	0.215	0.215	0.215	0.215	0.214	0.215	
74S TTL												0-6
74S00	0.141	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
74S74	0.174	0.174	0.174	0.174	0.174	0.174	0.179	0.179	0.179	0.179	0.179	
74S138	0.258	0.257	0.257	0.257	0.257	0.257	0.259	0.259	0.259	0.259	0.259	
74S244	0.528	0.515	0.500	0.500	0.500	0.504	0.500	0.500	0.500	0.500	0.500	
74S373	0.529	0.515	0.500	0.500	0.500	0.504	0.500	0.500	0.500	0.500	0.500	
74F TTL												0-6
74F00	0.100	0.100	0.100	0.105	0.105	0.103	0.105	0.105	0.107	0.107	0.106	
74F74	0.118	0.118	0.118	0.117	0.115	0.117	0.115	0.115	0.115	0.115	0.115	
74F138	0.172	0.160	0.160	0.160	0.160	0.160	0.159	0.158	0.158	0.158	0.158	
74F244	0.244	0.229	0.228	0.227	0.226	0.228	0.223	0.221	0.219	0.219	0.221	
74F373	0.241	0.228	0.227	0.225	0.224	0.226	0.221	0.220	0.218	0.217	0.219	
74HC CMOS												0-7
74HC00	0.100	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	
74HC74	0.119	0.120	0.120	0.120	0.120	0.120	0.125	0.125	0.125	0.125	0.125	
74HC138	0.154	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	
74HC244	0.236	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.233	0.233	0.231	
74HC373	0.235	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.233	0.233	0.231	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Family	1990	1991	1992	1993	1994	1995
74LS TTL						
74LS00	0.098	0.100	0.110	0.110	0.110	0.110
74LS74	0.115	0.115	0.117	0.117	0.117	0.117
74LS138	0.156	0.150	0.152	0.152	0.152	0.152
74LS244	0.215	0.215	0.215	0.205	0.199	0.195
74LS373	0.216	0.215	0.215	0.206	0.199	0.195
74S TTL						
74S00	0.141	0.140	0.140	0.140	0.140	0.142
74S74	0.174	0.174	0.179	0.179	0.179	0.179
74S138	0.258	0.257	0.259	0.259	0.259	0.259
74S244	0.528	0.504	0.500	0.500	0.500	0.500
74S373	0.529	0.504	0.500	0.500	0.500	0.500
74F TTL						
74F00	0.100	0.103	0.106	0.105	0.105	0.105
74F74	0.118	0.117	0.115	0.112	0.108	0.105
74F138	0.172	0.160	0.158	0.151	0.149	0.147
74F244	0.244	0.228	0.221	0.217	0.215	0.213
74F373	0.241	0.226	0.219	0.215	0.215	0.214
74HC CMOS						
74HC00	0.100	0.105	0.105	0.108	0.110	0.110
74HC74	0.119	0.120	0.125	0.125	0.125	0.125
74HC138	0.154	0.155	0.155	0.157	0.160	0.162
74HC244	0.236	0.230	0.231	0.237	0.240	0.242
74HC373	0.235	0.230	0.231	0.236	0.240	0.241

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74AC CMOS												0-6
74AC00	0.218	0.200	0.193	0.190	0.190	0.193	0.180	0.180	0.180	0.180	0.180	
74AC74	0.282	0.267	0.263	0.260	0.256	0.262	0.254	0.253	0.251	0.250	0.252	
74AC138	0.359	0.345	0.344	0.342	0.338	0.342	0.337	0.337	0.337	0.337	0.337	
74AC244	0.516	0.498	0.495	0.491	0.488	0.493	0.485	0.483	0.480	0.478	0.481	
74AC373	0.538	0.525	0.515	0.505	0.495	0.510	0.490	0.488	0.485	0.483	0.486	
74ALS TTL												0-6
74ALS00	0.136	0.135	0.135	0.135	0.135	0.135	0.130	0.130	0.130	0.130	0.130	
74ALS74	0.168	0.165	0.164	0.163	0.162	0.164	0.159	0.157	0.156	0.155	0.157	
74ALS138	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285	
74ALS244	0.393	0.385	0.383	0.381	0.380	0.382	0.378	0.375	0.371	0.369	0.373	
74ALS373	0.393	0.385	0.383	0.381	0.380	0.382	0.378	0.375	0.371	0.369	0.373	
74AS TTL												0-7
74AS00	0.172	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	
74AS74	0.179	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	
74AS138	0.444	0.440	0.440	0.440	0.440	0.440	0.430	0.430	0.430	0.430	0.430	
74AS244	0.770	0.760	0.760	0.750	0.740	0.753	0.740	0.740	0.740	0.740	0.740	
74AS373	0.776	0.750	0.750	0.745	0.735	0.745	0.730	0.730	0.730	0.730	0.730	
74BC*												3-6
74BC00	0.398	0.344	0.333	0.323	0.314	0.328	0.297	0.286	0.279	0.272	0.284	
74BC244	0.906	0.846	0.809	0.779	0.752	0.796	0.725	0.698	0.672	0.648	0.686	
74BC373	0.909	0.849	0.811	0.781	0.754	0.799	0.726	0.700	0.674	0.649	0.687	
10KH ECL												6
10H102	0.494	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	
10H131	NA	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	
10H173	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	

NA = Not available
*Prices for 74BC exclude 74ABT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

Table 4
Estimated Long-Range Standard Logic Price Trends—North American Bookings (Dollars)

Family	1990	1991	1992	1993	1994	1995
74AC CMOS						
74AC00	0.218	0.193	0.180	0.177	0.173	0.170
74AC74	0.282	0.262	0.252	0.240	0.225	0.220
74AC138	0.359	0.342	0.337	0.310	0.294	0.280
74AC244	0.516	0.493	0.481	0.442	0.418	0.399
74AC373	0.538	0.510	0.486	0.447	0.418	0.399
74ALS TTL						
74ALS00	0.136	0.135	0.130	0.132	0.135	0.135
74ALS74	0.168	0.164	0.157	0.147	0.140	0.140
74ALS138	0.285	0.285	0.285	0.261	0.253	0.249
74ALS244	0.393	0.382	0.373	0.363	0.359	0.356
74ALS373	0.393	0.382	0.373	0.363	0.360	0.357
74AS TTL						
74AS00	0.172	0.169	0.169	0.165	0.163	0.160
74AS74	0.179	0.180	0.180	0.179	0.179	0.179
74AS138	0.444	0.440	0.430	0.410	0.405	0.398
74AS244	0.770	0.753	0.740	0.715	0.690	0.669
74AS373	0.776	0.745	0.730	0.705	0.680	0.659
74BC*						
74BC00	0.398	0.328	0.284	0.267	0.260	0.242
74BC244	0.906	0.796	0.686	0.640	0.611	0.587
74BC373	0.909	0.799	0.687	0.610	0.612	0.588
10KH ECL						
10H102	0.494	0.490	0.490	0.490	0.490	0.490
10H131	NA	1.200	1.200	1.200	1.200	1.200
10H173	1.200	1.200	1.200	1.200	1.200	1.200

NA = Not available
*Prices for 74BC exclude 74ABT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8-Bit MPUs												
Z80-6	0.78	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	4-8
Z84C00-6	1.04	0.99	0.98	0.98	0.98	0.98	0.96	0.94	0.92	0.92	0.94	5-8
16-Bit MPUs												
68000-8	3.32	4.00	4.00	4.00	4.00	4.00	3.75	3.75	3.75	3.75	3.75	5-9
68000-12	5.98	5.65	5.60	5.55	5.50	5.58	5.50	5.50	5.50	5.50	5.50	5-9
68010-12	NA	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	5-9
80186-8 PLCC	7.90	6.70	6.37	6.05	5.74	6.21	5.57	5.43	5.32	5.30	5.41	6-8
80286-10 PLCC	9.37	6.92	6.91	6.71	6.51	6.76	6.46	6.39	6.30	6.25	6.35	2-14
80286-12 PLCC	12.00	7.90	7.48	7.29	7.10	7.44	6.96	6.82	6.68	6.55	6.75	2-14
80286-16 PLCC[1]	NA	18.68	17.14	15.99	14.80	16.65	14.09	13.46	12.92	12.43	13.23	NA
CISC 32-Bit MPUs/Peripherals												
68020-16 QFP	NA	37.73	36.92	36.11	35.67	36.61	34.62	33.70	32.89	32.55	33.44	5-9
68881-16 PLCC	NA	30.00	28.00	26.00	25.00	27.25	23.10	22.00	21.00	20.00	21.53	5-10
68851-16 PGA	NA	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	5-10
68020-25	131.20	100.00	95.00	92.00	89.00	94.00	85.00	85.00	85.00	85.00	85.00	5-10
68030-16	138.00	122.00	121.00	120.00	119.00	120.50	118.00	118.00	118.00	118.00	118.00	5-9
68882-16	87.51	65.00	65.00	65.00	65.00	65.00	60.00	60.00	60.00	60.00	60.00	5-10
68030-25	189.28	167.00	163.00	159.00	155.00	161.00	150.25	146.45	143.00	140.00	144.93	5-10
68040-25	730.38	593.25	554.09	517.16	490.91	538.85	455.08	430.10	413.90	400.90	425.00	14-20
80386SX-16 PQFP	62.73	60.50	58.88	57.42	56.25	58.26	55.00	54.00	52.33	52.05	53.34	9-14

(Continued)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
80386SX-20 PQFP	NA	94.00	91.18	88.44	85.79	89.85	83.91	81.96	79.51	77.53	80.73	9-14
80386-25[2]	184.21	162.20	159.95	154.00	150.55	156.68	148.50	144.50	142.50	138.50	143.50	6-8
80387-25[3]	326.78	308.00	277.00	249.30	239.50	268.45	234.00	229.00	224.00	220.00	226.75	4-8
80486-25	790.39	690.00	585.00	501.00	429.25	551.31	417.00	407.00	390.72	375.09	397.45	6-8
80486-33[1]	NA	817.78	702.00	596.70	495.60	653.02	466.88	441.54	413.28	403.20	431.22	NA
RISC 32-Bit MPUs												
29000-25[4]	NA	146.34	132.98	125.76	118.92	131.00	112.90	107.00	102.00	98.10	105.00	NA
88100-25[4]	NA	82.25	77.00	74.00	71.00	76.06	69.50	68.05	67.45	67.00	68.00	NA
R3000-25[4]	NA	150.79	136.42	127.59	121.95	134.19	115.00	108.00	105.00	103.98	108.00	NA
SPARC-25[4]	NA	100.35	90.72	84.70	79.21	88.74	75.62	72.30	69.51	66.55	71.00	NA

NA = Not available
[1] Estimated but not by survey
[2] Excludes AM386
[3] Volume of <1,000 pieces for 80387-25
[4] Price excludes floating point/memory management units
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Family	1990 Year	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year
8-Bit MPUs						
Z80-6	0.78	0.75	0.75	0.75	0.75	0.75
Z84C00-6	1.04	0.98	0.94	0.91	0.89	0.88
16-Bit MPUs						
68000-8	3.32	4.00	3.75	3.65	3.60	3.56
68000-12	5.98	5.58	5.50	5.35	5.20	5.10
68010-12	NA	25.00	25.00	25.00	25.00	25.00
80186-8 PLCC	7.91	6.21	5.41	5.30	5.30	5.30
80286-10 PLCC	9.37	6.76	6.35	6.20	6.15	6.18
80286-12 PLCC	12.00	7.44	6.75	6.45	6.36	6.21
80286-16 PLCC	NA	16.65	13.23	NA	NA	NA
CISC 32-Bit MPUs/Peripherals						
68020-16 QFP	NA	36.61	33.44	31.42	29.97	29.97
68881-16 PLCC	NA	27.25	21.53	20.00	19.60	19.30
68851-16 PGA	NA	110.00	110.00	110.00	110.00	110.00
68020-25	131.20	94.00	85.00	82.76	81.10	80.60
68030-16	138.00	120.50	118.00	114.00	111.00	110.00
68882-16	87.51	65.00	60.00	59.50	59.00	59.00
68030-25	189.28	161.00	144.93	137.00	132.00	130.00
68040-25	730.38	538.85	425.00	380.00	365.00	350.00
80386SX-16 PQFP	62.73	58.26	53.34	50.00	NA	NA
80386SX-20 PQFP	NA	89.85	80.73	76.56	75.15	75.15
80386-25[1]	184.21	156.68	143.50	135.00	133.00	133.00
80387-25[2]	326.78	268.45	226.75	204.00	199.00	199.00
80486-25	790.39	551.31	397.45	360.00	355.00	355.00
80486-33	NA	653.02	431.22	NA	NA	NA

(Continued)

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

Family	1990 Year	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year
RISC 32-Bit MPUs						
29000-25[3]	NA	131.00	105.00	95.00	90.40	84.00
88100-25[3]	NA	76.06	68.00	62.35	57.80	54.00
R3000-25[3]	NA	134.19	108.00	97.10	90.50	82.50
SPARC-25[3]	NA	88.74	71.00	62.40	59.00	53.66

NA = Not available
[1]Excludes AM386.
[2]Volume of <1,000 pieces for 80387-25.
[3]Price excludes floating point/memory management units.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992
Source: Dataquest (March 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
256Kx1 DRAM 100-120ns (DIP)	1.93	1.70	1.70	1.70	1.70	1.70	1.66	1.66	1.66	1.66	1.66	1-12
64Kx4 DRAM 100ns (DIP)	1.98	1.71	1.71	1.71	1.71	1.71	1.69	1.69	1.69	1.69	1.69	1-12
64Kx4 VRAM 120ns [2] (ZIP)	4.06	3.28	3.25	3.15	3.10	3.20	3.05	3.00	2.95	2.92	2.98	2-9
1Mbx1 DRAM 80ns (DIP/SOJ)	6.06	4.47	4.56	4.50	4.24	4.44	4.08	3.99	3.92	3.89	3.97	1-12
256Kx4 DRAM 80-100ns (SOJ)	6.09	4.49	4.58	4.51	4.25	4.46	4.09	4.00	3.93	3.90	3.98	2-12
64Kx16 DRAM 80ns [2] (SOJ)	NA	12.26	11.48	10.77	10.15	11.16	9.53	9.09	8.77	8.41	8.95	2-8
256Kx4 VRAM 120ns [2] (ZIP)	13.91	10.11	9.60	9.25	8.96	9.48	8.63	8.36	8.16	7.90	8.26	8-12
128Kx8 VRAM 100ns [2] (SOJ)	NA	11.35	10.93	10.33	9.81	10.61	9.40	9.07	8.76	8.42	8.91	8-14
4Mbx1 DRAM 80ns (SOJ, 300 mil)	36.36	19.99	17.07	15.69	14.52	16.82	13.70	13.05	12.55	12.18	12.87	2-10
1Mbx8 SIMM 100ns	54.71	38.63	39.03	38.57	36.46	38.17	34.94	34.19	33.54	33.33	34.00	4-10
1Mbx9 SIMM 80ns	61.14	43.26	44.12	43.29	41.02	42.92	39.67	38.82	38.09	37.85	38.61	4-10
256Kx9 SIMM 100ns	17.10	14.20	13.73	13.33	12.98	13.56	12.63	12.17	12.07	12.03	12.23	2-10
256Kx36 SIMM 80ns	66.37	50.96	51.32	49.69	48.24	50.05	47.45	46.73	46.17	45.50	46.46	4-10

NA = Not available
[1] Contract volume = at least 100,000 per order except as specified
[2] Contract volume may be less than 100,000 per order
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990 Year	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year
256Kx1 DRAM 100-120ns (DIP)	1.93	1.70	1.66	1.50	1.50	1.55
64Kx4 DRAM 100ns (DIP)	1.98	1.71	1.69	1.55	1.55	1.57
64Kx4 VRAM 120ns (ZIP)	4.06	3.20	2.98	2.90	2.88	2.87
1Mbx1 DRAM 80ns[2] (DIP/SOJ)	6.06	4.44	3.97	3.75	3.75	3.75
256Kx4 DRAM 80-100ns (SOJ)[3]	6.09	4.46	3.98	3.76	3.76	3.76
64Kx16 DRAM 80ns (SOJ)	NM	11.16	8.95	7.57	6.96	6.48
256Kx4 VRAM 120ns (ZIP)	13.91	9.48	8.26	7.60	7.05	6.75
128Kx8 VRAM 100ns (SOJ)	NM	10.61	8.91	8.28	7.72	7.40
4Mbx1 DRAM 80ns[2] (SOJ, 300 mil)[4]	36.36	16.82	12.87	11.30	9.99	8.50
1Mbx8 SIMM 100ns	54.71	38.17	34.00	32.10	31.24	30.39
1Mbx9 SIMM 80ns	61.14	42.92	38.61	36.28	35.15	34.19
256Kx9 SIMM 100ns	17.10	13.56	12.23	10.20	9.60	9.35
256Kx36 SIMM 80ns	66.37	50.05	46.46	39.99	37.05	35.30

NM = Not meaningful
[1] Contract volume = at least 100,000 per order
[2] 80-100ns for 1990
[3] 100ns for 1990
[4] 300-350 mil for 1990
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
Fast 4Kx4 (25ns)	2.88	2.37	2.34	2.30	2.28	2.32	2.24	2.23	2.23	2.23	2.23	2-13
Fast 2Kx8 (25ns)	3.49	2.70	2.63	2.56	2.52	2.60	2.46	2.43	2.36	2.33	2.40	2-13
Fast 64Kx1 (25ns)	4.27	3.54	3.44	3.37	3.32	3.42	3.27	3.25	3.25	3.25	3.25	2-12
Fast 16Kx4 (25ns)	4.54	3.64	3.58	3.53	3.49	3.56	3.39	3.38	3.38	3.38	3.38	7-18
Fast 8Kx8 (25ns)	5.14	4.32	4.07	4.03	4.00	4.10	3.72	3.72	3.75	3.80	3.75	6-20
Fast 16Kx4 (35ns)	3.97	3.22	3.18	3.14	3.11	3.16	3.05	3.05	3.05	3.05	3.05	6-16
Fast 8Kx8 (45ns)	3.98	3.35	3.25	3.21	3.18	3.25	3.10	3.10	3.05	3.00	3.06	6-14
Slow 8Kx8 (120-150ns)	1.96	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.70	6-11
Fast 64Kx4 (25ns)	15.71	11.00	9.90	8.87	8.60	9.59	8.52	8.45	8.31	8.17	8.36	5-10
Fast 32Kx8 (35ns)	14.74	9.97	8.90	8.25	7.63	8.69	7.20	6.75	6.43	6.10	6.62	5-12
Slow 32Kx8 (100ns)	5.37	4.35	4.14	4.03	3.95	4.12	3.80	3.75	3.75	3.75	3.76	6-10
Slow 128Kx8 (100ns)	30.79	19.27	16.40	14.50	12.70	15.72	12.20	11.80	11.44	11.09	11.63	2-10
Fast 128Kx8 (25ns)	NA	85.00	70.00	62.50	55.60	70.20	46.90	41.00	36.00	32.00	38.98	8-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
Fast 4Kx4 (25ns)	2.88	2.32	2.23	2.20	2.20	2.20
Fast 2Kx8 (25ns)	3.49	2.60	2.40	2.33	2.33	2.33
Fast 64Kx1 (25ns)	4.27	3.42	3.25	2.90	2.85	2.80
Fast 16Kx4 (25ns)	4.54	3.56	3.38	3.34	3.30	3.27
Fast 8Kx8 (25ns)	5.14	4.10	3.75	3.70	3.60	3.60
Fast 16Kx4 (35ns)	3.97	3.16	3.05	3.03	2.98	2.98
Fast 8Kx8 (45ns)	3.98	3.25	3.06	2.81	2.81	3.00
Slow 8Kx8 (120-150ns)	1.96	1.75	1.75	1.75	1.80	1.90
Fast 64Kx4 (25ns)	15.71	9.59	8.36	7.10	6.30	5.60
Fast 32Kx8 (35ns)	14.74	8.69	6.62	5.70	5.55	5.50
Slow 32Kx8 (100ns)	5.37	4.12	3.76	3.75	3.75	3.75
Slow 128Kx8 (100ns)	30.79	15.72	11.63	9.90	7.75	7.50
Fast 128Kx8 (25ns)	NA	68.28	38.98	NA	NA	NA

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Product	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Times (Weeks)
CMOS												
32Kx8 ROM	1.75	1.60	1.60	1.60	1.60	1.60	1.63	1.63	1.63	1.63	1.63	5-10
64Kx8 ROM	2.40	2.15	2.10	2.05	2.02	2.08	2.00	1.95	1.90	1.90	1.94	5-10
128Kx8 ROM	3.06	2.38	2.33	2.29	2.26	2.32	2.24	2.22	2.20	2.16	2.20	4-10
64Kx16 ROM	NA	3.18	3.02	2.87	2.73	2.95	2.61	2.51	2.41	2.35	2.47	5-9
256Kx8 ROM	3.90	3.25	3.19	3.13	3.08	3.16	3.04	3.00	2.96	2.93	2.98	4-10
512Kx8 ROM	5.43	4.05	3.92	3.86	3.80	3.91	3.70	3.63	3.54	3.51	3.60	4-12
256Kx16 ROM*	NA	5.52	5.21	5.04	4.91	5.17	4.69	4.48	4.35	4.27	4.45	5-12

*256Kx16 ROM: 150ns and above; 40-pin PDIP
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
CMOS						
32Kx8 ROM	1.75	1.60	1.63	2.00	NA	NA
64Kx8 ROM	2.40	2.08	1.94	2.55	2.55	2.55
128Kx8 ROM	3.06	2.32	2.20	2.05	2.05	2.05
64Kx16 ROM	NA	2.95	2.47	2.32	2.28	2.24
256Kx8 ROM	3.90	3.16	2.98	2.92	2.79	2.73
512Kx8 ROM	5.43	3.91	3.60	3.45	3.30	3.22
256Kx16 ROM*	NA	5.17	4.45	4.13	3.98	3.92

*256Kx16 ROM: 150ns and above; 40-pin PDIP
NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Times (Weeks)
TTL												
4K PROM	0.94	0.95	0.97	0.98	0.99	0.97	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM	2.14	2.15	2.20	2.30	2.40	2.26	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM	6.38	5.57	5.12	4.71	4.80	5.05	4.70	4.60	4.50	4.50	4.58	6-8
64K PROM	7.89	7.18	7.00	6.86	6.75	6.95	6.62	6.47	6.36	6.23	6.42	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
TTL						
4K PROM	0.94	0.97	1.00	NA	NA	NA
16K PROM	2.14	2.26	2.40	2.40	NA	NA
32K PROM	6.38	5.05	4.58	4.50	4.50	NA
64K PROM	7.89	6.95	6.42	5.92	5.54	5.45

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This price forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8Kx8 EPROM	1.75	1.65	1.65	1.74	1.80	1.71	1.81	1.88	1.93	2.00	1.90	2-8
16Kx8 EPROM	2.19	2.05	2.04	2.04	2.04	2.04	2.04	2.05	2.10	2.10	2.07	2-8
32Kx8 EPROM	2.02	1.98	1.99	2.01	2.08	2.01	2.15	2.17	2.19	2.25	2.19	2-10
64Kx8 EPROM	3.10	2.80	2.75	2.70	2.68	2.73	2.68	2.68	2.68	2.68	2.68	3-12
128Kx8 EPROM	5.96	5.00	4.84	4.70	4.60	4.78	4.49	4.39	4.29	4.20	4.34	4-10
256Kx8 EPROM	NA	12.37	11.15	10.02	9.00	10.64	8.29	7.60	7.00	6.60	7.37	4-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
8Kx8 EPROM	1.75	1.71	1.90	2.80	3.50	NA
16Kx8 EPROM	2.19	2.04	2.07	2.90	3.50	NA
32Kx8 EPROM	2.02	2.01	2.19	2.50	3.00	3.00
64Kx8 EPROM	3.10	2.73	2.68	2.60	2.50	2.55
128Kx8 EPROM	5.96	4.78	4.34	4.10	4.01	4.01
256Kx8 EPROM	NA	10.64	7.37	6.10	5.60	5.40

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.68	1.40	1.40	1.48	1.53	1.45	1.60	1.60	1.60	1.60	1.60	2-12
32Kx8	1.77	1.61	1.61	1.61	1.61	1.61	1.60	1.60	1.60	1.60	1.60	2-12
64Kx8	3.08	2.52	2.50	2.45	2.40	2.47	2.35	2.31	2.27	2.23	2.29	2-12
128Kx8	NA	4.55	4.31	4.25	4.03	4.28	4.00	3.91	3.77	3.57	3.81	6-12

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
16Kx8	1.68	1.45	1.60	NA	NA	NA
32Kx8	1.77	1.61	1.60	NA	NA	NA
64Kx8	3.08	2.47	2.29	2.76	3.23	3.52
128Kx8	NA	4.28	3.81	3.53	3.44	3.40

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K EEPROM	3.28	3.25	3.20	3.00	2.95	3.10	2.95	2.90	2.90	2.90	2.91	2-7
8Kx8 EEPROM	5.26	4.90	4.70	4.55	4.40	4.64	4.20	4.14	3.99	3.95	4.07	3-8
32Kx8 EEPROM	40.08	23.00	20.60	18.60	17.00	19.80	14.00	12.40	11.00	9.78	11.80	3-8
64Kx8 EEPROM	NA	99.00	60.00	40.00	25.00	56.00	21.25	19.13	17.21	15.84	18.36	3-8
128Kx8 EEPROM*	NA	150.00	132.00	118.00	110.00	127.50	100.00	87.00	75.00	65.00	81.80	3-8

*Estimated but not by survey
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
16K EEPROM	3.28	3.10	2.91	2.85	2.80	2.80
8Kx8 EEPROM	5.26	4.64	4.07	3.74	3.58	3.46
32Kx8 EEPROM	40.08	19.80	11.80	9.30	8.95	8.55
64Kx8 EEPROM	NA	56.00	18.36	NA	NA	NA
128Kx8 EEPROM	NA	127.50	81.75	NA	NA	NA

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
32Kx8, PDIP	NA	6.45	5.95	5.70	5.50	5.90	5.25	5.05	4.92	4.83	5.01	4-10
128Kx8, TSOP	NA	16.00	13.90	12.10	11.10	13.28	10.60	10.20	9.85	9.65	10.08	4-12
256Kx8, TSOP	NA	29.00	23.50	19.50	16.20	22.05	15.75	15.20	14.70	14.34	15.00	6-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Product	1990	1991	1992	1993	1994	1995
32Kx8, PDIP	NA	5.90	5.01	4.70	4.50	NA
128Kx8, TSOP	NA	13.28	10.08	7.99	6.35	NA
256Kx8, TSOP	NA	22.05	15.00	11.25	8.99	NA

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	**1990**	**1991**	**1992**	**1990**	**1991**	**1992**	**1990**	**1991**	**1992**	**Times (Weeks)**
CMOS										Production
2.0 Microns	127.0	95.0	79.1	95.0	90.2	82.8	90.0	85.8	74.7	9-13
1.5 Microns	123.0	106.0	85.6	95.0	92.5	89.0	80.7	80.3	71.0	9-12
1.25 Microns	111.0	99.0	84.2	85.0	80.0	68.0	87.0	82.0	69.7	8-11
1.0 Micron	161.6	108.5	86.3	88.5	80.8	71.0	88.5	78.1	70.0	10-13
ECL	6,017	5,360	4,850	4,750	4,588	3,823	4,250	3,875	3,210	10-13
NRE Charges ($K)										
CMOS										Prototypes
2.0 Microns	15.50	13.50	13.00	20.20	18.00	16.50	21.47	21.00	19.75	3-5
1.5 Microns	16.50	14.38	13.50	23.50	20.00	18.50	26.60	25.50	24.00	3-5
1.25 Microns	12.95	12.70	12.50	19.40	18.00	16.30	NA	21.20	20.00	3-6
1.0 Micron	NA	23.00	16.50	NA	24.00	21.00	NA	27.00	23.00	3-7
ECL	39.00	32.00	30.00	54.00	50.00	45.00	75.00	59.67	53.00	12-14

(Continued)

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

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Times (Weeks)
CMOS										Production
2.0 Microns	96.7	90.5	76.9	NA	94.1	83.8	NA	103.1	88.0	10-14
1.5 Microns	87.5	80.0	70.4	92.0	81.5	69.8	NA	100.0	79.0	10-12
1.25 Microns	94.0	79.0	68.9	115.0	99.0	83.7	NA	99.9	78.7	8-12
1.0 Micron	77.9	78.3	62.0	115.0	78.7	72.4	NA	95.7	80.0	10-13
ECL	5,250	4,650	4,013	4,600	3,838	3,200	NA	3,600	3,050	10-14
NRE Charges ($K)										
CMOS										Prototypes
2.0 Microns	34.70	33.10	33.00	NA	54.80	53.00	NA	105.00	100.80	4-7
1.5 Microns	41.88	40.00	40.00	60.00	60.00	60.00	NA	100.00	94.59	3-6
1.25 Microns	NA	39.80	39.30	NA	54.60	52.10	NA	100.00	94.00	4-7
1.0 Micron	49.00	43.75	43.25	68.50	62.50	57.00	NA	105.00	102.00	4-7
ECL	85.67	73.50	71.00	117.50	105.00	100.00	NA	170.00	146.67	6-14

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality or service. These prices are intended for use as guidelines.
This forecast correlates to Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Time (Weeks)
CMOS										Production
2.0 Microns	107.1	94.6	79.6	107.1	92.6	77.6	116.0	92.6	78.1	10-13
1.5 Microns	150.5	120.5	110.0	110.0	110.0	100.0	95.0	92.5	80.0	10-14
1.25 Microns	125.0	90.0	76.5	85.0	70.4	63.5	80.0	70.4	59.8	8-15
1.0 Micron	134.0	97.0	89.6	109.9	96.0	80.3	102.0	82.5	74.3	10-15
NRE Charges ($K)										Prototypes
2.0 Microns	45.00	44.00	39.00	55.00	50.00	47.00	65.00	60.00	56.00	4-8
1.5 Microns	36.44	35.00	33.50	37.50	36.00	34.50	47.75	46.00	43.00	5-8
1.25 Microns	34.50	33.90	32.50	34.90	35.80	33.50	46.50	45.95	44.00	5-8
1.0 Micron	45.00	36.00	39.00	48.33	42.00	37.00	59.00	54.30	48.00	4-8

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1990	1991	1992	1990	1991	1992	1990	1991	1992	Time (Weeks)
CMOS										Production
2.0 Micron	128.0	105.0	95.7	132.0	123.6	111.7	NA	127.6	105.9	10-13
1.5 Micron	95.0	82.5	65.9	100.0	83.5	71.9	NA	90.1	77.5	10-14
1.25 Micron	88.8	72.0	69.2	123.0	98.0	88.3	NA	102.9	87.4	9-15
1.0 Micron	109.3	82.8	71.4	102.6	93.0	78.1	NA	99.9	83.4	10-15
NRE Charges ($K)										Prototypes
2.0 Micron	75.00	74.00	72.50	85.00	80.00	80.00	NA	120.00	108.00	4-8
1.5 Micron	70.45	67.00	65.00	100.00	90.00	88.00	NA	115.00	109.00	5-8
1.25 Micron	69.00	63.00	59.90	89.00	85.00	84.00	NA	126.00	108.36	5-8
1.0 Micron	76.50	72.00	65.00	105.00	89.00	87.00	NA	137.15	117.50	4-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤ 20						
	≤ 6	8.15	7.35	6.73	6.23	3-9
	6.1-7.5	3.54	3.28	3.10	2.95	3-8
	7.6-10.0	1.81	1.73	1.59	1.50	2-8
	10.1-14.99	1.41	1.32	1.27	1.23	3-8
	15-<25	0.78	0.74	0.70	0.65	2-8
	25-<35	0.55	0.53	0.52	0.50	2-8
	≥ 35	0.55	0.53	0.53	0.52	2-6
24	≤ 6	10.85	10.70	10.10	9.50	3-9
	6.1-7.5	6.05	5.55	5.30	5.11	3-8
	7.6-10.0	4.20	3.81	3.58	3.36	2-8
	10.1-14.99	3.28	3.12	3.00	2.88	3-8
	15-<25	1.30	1.24	1.15	1.12	2-8
	≥ 25	0.86	0.81	0.78	0.77	2-6
24						
22V10						
	15-<25	5.95	5.67	5.40	5.20	3-8
	25-<35	2.69	2.59	2.43	2.32	2-8

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
≤ 20							
	≤ 6	9.00	7.75	6.48	6.02	5.75	5.50
	6.1-7.5	4.14	3.41	3.03	2.70	2.51	2.40
	7.6-10.0	2.11	1.77	1.55	1.40	1.39	1.32
	10.1-14.99	1.63	1.37	1.25	1.12	1.08	1.00
	15-<25	0.98	0.76	0.68	0.63	0.61	0.60
	25-<35	0.60	0.54	0.51	0.49	0.48	0.48
	≥ 35	0.62	0.54	0.52	0.52	0.52	0.52
24							
	≤ 6	12.18	10.78	9.80	8.50	7.36	6.60
	6.1-7.5	6.92	5.80	5.21	4.75	4.40	4.22
	7.6-10.0	4.64	4.01	3.47	3.20	3.03	2.90
	10.1-14.99	3.71	3.20	2.94	2.72	2.54	2.40
	15-<25	1.58	1.27	1.14	1.12	1.10	1.08
	≥ 25	1.00	0.84	0.78	0.73	0.70	0.70
24							
22V10							
	15-<25	NA	5.81	5.30	4.98	4.68	4.49
	25-<35	NA	2.64	2.37	2.19	2.07	1.98

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤ 20	6.1-7.5	6.73	6.28	5.75	5.31	4-10
	7.6-10.0	3.96	3.68	3.32	3.08	4-12
	10.1-14.99	2.83	2.53	2.08	2.02	2-6
	15-<25	1.07	1.03	0.90	0.84	1-6
	≥ 25	0.78	0.74	0.72	0.68	2-6
24						
	7.6-10.0	7.35	6.55	6.23	5.87	2-10
	10.1-14.99	3.80	3.60	3.40	3.24	1-6
	15-< 25	1.75	1.67	1.55	1.51	1-8
	≥ 25	1.32	1.20	1.15	1.10	2-8
24						
22V10	15-< 25	7.75	6.87	6.32	5.70	1-12
	25-< 35	3.59	3.16	2.89	2.54	1-6

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
≥ 20	6.1-7.5	NA	6.50	5.53	5.15	4.80	4.45
	7.6-10.0	4.36	3.82	3.20	2.70	2.48	2.30
	10.1-14.99	3.33	2.68	2.05	1.84	1.69	1.59
	15-<25	1.30	1.05	0.87	0.81	0.78	0.73
	≥ 25	0.93	0.76	0.70	0.64	0.62	0.59
24							
	7.6-10.0	8.22	6.95	6.05	5.40	4.90	4.55
	10.1-14.99	4.35	3.70	3.32	3.05	1.39	2.64
	15- < 25	2.05	1.71	1.53	1.47	2.82	1.33
	≥ 25	1.64	1.26	1.12	1.07	1.05	1.05
24							
22V10							
	15-<25	NA	7.31	6.01	5.45	5.15	4.91
	25-<35	NA	3.38	2.72	2.27	2.20	2.00

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
24						
	≤ 2.0	40.00	35.00	33.75	32.75	6-8
	2.01-4.0	33.00	30.00	27.90	26.40	8-10
	4.1-6.0	8.00	7.00	6.83	6.71	4
	6.1-15.0	6.50	6.00	5.80	5.71	4

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Pin Count	Speed* (ns)	1990	1991	1992	1993	1994	1995
24							
	≤ 2.0	42.50	37.50	33.25	30.00	27.40	25.07
	2.01-4.0	35.00	31.50	27.15	24.46	21.99	20.24
	4.1-6.0	9.50	7.50	6.77	6.27	5.86	5.68
	6.1-15.0	7.00	6.25	5.76	5.54	5.32	5.32

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Times (Weeks)
Voltage Regulators					
7800CT	0.890	0.880	0.875	0.865	4-6
78L00CP	0.123	0.121	0.120	0.118	
7805-TO92*	0.140	0.140	0.140	0.140	
Comparators					
LM339	0.139	0.138	0.137	0.137	4-6
LM393	0.130	0.130	0.129	0.127	
Op Amps					
741*	0.140	0.140	0.140	0.140	
3403P	0.187	0.184	0.182	0.178	4-6
1741CP1	0.125	0.125	0.124	0.120	
Interface ICs					
1488P	0.160	0.150	0.150	0.150	4-6
3486P	0.935	0.900	0.895	0.885	
Telecom IC					
34017P	0.357	0.334	0.330	0.320	5-8

*Estimated but not by survey
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Voltage Regulators						
7800CT (TO-220)	0.900	0.885	0.870	0.860	0.856	0.852
78L00CP	0.126	0.122	0.119	1.170	0.116	0.116
7805-TO92	NA	0.140	0.140	NA	NA	NA
Comparators						
LM339	0.135	0.139	0.137	0.131	0.130	0.130
LM393	0.133	0.130	0.128	0.127	0.126	0.126
Op Amps						
741	NA	0.140	0.140	0.140	0.140	0.140
3403P	0.193	0.186	0.180	0.175	0.173	0.171
1741CP1	0.128	0.122	0.122	0.118	0.117	0.116
Interface ICs						
1488P	0.175	0.155	0.150	0.145	0.140	0.137
3486P	0.995	0.918	0.890	0.870	0.850	0.840
Telecom IC						
34017P	0.400	0.346	0.325	0.310	0.298	0.290

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Small Signal Transistors					4-8
2N2222A	0.135	0.135	0.140	0.140	
2N3904	0.038	0.035	0.035	0.035	
2N2907A	0.100	0.100	0.097	0.095	
MPSA 43	0.059	0.055	0.052	0.049	
2N2222	0.051	0.047	0.046	0.045	
Bipolar Power Transistors					5-8
2N3772	1.040	1.040	1.040	1.040	
2N3055	0.650	0.650	0.620	0.620	
2N6107	0.235	0.235	0.235	0.235	
Power MOSFETs					5-8
IRF530	0.600	0.580	0.565	0.550	
IRF540	1.365	1.340	1.320	1.300	
IRF9531	1.064	1.052	1.040	1.030	
IRF9520	0.430	0.420	0.416	0.414	
Small Signal Diodes					4-6
1N4002	0.020	0.020	0.020	0.020	
1N645	0.047	0.047	0.047	0.046	
Power Diodes					4-7
1N3891	0.900	0.900	0.888	0.878	
1N3737	7.162	7.160	7.120	7.090	
1N4936	0.097	0.095	0.095	0.094	
Zener Diodes					4-8
1N829	1.165	1.165	1.165	1.165	
1N752A	0.028	0.027	0.026	0.025	
1N963B	0.027	0.026	0.026	0.025	
1N4735A	0.040	0.040	0.040	0.039	

(Continued)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Zener Diodes (Continued)					
1.5KE62A	0.670	0.647	0.625	0.610	
1.5KE30CA	1.330	1.277	1.230	1.200	
P6KE30CA	0.763	0.734	0.708	0.690	
Thyristors					4-8
2N6400	0.650	0.650	0.620	0.620	
2N4186	2.295	2.285	2.275	2.265	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Small Signal Transistors						
2N2222A	0.113	0.135	0.140	0.140	0.140	0.140
2N3904	0.040	0.037	0.035	0.040	0.040	0.040
2N2907A	0.100	0.100	0.096	0.090	0.089	0.089
MPSA 43	NA	0.057	0.050	0.048	0.046	0.045
2N2222	NA	0.049	0.046	NA	NA	NA
Bipolar Power Transistors						
2N3772	1.050	1.040	1.040	1.040	1.040	1.040
2N3055	NA	0.650	0.620	0.589	0.574	0.563
2N6107	0.235	0.235	0.235	0.235	0.235	0.235
Power MOSFET						
IRF530	0.600	0.590	0.558	0.484	0.478	0.476
IRF540	NA	1.353	1.310	1.280	1.260	1.250
IRF9531	1.088	1.058	1.035	1.028	1.022	1.017
IRF9520	0.443	0.425	0.415	0.410	0.408	0.406
Small Signal Diodes						
1N4002	0.020	0.020	0.020	0.020	0.020	0.020
1N645	0.049	0.047	0.046	0.045	0.045	0.045
Power Diodes						
1N3891	0.923	0.900	0.883	0.873	0.864	0.855
1N3737	7.233	7.161	7.105	7.010	6.930	6.850
1N4936	0.098	0.096	0.094	0.093	0.092	0.092
Zener Diodes						
1N829	1.165	1.165	1.165	1.165	1.165	1.165
1N752A	NA	0.028	0.026	0.026	0.026	0.026
1N963B	0.032	0.027	0.026	0.025	0.025	0.025

(Continued)

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

Device Family	1990	1991	1992	1993	1994	1995
Zener Diodes (Continued)						
1N4735A	NA	0.040	0.040	0.039	0.039	0.039
1.5KE62A	NA	0.659	0.617	0.604	0.595	0.585
1.5KE30CA	NA	1.304	1.215	1.186	1.167	1.154
P6KE30CA	NA	0.748	0.699	0.690	0.681	0.674
Thyristors						
2N6400	NA	0.650	0.620	0.583	0.562	0.548
2N4186	2.315	2.290	2.270	2.260	2.250	2.245

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Optoelectronic Round LED Lamps					6
T1 STD RED	0.054	0.054	0.054	0.053	
T1 3/4 STD RED	0.054	0.054	0.053	0.053	
T1 3/4 H.EF.RED	0.076	0.075	0.074	0.074	
Mold Frame LED					6
0.3-Inch Digital Display	0.500	0.500	0.490	0.490	
0.6-Inch Digital Display	0.590	0.590	0.580	0.580	
Optical Couplers					6-8
4N25	0.200	0.200	0.200	0.200	
4N36	0.230	0.230	0.229	0.229	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (March 1991)

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

Device Family	1990	1991	1992	1993	1994	1995
Optoelectronic Round LED Lamps						
T1 STD RED	0.055	0.054	0.053	0.052	0.051	0.051
T1 3/4 STD RED	0.056	0.054	0.053	0.052	0.051	0.051
T1 3/4 H.EF.RED	0.079	0.076	0.074	0.073	0.072	0.071
Mold Frame LED						
0.3-Inch Digital Display	0.528	0.500	0.490	0.485	0.480	0.476
0.6-Inch Digital Display	0.615	0.590	0.580	0.570	0.565	0.560
Optical Couplers						
4N25	0.205	0.200	0.200	0.200	0.200	0.200
4N36	0.238	0.230	0.229	0.229	0.229	0.229

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
This forecast correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

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North American Semiconductor Price Outlook

First Quarter 1991

Source: Dataquest

Semiconductor Procurement

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North American Semiconductor Price Outlook

First Quarter 1991

Source: Dataquest

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North American Semiconductor Price Outlook: First Quarter 1991

METHODOLOGY AND SOURCES

The Semiconductor Procurement provides information 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 for consistency and reconciliation. The information is then rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast.

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

PRICE AND LEAD TIME TRENDS

Tables 1 through 19 present price and lead time information (see the List of Tables).

Table 1
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

Part	Price Trend (Dollars) Fourth-Quarter Price Range	Forecast for First Quarter	Lead Times Current (Weeks)	Trend	Other Trends
Semiconductor Memory					
64Kx1 DRAM 150ns (DIP)	1.50-2.10	1.37	2-8	Steady	Decline stage of life cycle
256Kx1 DRAM 100-120ns (DIP)	1.50-2.55	1.70	1-10	Steady	Shifting supplier base
64Kx4 VRAM 120ns (ZIP)	3.30-3.39	3.35	2-9	Steady	Narrow supply base
1Mbx1 DRAM 80-100ns (DIP/SOJ)	4.25-4.82	4.29[1]	1-8	1-2 weeks longer	No 4Mb crossover till Q2 1991
256Kx4 VRAM 120ns (ZIP)	NA	10.10	8-15	Steady	Learning curve price declines
4Mbx1 DRAM 80-100ns (300-350 mil SOJ)	21.25-25.10	19.80[1,2]	2-10	Steady	Demand accelerates; market trend toward 300-mil SOJ
1Mbx8 SIMM 100ns	38.03-40.70	38.05	4-10	1 week shorter	Crossover hedge
1Mbx9 SIMM 80ns	45.00-45.40	43.10	4-10	1 week shorter	Crossover hedge
256Kx9 SIMM 100ns	14.45-16.04	14.20	2-8	Steady	Shift from 256Kx1x9 organization to 256Kx4x2, 256Kx1
4Kx4 SRAM 25ns (PDIP)	2.39-3.00	2.51	2-8	Steady	Shifting supplier base
2Kx8 SRAM 25ns (PDIP)	3.04-3.09	2.95	2-8	Steady	Supplier base narrows in 1991
16Kx4 SRAM 25ns (PDIP)	3.40-4.82	4.06	6-12	1 week shorter	Wide spread of prices
16Kx4 SRAM 35ns (PDIP)	3.60-4.17	3.62	4-12	1 week shorter	Shifting supplier base
8Kx8 SRAM 25ns (PDIP)	4.20-4.98	4.45	2-8	Steady	Narrow supply base
8Kx8 SRAM 45ns (PDIP)	3.00-3.54	3.40	4-8	Steady	Narrow supply base
64Kx4 SRAM 25ns (PDIP)	11.90-12.70	11.00	4-12	Steady	Growth stage of life cycle
32Kx8 SRAM 100ns (PDIP)	4.34-4.39	4.27	2-10	Steady	Suppliers now need accurate 1991 demand forecasts
128Kx8 SRAM 100ns (PDIP)	21.30-21.55	19.27	2-10	Steady	Impending 1Mb slow SRAM crossover
32Kx8 ROM 150ns+ CMOS (28-pin PDIP)	1.50-1.89	1.80	6-10	Steady	Shifting supplier base

(Continued)

Table 1 (Continued)
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

Part	Price Trend (Dollars) Fourth-Quarter Price Range	Forecast for First Quarter	Lead Times Current (Weeks)	Trend	Other Trends
64Kx8 ROM 150ns+ CMOS (28-pin PDIP)	1.80-2.35	2.20	6-10	Steady	Shifting supplier base
128Kx8 ROM 150ns+ CMOS (28-pin PDIP)	2.00-2.98	2.37	4-10	Steady	Competitive pricing
256Kx8 ROM 200ns+ CMOS (32-pin PDIP)	3.00-3.47	3.35	4-10	Steady	Competitive pricing
512Kx8 ROM 200ns+ CMOS (32-pin PDIP)	4.25-5.90	4.02	4-12	Steady	Wide spectrum of pricing
256Kx16 ROM 150ns+ CMOS (40-pin PDIP)	5.95-7.75	5.52	12	Steady	Early stage of life cycle
32Kx8 EPROM 150ns+ (Windowed CERDIP)	1.91-2.00	1.94	2-10	Steady	Competitive pricing
64Kx8 EPROM 150ns+ (Windowed CERDIP)	2.83-3.62	2.80	2-10	Steady	Narrow but competitive supply base
128Kx8 EPROM 150ns+ (Windowed CERDIP)	5.00-5.43	5.00	4-10	Steady	Competitive pricing
256Kx8 EPROM 150ns+ (Windowed CERDIP)	14.00	12.37	4-14	1 week shorter	Growth stage of cycle
Standard Logic Products					
74LS00	0.95-0.10	0.10	2-5	Steady and short	Decline stage of life cycle
74LS74	0.105-0.12	0.11	2-5	Steady and short	Decline stage of life cycle
74LS138	0.135-0.15	0.149	2-5	Steady and short	Decline stage of life cycle
74LS244	0.20-0.215	0.215	2-5	Steady and short	Decline stage of life cycle
74LS373	0.195-0.215	0.215	2-5	Steady and short	Decline stage of life cycle
74S00	0.13-0.17	0.14	5-7	Steady	Late decline stage
74S74	0.13-0.20	0.174	5-7	Steady	Late decline stage
74S138	0.257-0.26	0.257	5-7	Steady	Late decline stage
74S244	0.51-0.52	0.515	5-7	Steady	Late decline stage
74S373	0.50-0.55	0.515	5-7	Steady	Late decline stage
74F00	0.10-0.11	0.10	2-5	Steady and short	Maturity stage
74F74	0.105-0.125	0.117	2-5	Steady and short	Maturity stage
74F138	0.155-0.17	0.16	2-5	Steady and short	Maturity stage

(Continued)

Table 1 (Continued)
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

	Price Trend (Dollars)		Lead Times		
Part	Fourth-Quarter Price Range	Forecast for First Quarter	Current (Weeks)	Trend	Other Trends
74F244	0.225-0.25	0.227	2-5	Steady and short	Maturity stage
74F373	0.22-0.24	0.222	2-5	Steady and short	Maturity stage
74HC00	0.10-0.105	0.105	2-6	Steady and short	Decline stage
74HC74	0.12	0.12	2-6	Steady and short	Decline stage
74HC138	0.15-0.16	0.155	2-6	Steady and short	Decline stage
74HC244	0.23-0.25	0.23	2-6	Steady and short	Decline stage
74HC373	0.23-0.235	0.23	2-6	Steady and short	Decline stage
74AC00	0.18-0.22	0.19	2-6	Steady	Early maturity
74AC74	0.25-0.28	0.26	2-6	Steady	Early maturity
74AC138	0.35-0.387	0.345	2-6	Steady	Early maturity
74AC244	0.41-0.54	0.495	2-6	Steady	Early maturity
74AC373	0.53-0.54	0.525	2-6	Steady	Early maturity
74ALS00	0.13-0.14	0.135	5-7	Steady	Maturity stage
74ALS74	0.13-0.17	0.165	5-7	Steady	Maturity stage
74ALS138	0.275-0.28	0.274	5-7	Steady	Maturity stage
74ALS244	0.38-0.40	0.385	5-7	Steady	Maturity stage
74ALS373	0.38-0.40	0.385	5-7	Steady	Maturity stage
74AS00	0.165-0.18	0.169	4-7	Steady	Maturity stage
74AS74	0.18-0.20	0.179	4-7	Steady	Maturity stage
74AS138	0.44-0.445	0.425	4-7	Steady	Maturity stage
74AS244	0.76-0.78	0.755	4-7	Steady	Maturity stage
74ALS373	0.764-0.82	0.759	4-7	Steady	Maturity stage
ECL 10K 10102	0.22-0.295	0.216	6	Steady	Decline stage
ECL 10K 10173	0.62-0.98	0.98	6	Steady	Decline stage
ECL 10KH 10H102	0.49-0.54	0.49	6	Steady	Saturation stage
ECL 10KH 10H173	0.90-1.20	1.20	6	Steady	Saturation stage
Microcomponent Products					
8085 (PDIP)	1.70-2.55	1.69	2-8	Steady	Ample supply
68000-8 (PDIP)	3.30-4.00	4.00	5-9	Steady	Stable price
68000-12 (PDIP)	5.70	5.65	5-9	Steady	Flat price profile
68010-12 (CPGA)	35.00-25.00	25.00	5-9	Steady	Higher price
80186-8 (PLCC)	6.60-7.55	7.20	6-8	Steady	

(Continued)

Table 1 (Continued)
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

	Price Trend (Dollars)		Lead Times		
Part	Fourth-Quarter Price Range	Forecast for First Quarter	Current (Weeks)	Trend	Other Trends
80286-10 (PDIP)	7.75-8.70	8.16	2-8	Steady	NMOS is lower end of price range
80286-12 (PDIP)	8.60-9.60	9.11	2-4	Steady	Price converging with 80286-10 price
68020-25 (CPGA)	122.00-130.00	100.00	5-10	Steady	Lower price trend than originally expected
68030-16 (CPGA)	104.50-124.00	122.00	5-9	Steady	Higher price trend than originally expected
68882-16 (CPGA)	78.00	65.00	5-10	Steady	Lower price trend
68030-25 (CPGA)	120.00-171.00	167.00	5-10	Steady	Higher price trend
68040-25 (CPGA)	635.00-675.00	635.00	14-20	Steady	Limited supply
80386SX-16 (CPGA)	61.25-62.20	59.70	9-12	1 week shorter	Market shifting to 80386SX-20
80386SX-20 (CPGA)	100.00	94.00	9-12	Steady	Supply increases during 1991
80386-25 (CPGA)	160.00-168.00	162.00	6-8	Steady	1991 market shift to 80486
80486-25 (CPGA)	685.00-704.00	690.00	6-8	Steady	Price cutting during Q2 1991
80387-25 (CPGA)	323.00-325.00	308.00	NA	Steady	Litigation has started

	Price Trend (Percentage)		Lead Times		
Part	Fourth Quarter	Forecast	Current (NRE-$K)	Trend (%)	Other
Cell-Based ICs (CBICs)					
CMOS					
2.0um	9.2-11.3 down	2.0-5.5 down	32.6-83.5	1.0-2.0 down	Production lead time: 10-12 weeks
1.5um	10.0-11.9 down	4.5-7.1 down	36.4-100.0	1.0-1.4 down	Production lead time: 10-15 weeks
1.25um	NA	4.9-5.5 down	33.5-89.0	1.4-2.1 down	Production lead time: 10-15 weeks
1.0um	9.8-12.2 down	2.3-6.8 down	43.8-105.0	0-2.2 down	Production lead time: 10-16 weeks
Gate Arrays					
CMOS					
2.0um	5.1-10.4 down	1.6-6.7 down	13.0-34.7	1.2-1.6 down	Production lead time: 9-14 weeks

(Continued)

Table 1 (Continued)
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

	Price Trend (Percentage)		Lead Times		
Part	Fourth Quarter	Forecast	Current (NRE-$K)	Trend (%)	Other
1.5um	5.8-11.0 down	2.3-6.2 down	15.8-52.5	0-3.9 down	Production lead time: 9-12 weeks
1.25um	NA	1.4-4.7 down	12.5-NA	0-1.1 down	Production lead time: 7-12 weeks
1.0um	6.6-11.4 down	1.9-6.5 down	17.5-66.0	1.4-4.5 down	Production lead time: 10-14 weeks
ECL	1.0-5.0 down	0-3.5 down	30.0-112.0	1.4-4.4 down	Production lead time: 10-14 weeks

	Price Trend (Dollars)		Lead Times		
Part	Second-Half 1990 Price Range	Forecast for First Half 1991	Current (Weeks)	Trend	Other Trends
Programmable Logic Devices					
TTL PLDs, 20 pins					
≤6ns	8.50-9.20	8.45	3-9	Steady	New technology
6.1-7.5ns	3.90-4.30	3.54	3-8	Steady	Competitive pricing
7.6-10.0ns	1.95-2.06	1.89	2-8	Steady	Competitive pricing
10.1-14.99ns	1.55-1.62	1.41	3-8	Steady	Competitive pricing
15-<25ns	0.85-1.25	0.90	2-8	Steady	Wide price range
25-<35ns	0.62-0.98	0.59	4-8	Steady	Wide price range
≥35ns	0.64-1.44	0.60	4-6	Steady	Wide price range
TTL PLDs, 24 pins (Excludes 22V10s)					
≤6ns	11.60	10.85	3-9	Steady	New technology
6.1-7.5ns	6.60-7.60	6.05	3-8	Steady	Competitive pricing
7.6-10.0ns	3.95-4.50	4.20	4-8	Steady	
10.1-14.99ns	3.45-3.55	3.28	3-8	Steady	Competitive pricing
15-<25ns	1.55-1.60	1.39	2-8	Steady	Competitive pricing
≥25ns	1.02-2.50	0.91	4-6	Steady	Wide price range
CMOS PLDs, 20 pins					
6.1-7.5ns	NA	7.00	4-6	Steady	New product
7.6-10.0ns	3.90-4.04	3.67	4-12	Steady	Competitive pricing
10.1-14.99ns	3.45-3.53	2.45	2-10	Steady	Competitive pricing
15-<25ns	1.15-1.21	1.07	2-8	Steady	Competitive pricing
≥25ns	0.85-0.87	0.78	2-8	Steady	Competitive pricing

(Continued)

Table 1 (Continued)
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

Part	Price Trend (Dollars) Second-Half 1990 Price Range	Forecast for First Half 1991	Lead Times Current (Weeks)	Trend	Other Trends
CMOS PLDs, 24 pins					
7.6-10.0ns	NA	7.50	6-9	Steady	Narrow supplier base
10.1-14.99ns	4.00-6.30	3.80	2-10	Steady	Wide price range
15-<25ns	1.75-1.80	1.75	2-8	Steady	Competitive pricing
≥25ns	1.35-2.54	1.32	2-8	Steady	Wide price range
CMOS PLDs, 24 pins, 22V10s					
15-<25ns	9.90-10.00	8.50	2-8	Steady	Narrow supplier base
25-<35ns	3.00-4.80	3.88	2-6	Steady	Narrow supplier base

[1]80ns for first quarter 1991 and thereafter
[2]300 mil for first quarter 1991 and thereafter
NA = Not available
Source: Dataquest (January 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74LS TTL												2-5
74LS00	0.098	0.100	0.100	0.100	0.100	0.100	0.110	0.110	0.110	0.110	0.110	
74LS74	0.114	0.110	0.115	0.115	0.115	0.114	0.115	0.115	0.115	0.115	0.115	
74LS138	0.156	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	
74LS244	0.215	0.215	0.215	0.215	0.215	0.215	0.212	0.210	0.209	0.208	0.210	
74LS373	0.216	0.215	0.215	0.215	0.215	0.215	0.212	0.210	0.209	0.208	0.210	
74S TTL												5-7
74S00	0.141	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
74S74	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	
74S138	0.258	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	
74S244	0.528	0.515	0.510	0.505	0.500	0.508	0.500	0.500	0.500	0.500	0.500	
74S373	0.529	0.515	0.515	0.505	0.505	0.510	0.500	0.500	0.500	0.500	0.500	
74F TTL												2-5
74FOO	0.100	0.100	0.100	0.105	0.105	0.103	0.105	0.105	0.105	0.105	0.105	
74F74	0.118	0.117	0.116	0.116	0.115	0.116	0.115	0.115	0.115	0.115	0.115	
74F138	0.172	0.160	0.160	0.160	0.158	0.160	0.157	0.155	0.155	0.155	0.155	
74F244	0.244	0.227	0.226	0.225	0.225	0.226	0.223	0.221	0.219	0.219	0.220	
74F373	0.241	0.222	0.222	0.222	0.220	0.222	0.219	0.217	0.215	0.215	0.216	
74HC CMOS												2-6
74HC00	0.100	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	
74HC74	0.119	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	
74HC138	0.154	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	
74HC244	0.237	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	
74HC373	0.235	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	

(Continued)

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

Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
74AC CMOS												2-6
74AC00	0.216	0.190	0.190	0.190	0.190	0.190	0.180	0.180	0.180	0.180	0.180	
74AC74	0.282	0.260	0.260	0.260	0.255	0.259	0.250	0.250	0.250	0.250	0.250	
74AC138	0.359	0.345	0.342	0.339	0.336	0.341	0.333	0.333	0.333	0.333	0.333	
74AC244	0.516	0.495	0.490	0.490	0.485	0.490	0.480	0.475	0.470	0.466	0.473	
74AC373	0.538	0.525	0.515	0.505	0.495	0.510	0.490	0.485	0.480	0.475	0.483	
74ALS TTL												5-7
74ALS00	0.136	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	
74ALS74	0.168	0.165	0.163	0.161	0.160	0.162	0.155	0.151	0.148	0.145	0.150	
74ALS138	0.274	0.274	0.274	0.274	0.274	0.274	0.270	0.269	0.268	0.267	0.269	
74ALS244	0.393	0.385	0.384	0.383	0.382	0.384	0.376	0.372	0.370	0.369	0.372	
74ALS373	0.393	0.385	0.384	0.383	0.382	0.384	0.376	0.372	0.370	0.369	0.372	
74AS TTL												4-7
74AS00	0.172	0.169	0.168	0.167	0.167	0.168	0.160	0.160	0.160	0.160	0.160	
74AS74	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	
74AS138	0.443	0.425	0.420	0.415	0.410	0.418	0.405	0.401	0.399	0.396	0.400	
74AS244	0.770	0.755	0.750	0.745	0.740	0.748	0.728	0.718	0.708	0.702	0.714	
74AS373	0.776	0.759	0.752	0.745	0.740	0.749	0.728	0.718	0.708	0.702	0.714	
10K ECL												6
10102	0.223	0.216	0.215	0.210	0.208	0.212	0.206	0.205	0.203	0.202	0.204	
10131	0.750	0.750	0.750	0.750	0.750	0.750	0.670	0.600	0.545	0.500	0.579	
10173	0.980	0.980	0.980	0.980	0.980	0.980	0.870	0.790	0.730	0.675	0.766	
10KH ECL												6
10H102	0.494	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	
10H131	NA	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	
10H173	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8-Bit MPU												
8085	1.76	1.69	1.67	1.67	1.65	1.67	1.62	1.61	1.59	1.57	1.60	2-8
8088-6	2.58	2.44	2.41	2.38	2.38	2.40	2.36	2.35	2.33	2.31	2.34	3-8
80C88-6	3.33	2.90	2.78	2.62	2.58	2.72	2.58	2.58	2.58	2.58	2.58	4-8
Z80-6	0.78	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	4-8
Z84C00-6	1.04	0.99	0.98	0.98	0.98	0.98	0.96	0.94	0.92	0.92	0.94	4-8
16-Bit MPUs												
8086-8	2.87	2.67	2.65	2.63	2.61	2.64	2.57	2.51	2.49	2.48	2.51	7-10
68000-8	3.32	4.00	4.00	4.00	4.00	4.00	3.75	3.75	3.75	3.75	3.75	5-9
68000-12	5.98	5.65	5.60	5.55	5.50	5.58	5.50	5.50	5.50	5.50	5.50	5-9
68010-12	NA	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	5-9
80186-8 PLCC	7.91	7.20	7.05	6.95	6.70	6.98	6.48	6.37	6.30	6.25	6.35	6-8
80286-10	9.53	8.16	7.90	7.57	7.24	7.72	7.14	7.04	7.00	6.96	7.04	2-8
80286-12	12.09	9.11	8.57	8.20	8.00	8.47	7.96	7.92	7.88	7.82	7.90	2-4
CISC 32-Bit MPUs/Peripherals												
68020-16 QFP	NA	37.70	36.90	36.10	35.70	36.60	34.60	33.74	32.90	32.53	33.44	5-9
68881-16 PLCC	NA	30.00	28.00	26.20	25.00	27.30	23.20	22.00	21.00	20.00	21.55	5-10
68851-16 PGA	NA	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	5-10
68020-25	131.20	100.00	95.00	92.00	89.00	94.00	85.00	85.00	85.00	85.00	85.00	5-10
68030-16	138.00	122.00	121.00	120.00	119.00	120.50	118.00	118.00	118.00	118.00	118.00	5-9
68882-16	87.51	65.00	65.00	65.00	65.00	65.00	60.00	60.00	60.00	60.00	60.00	5-10
68030-25	189.28	167.00	163.00	159.00	155.00	161.00	150.25	146.45	143.00	140.00	144.93	5-10
68040-25[1]	730.38	593.25	554.09	517.16	490.91	538.85	455.08	430.10	413.90	400.90	425.00	14-20
80386SX-16	62.73	59.70	58.75	57.90	57.50	58.46	57.00	57.00	57.00	57.00	57.00	9-12

(Continued)

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

	1990	1991				1991	1992				1992	Current Lead
Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
CISC 32-Bit MPUs/Peripherals (Continued)												
80386SX-20	NA	94.00	91.18	88.44	85.79	89.85	83.91	81.96	80.97	79.82	81.67	9-12
80386-25	184.21	162.20	156.50	154.00	151.00	155.93	150.00	149.00	148.00	146.00	148.25	6-8
80387-25[1]	326.78	308.00	295.68	283.85	272.50	290.01	270.00	270.00	270.00	270.00	270.00	NA
80486-25	790.39	690.00	524.00	475.00	434.00	530.75	425.00	420.00	418.00	416.00	419.75	6-8
RISC 32-bit MPUs												
29000-25[2]	NA	146.34	132.98	125.76	118.92	131.00	112.90	107.00	102.00	98.10	105.00	NA
88100-25[2]	NA	82.25	77.00	74.00	71.00	76.06	69.50	68.05	67.45	67.00	68.00	NA
R3000-25[2]	NA	150.79	136.42	127.59	121.95	134.19	115.00	108.00	105.00	103.98	108.00	NA
SPARC-25[2]	NA	100.35	90.72	84.70	79.21	88.74	75.62	72.30	69.51	66.55	71.00	NA

NA = Not available
[1]Volume of 1,000 pieces for 80387-25; volume of 1,000 pieces for 68040-25
[2]Pricing excludes floating point/memory management units.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 4
Estimated DRAM Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product/Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
64Kx1 DRAM 150ns (DIP)	1.52	1.37	1.37	1.40	1.40	1.39	1.45	1.45	1.45	1.45	1.45	2-8
256Kx1 DRAM 100-120ns (DIP)	1.93	1.70	1.70	1.70	1.70	1.70	1.64	1.64	1.64	1.64	1.64	1-10
64Kx4 DRAM 100ns (DIP)	1.98	1.75	1.75	1.75	1.75	1.75	1.69	1.69	1.69	1.69	1.69	1-10
64Kx4 Video RAM 120ns (ZIP)	4.06	3.35	3.27	3.20	3.15	3.24	3.10	3.05	3.00	2.98	3.03	2-9
1Mbx1 DRAM 80ns (DIP/SOJ)[1]	6.06	4.29	4.08	3.94	3.79	4.02	3.75	3.70	3.65	3.60	3.68	1-8
256Kx4 DRAM 100ns (SOJ)	6.09	4.31	4.10	3.96	3.83	4.05	3.75	3.70	3.65	3.60	3.68	2-8
256Kx4 Video RAM 120ns (ZIP)	13.91	10.10	9.75	9.50	9.20	9.64	8.95	8.59	8.34	8.10	8.50	8-15
128Kx8 Video RAM 100ns (SOJ)	NA	12.44	11.65	11.00	10.34	11.36	9.85	9.40	8.99	8.63	9.22	10-16
4Mbx1 DRAM 80ns (SOJ 300 mil)[1,2]	36.36	19.80	16.55	15.23	13.99	16.39	13.50	13.00	12.55	12.20	12.81	2-10
1Mbx8 SIMM 100ns	54.71	38.05	35.98	34.06	33.00	35.27	32.80	32.56	32.41	32.26	32.51	4-10
1Mbx9 SIMM 80ns	61.14	43.10	40.82	38.54	37.52	40.00	37.19	37.00	36.70	36.30	36.80	4-10
256Kx9 SIMM 100ns	17.10	14.20	13.49	12.80	12.25	13.19	11.70	11.30	11.00	10.90	11.23	2-8
256Kx36 SIMM 80ns	67.46	54.00	51.32	48.94	47.20	50.36	45.40	43.95	42.83	41.50	43.42	4-8

NA = Not available
[1]80-100ns for 1990
[2]300-350 mil for 1990
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1991)

Table 5
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/Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
Fast 4Kx4 (25ns)	2.93	2.51	2.39	2.30	2.25	2.36	2.21	2.16	2.13	2.10	2.15	2-8
Fast 4Kx4 (35ns)	2.46	2.20	2.20	2.20	2.15	2.19	2.10	2.10	2.10	2.10	2.10	2-8
Fast 2Kx8 (25ns)	3.49	2.95	2.85	2.76	2.72	2.82	2.70	2.70	2.70	2.75	2.71	2-8
Fast 64Kx1 (25ns)	4.27	3.60	3.46	3.34	3.24	3.41	3.14	3.07	3.01	2.95	3.04	2-9
Fast 16Kx4 (25ns)	4.54	4.06	3.94	3.83	3.72	3.89	3.62	3.50	3.40	3.37	3.47	6-12
Fast 8Kx8 (25ns)	5.14	4.45	4.34	4.27	4.20	4.32	4.06	3.95	3.89	3.86	3.94	2-8
Fast 16Kx4 (35ns)	4.05	3.62	3.50	3.40	3.30	3.46	3.22	3.19	3.17	3.16	3.19	4-12
Fast 8Kx8 (45ns)	3.98	3.40	3.30	3.20	3.12	3.26	3.06	2.99	2.89	2.81	2.94	4-8
Slow 8Kx8 (120-150ns)	1.96	1.75	1.75	1.75	1.73	1.74	1.70	1.70	1.70	1.70	1.70	3-12
Fast 64Kx4 (25ns)	15.71	11.00	9.90	8.87	8.60	9.59	8.52	8.45	8.31	8.17	8.36	4-12
Fast 32Kx8 (35ns)	14.74	10.35	9.35	8.50	7.70	8.98	7.20	6.75	6.43	6.10	6.62	5-12
Slow 32Kx8 (100ns)	5.37	4.27	4.08	3.90	3.85	4.03	3.80	3.75	3.75	3.75	3.76	2-10
Slow 128Kx8 (100ns)	30.79	19.27	17.00	14.99	13.90	16.29	12.86	12.10	11.64	11.38	12.00	2-10

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 6
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)

	1990	1991				1991	1992				1992	Current Lead
Product/Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
CMOS												
32Kx8 ROM	1.75	1.80	1.80	1.80	1.80	1.80	1.85	1.85	1.85	1.85	1.85	6-10
64Kx8 ROM	2.35	2.20	2.18	2.15	2.12	2.16	2.20	2.20	2.20	2.20	2.20	6-10
128Kx8 ROM	3.00	2.37	2.30	2.26	2.22	2.29	2.18	2.13	2.09	2.06	2.12	4-10
64Kx16 ROM[1]	NA	3.18	3.02	2.87	2.73	2.95	2.61	2.51	2.41	2.35	2.47	NA
256Kx8 ROM	3.85	3.35	3.28	3.21	3.16	3.25	3.11	3.08	3.04	3.00	3.06	4-10
512Kx8 ROM	5.43	4.05	3.92	3.86	3.80	3.91	3.70	3.63	3.56	3.52	3.60	4-12
256Kx16 ROM[2]	NA	5.52	5.21	5.04	4.91	5.17	4.69	4.48	4.35	4.23	4.44	12

[1]Estimated but not by survey
[2]256Kx16 ROM: 150ns and above; 40-pin PDIP
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 7
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Dollars)

Product/Family	1990 Year	1991 Q1	1991 Q2	1991 Q3	1991 Q4	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
TTL												
4K PROM	0.94	0.95	0.97	0.98	0.99	0.97	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM	2.14	2.00	2.00	1.95	1.90	1.96	1.88	1.86	1.84	1.82	1.85	6-8
32K PROM	6.38	6.32	6.32	6.32	6.32	6.32	6.15	6.03	5.94	5.88	6.00	6-8
64K PROM	7.89	7.18	7.00	6.86	6.75	6.95	6.62	6.47	6.36	6.23	6.42	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 8
Estimated OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

	1990	1991				1991	1992				1992	Current Lead
Product/Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.70	1.55	1.52	1.52	1.52	1.53	1.60	1.60	1.60	1.60	1.60	4-12
32Kx8	1.77	1.61	1.61	1.61	1.61	1.61	1.60	1.60	1.60	1.60	1.60	6-12
64Kx8	3.08	2.55	2.49	2.44	2.40	2.47	2.39	2.35	2.33	2.31	2.35	6-12
128Kx8[1]	NA	6.20	6.05	5.95	5.80	6.00	5.56	5.43	5.33	5.25	5.39	7-12

[1]Estimated but not by survey.
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 9
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

	1990	1991				1991	1992				1992	Current Lead
Product/Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8Kx8 EPROM	1.75	1.65	1.65	1.70	1.75	1.69	1.81	1.87	1.91	1.95	1.89	2-10
16Kx8 EPROM	2.19	2.05	2.04	2.03	2.03	2.04	2.03	2.05	2.10	2.10	2.07	2-10
32Kx8 EPROM	2.02	1.94	1.95	1.98	2.00	1.97	2.03	2.06	2.08	2.10	2.07	2-10
64Kx8 EPROM	3.10	2.80	2.75	2.70	2.68	2.73	2.68	2.68	2.68	2.68	2.68	2-8
128Kx8 EPROM	6.41	5.00	4.82	4.70	4.60	4.78	4.49	4.39	4.29	4.20	4.34	4-10
256Kx8 EPROM	NA	12.37	11.15	10.02	9.00	10.64	8.29	7.60	7.00	6.60	7.37	4-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

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

	1990	1991				1991	1992				1992	Current Lead
Product/Family	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K EEPROM	3.28	3.20	3.00	3.00	2.90	3.03	2.90	2.90	2.90	2.90	2.90	2-7
8Kx8 EEPROM	5.26	4.80	4.60	4.45	4.30	4.54	4.14	4.02	3.94	3.90	4.00	3-8
32Kx8 EEPROM	40.08	23.00	20.60	18.60	17.00	19.80	14.00	12.40	11.00	9.78	11.80	3-8
64Kx8 EEPROM	NA	99.00	60.00	40.00	25.00	56.00	NA	NA	NA	NA	NA	12-20

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 11
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product/Family	1990 Year	1991 Q1	Q2	Q3	Q4	1991 Year	1992 Q1	Q2	Q3	Q4	1992 Year	Current Lead Time (Weeks)
32Kx8, PDIP	NA	7.40	7.25	7.00	6.60	7.06	6.50	6.40	6.30	6.25	6.36	4-8
128Kx8, TSOP	NA	16.25	14.10	12.70	12.00	13.76	11.50	10.95	10.25	9.85	10.64	4-12
256Kx8, TSOP	NA	38.50	32.30	27.50	24.00	30.58	21.25	19.70	17.95	16.75	18.91	6-9

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 12
Estimated Gate Array Price Trends—North American Bookings
(Package: CMOS—84-Pin PLCC for <10K gates, 160-Pin PQFP for ≥10K; ECL—Ceramic QFP)
(Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL; Millicents per Gate)

Gate Count	0-1.99K Gates		2.-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1990	1991	1990	1991	1990	1991	Times (Weeks)
CMOS							Production
2.00 Microns	127.0	93.0	94.8	87.5	88.2	81.6	9-13
1.50 Microns	123.0	92.6	75.9	67.3	76.0	67.0	9-12
1.25 Microns	122.0	99.0	85.0	80.0	87.0	82.0	7-11
1.00 Micron	131.8	97.5	88.5	67.3	88.5	67.3	10-14
ECL	6,016.7	5,820.0	4,750.0	4,558.1	4,250.0	3,650.0	10-14
NRE Charges ($K)							
2.00 Microns	13.00	12.18	16.95	15.96	21.47	20.07	3-5
1.50 Microns	15.75	13.31	20.70	18.30	25.50	21.93	3-5
1.25 Microns	12.52	12.10	16.90	16.15	20.88	20.70	3-6
1.00 Micron	17.50	14.37	20.70	18.85	25.00	22.38	3-6
ECL	30.00	28.35	47.85	44.75	56.00	50.00	12-14

Gate Count	10-19.99K Gates		20-50K Gates		Current Lead
Technology	1990	1991	1990	1991	Times (Weeks)
CMOS					Production
2.00 Microns	96.7	90.5	NA	NA	10-14
1.50 Microns	68.2	62.0	92.0	77.9	10-12
1.25 Microns	94.0	83.0	115.0	99.0	8-12
1.00 Micron	77.9	71.9	99.0	89.9	10-13

(Continued)

Table 12 (Continued)
Estimated Gate Array Price Trends—North American Bookings
(Package: CMOS—84-Pin PLCC for <10K gates, 160-Pin PQFP for ≥10K; ECL—Ceramic QFP)
(Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL; Millicents per Gate)

Gate Count	10-19.99K Gates		20-50K Gates		Current Lead
Technology	1990	1991	1990	1991	Times (Weeks)
ECL	5,250.0	4,650.0	4,600.0	4,175.0	12-14
NRE Charges ($K)					Prototypes
2.00 Microns	34.70	33.10	NA	NA	4-7
1.50 Microns	40.25	40.00	52.50	49.89	3-6
1.25 Microns	NA	NA	NA	NA	4-7
1.00 Micron	45.80	43.25	66.00	62.00	4-7
ECL	70.00	64.00	112.00	92.50	11-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as special features, service, delivery or other factors. These prices are intended as guidelines.
Source: Dataquest (January 1991)

Table 13
Estimated CBIC Price Trends—North American Bookings
(Package: 84-Pin PLCC for <10K gates; 160-Pin PQFP for ≥10K gates)
(Based on Utilized Gates Only; NRE = Netlist to Prototypes)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year; Millicents per Gate)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1990	1991	1990	1991	1990	1991	Times (Weeks)
CMOS							Production
2.00 Microns	107.10	93.60	107.10	88.60	116.00	90.60	10-12
1.50 Microns	120.50	97.10	95.80	73.00	95.00	73.00	10-15
1.25 Microns	112.00	90.00	88.00	71.50	85.00	70.40	10-15
1.00 Micron	134.00	100.30	109.90	81.20	102.00	81.00	10-16
NRE Charges ($K)							Prototypes
2.00 Microns	32.55	30.20	34.50	32.45	53.49	49.25	6-8
1.50 Microns	36.44	35.00	37.50	36.00	47.75	45.00	5-8
1.25 Microns	33.51	31.70	34.90	32.85	45.10	41.90	5-8
1.00 Micron	43.75	39.90	46.40	43.75	57.00	56.00	6-11

Gate Count	10-19.99K Gates		20-50K Gates		Current Lead
Technology	1990	1991	1990	1991	Times (Weeks)
CMOS					Production
2.00 Microns	128.00	101.50	132.00	121.60	10-12
1.50 Microns	95.00	68.00	100.00	82.00	10-15
1.25 Microns	92.50	72.00	123.00	98.00	10-15
1.00 Micron	109.30	79.70	102.60	93.00	10-16

(Continued)

Table 13 (Continued)
Estimated CBIC Price Trends—North American Bookings
(Package: 84-Pin PLCC for <10K gates; 160-Pin PQFP for ≥10K gates)
(Based on Utilized Gates Only; NRE = Netlist to Prototypes)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year; Millicents per Gate)

Gate Count	10-19.99K Gates		20-50K Gates		Current Lead
Technology	1990	1991	1990	1991	Times (Weeks)
NRE Charges ($K)					Prototypes
2.00 Microns	74.00	69.97	83.50	80.00	6-8
1.50 Microns	70.45	67.00	100.00	95.00	5-8
1.25 Microns	65.00	59.50	89.00	84.00	5-8
1.00 Micron	76.50	72.50	105.00	105.50	6-11

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance or other factors that may enhance or detract from the value of a company's product. These prices are intended as price guidelines.
Source: Dataquest (January 1991)

Table 14
Estimated CMOS PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤20	6.1 - 7.5	7.00	6.50	6.00	5.50	4-6
	7.6 - 10.0	3.67	3.20	3.03	2.90	4-12
	10.1 - 14.99	2.45	2.15	2.08	1.75	2-10
	15 - <25	1.07	0.95	0.91	0.86	2-8
	≥25	0.78	0.72	0.71	0.67	2-8
24						
	7.6 - 10.0	7.50	6.50	6.17	5.86	6-9
	10.1 - 14.99	3.80	3.60	3.40	3.24	2-10
	15 - <25	1.75	1.67	1.60	1.54	2-8
	≥25	1.32	1.20	1.15	1.10	2-8
24						
22V10						
	15 - <25	8.50	7.10	6.35	5.70	2-8
	25 - <35	3.88	3.68	3.50	3.18	2-6

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 15
Estimated TTL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
≤20						
	≤6	8.45	8.40	7.95	7.55	3-9
	6.1 - 7.5	3.54	3.28	3.05	2.95	3-8
	7.6 - 10.0	1.89	1.77	1.66	1.57	2-8
	10.1 -14.99	1.41	1.32	1.27	1.23	3-8
	15 - <25	0.90	0.84	0.78	0.75	2-8
	25 - <35	0.59	0.57	0.56	0.55	4-8
	≥35	0.60	0.56	0.56	0.55	4-6
24						
	≤6	10.85	10.70	10.10	9.50	3-9
	6.1 - 7.5	6.05	5.55	5.30	5.11	3-8
	7.6 - 10.0	4.20	3.95	3.70	3.49	4-8
	10.1 - 14.99	3.28	3.12	3.00	2.88	3-8
	15 - <25	1.39	1.31	1.26	1.22	2-8
	≥25	0.91	0.83	0.79	0.77	4-6
22V10						
	15 - <25	7.35	7.04	6.75	6.46	NA
	25 - <35	3.85	3.70	3.54	3.39	NA

*Nanosecond speed is the TPD for the combinatorial device.
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 16
Estimated ECL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
>20, <25						
	≤2	40.00	35.00	33.75	32.75	6-8
	2.01-4.0	33.00	30.00	27.90	26.40	8-10
	4.1-6.0	8.00	7.00	6.83	6.71	4-6
	6.1-15.0	6.50	6.00	5.80	5.71	4-6

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 17
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Small-Signal Transistors					4-8
2N2222A	0.102	0.094	0.092	0.090	
2N3904	0.040	0.040	0.040	0.040	
2N2907A	0.102	0.094	0.092	0.090	
MPSA 43*	0.059	0.055	0.052	0.049	
Bipolar Power Transistors					4-8
2N3772	1.040	1.040	1.040	1.040	
2N3055	0.420	0.420	0.430	0.430	
2N6107	0.235	0.235	0.235	0.235	
Power MOSFET					4-8
IRF530	0.550	0.530	0.520	0.490	
IRF540*	1.365	1.340	1.320	1.300	
IRF9531	1.064	1.052	1.040	1.030	
IRF9520	0.430	0.420	0.416	0.414	
Small-Signal Diodes					4-6
1N4002	0.020	0.020	0.020	0.020	
1N645	0.047	0.047	0.047	0.046	
Power Diodes					4-7
1N3891	0.900	0.900	0.888	0.878	
1N3737	7.162	7.160	7.120	7.090	
1N4936	0.097	0.095	0.095	0.094	
Zener Diodes					4-8
1N829	1.165	1.165	1.165	1.165	
1N752A	0.028	0.027	0.026	0.025	
1N963B	0.025	0.025	0.025	0.025	
1N4735A*	0.040	0.040	0.040	0.039	
1.5KE62A*	0.670	0.647	0.625	0.610	
1.5KE30CA*	1.330	1.277	1.230	1.200	

(Continued)

Table 17 (Continued)
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
P6KE30CA*	0.763	0.734	0.708	0.690	
Thyristors					5-9
2N6400	0.470	0.455	0.450	0.445	
2N4186	2.295	2.285	2.275	2.265	

*Estimated and not by survey.
Note: These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 18
Estimated Optoelectronic Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Time (Weeks)
Optoelectronic					
Round LED Lamps					6
T1 STD RED	0.054	0.054	0.054	0.053	
T1 3/4 STD RED	0.054	0.054	0.053	0.053	
T1 3/4 H.EF.RED	0.076	0.075	0.074	0.074	
Mold Frame LED					6
0.3" Digital Display	0.500	0.500	0.490	0.490	
0.6" Digital Display	0.590	0.590	0.580	0.580	
Optical Couplers					6-8
4N25	0.200	0.200	0.200	0.200	
4N36	0.230	0.230	0.229	0.229	

Note: These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

Table 19
Estimated Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1991 H1	1991 H2	1992 H1	1992 H2	Current Lead Times (Weeks)
Voltage Regulators					
7800CT (TO-220)	0.890	0.880	0.875	0.865	4-6
78L00CP	0.123	0.121	0.120	0.118	4-6
Comparators					
LM339	0.135	0.135	0.133	0.131	4-6
LM393	0.130	0.130	0.129	0.127	4-6
Op Amps					
3403P	0.187	0.184	0.182	0.178	4-6
1741CP1	0.125	0.125	0.124	0.120	4-6
Interface ICs					
1488P	0.160	0.150	0.150	0.150	4-6
3486P	0.935	0.900	0.895	0.885	4-6
Telecom IC					
34017P	0.357	0.334	0.330	0.320	5-7

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery, or performance that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.
Source: Dataquest (January 1991)

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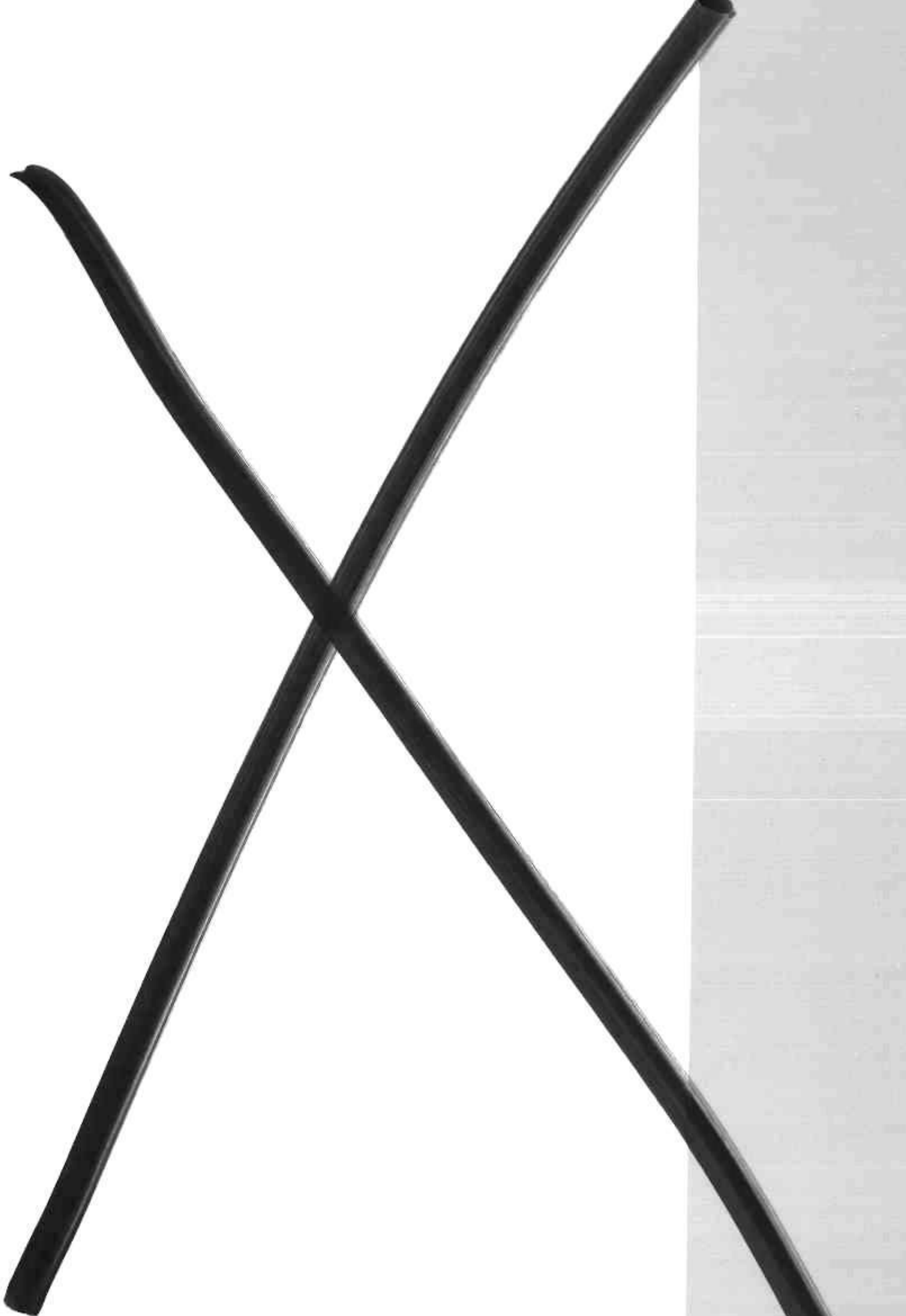

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SEMICONDUCTOR PROCUREMENT

COMPANY BACKGROUNDERS

Company	Fiscal Year-End
Advanced Micro Devices, Inc.	December
American Telephone & Telegraph Company	December
Analog Devices, Inc.	October
Fujitsu Limited	March
Harris Corporation	June
Hitachi, Ltd.	March
Intel Corporation	December
LSI Logic Corporation	December
Matsushita Electric Industrial Co., Ltd.	March
Mitsubishi Electric Corporation	March
Motorola Incorporated	December
National Semiconductor Corporation	May
NEC Corporation	March
N.V. Philips Gloeilampenfabrieken	December
Oki Electric Industry Company, Ltd.	March
Rohm Company, Ltd.	March
Samsung Electronics Company, Ltd.	December
Sanyo Electric Company, Ltd.	November
SGS-Thomson Microelectronics B.V.	December
Sharp Corporation	March
Siemens AG	September
Sony Corporation	March
Texas Instruments, Inc.	December
Toshiba Corporation	March

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B

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C

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M

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- ❐ Network Equipment Technologies Inc
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N

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P

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Q

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R

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T

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- ❒ Telenorma
- ❒ Telefunken Elektronic GmbH
- ❒ TeleVideo Systems Inc

T

- ❒ Texas Instruments Inc
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- ❒ Thorn-EMI Plc
- ❒ Tokyo Electron Ltd
- ❒ Tokyo Ohka Kogyo
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U

- ❒ Ultimate Corp
- ❒ Uniplex Integration Systems Inc
- ❒ Union Carbide Corp
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- ❒ US West Inc

V

- ❒ Valid Logic Systems Inc
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- ❒ VMX Inc

W

- ❒ Wang Laboratories Inc
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Telephone: 03-3216-3211
Fax: 03-3216-9365
Dun's Number: 08-292-1644

Date Founded: 1935

CORPORATE STRATEGIC DIRECTION

Fujitsu Limited, founded in 1935 as a spin-off of the Communications Division of Fuji Electric Company Ltd., is a multinational Japanese firm. Fujitsu designs, manufactures, and markets computers and information processing systems, telecommunications equipment, and electronic devices. To organize and unify such a diverse product offering, Fujitsu has segmented its corporate structure into the above-mentioned main divisions, as well as a category called "Other Operations," which includes electronic products such as car stereos, CD players, and digital audiotape players.

Although worldwide economic growth was slower than expected because of the Gulf War and a slowdown in U.S. and European economies, Fujitsu experienced a significant growth in business. The company had an increase of almost 18 percent in total revenue from $17.8 billion* in fiscal year 1990 to $21.0 billion in fiscal 1991. To achieve this growth, Fujitsu, as a total systems supplier, endeavored to offer a wide range of products from large-scale systems to personal equipment.

Almost 70 percent of Fujitsu's revenue was derived from the Computers and Information Processing Systems Division. The greatest focus in this division was on M Series general-purpose computers, UNIX open systems, and advanced value-added software services. Also showing considerable growth was the demand for office machines and personal equipment.

In the telecommunications field, Fujitsu supplied synchronous digital hierarchy (SDH) equipment to Nippon Telegraph and Telephone Corporation (NTT) in Japan and pioneered synchronous optical transmission (SONET) systems in the United States. In addition, the optical submarine cable system between the United Kingdom and Germany came nearer to completion, while the system between Japan and the United States went into operation.

Since the 1Mb DRAM market remained depressed in the world marketplace, business in electronic devices was difficult. Fujitsu, however, expanded the sales of its products in ASICs, microprocessors, and compound semiconductors.

According to Fujitsu, significant changes are occurring in the industry in downsizing, networks, and open systems. The company believes that these changes will define the technology that will be developed in the 1990s. Although downsizing has reduced their size and weight, products are being created with greater power and performance.

Fujitsu has continued to develop products that directly support International Service Digital Network (ISDN) and to offer Corporate Information Network System (COINS), which can be tailored to meet individual company needs. In addition, Fujitsu announced Multi-environment Information Systems Solution by Domain Concept (MISSION/DC), a domain-based mainframe concept that gives users the flexibility necessary to structure the systems they need. Fujitsu also announced a new approach to network system construction that offers a user-friendly connection to Fujitsu mainframes from workstations and PCs. This product is called MESSAGE 90s.

In the field of open systems, Fujitsu is promoting worldwide standardization of the UNIX operating system across industries, offering a full lineup of UNIX products from workstations to supercomputers. The company also developed the first operating system for mainframes and supercomputers to use UNIX System V Release 4. Other computers across the

*All dollar amounts are in U.S. dollars.

Fujitsu product line will be developed to run under this operating system.

In 1990, Fujitsu took a major step toward increasing its global presence by acquiring an 80 percent share in ICL plc, a computer unit of STC plc. In January 1991, as the first joint project between the two companies, Fujitsu began the marketing of DS/90 UNIX server systems, developed by ICL and distributed through Fujitsu's overseas marketing network.

Research and development costs were 11.1 percent of revenue in fiscal 1991. This increase represents $2.3 billion as compared to $2.1 billion for 1990. R&D continues to be an important part of Fujitsu's future strategy. During fiscal 1991, the R&D funds were used to maintain the company's position as a pioneer in the competitive field of electronics. Future R&D products produced by Fujitsu will be more powerful and targeted at customer networks, especially at the low end such as hand-held PCs and cellular telephones.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7, at the end of this backgrounder, present comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Computers and Data Processing

The Computers and Information Processing Systems Division's net sales increased approximately 23.1 percent to $14.6 billion in fiscal 1991, accounting for 69 percent of the company's total net sales. This increase was mainly due to well-received mainframe systems, including the new M-1800 group of very-large-scale general-purpose computers, and to the strong performance of office machines and personal equipment in the domestic market, as well as the contribution of ICL.

Computer Systems

Within the computer systems product line, Fujitsu offers products from supercomputers to general-purpose computers. In August 1991, Fujitsu introduced two new models of the VP2000 Series supercomputers. The new systems, the VP2400/40 and VP2200/40, feature a four-scalar processor, two-vector processor configuration, which enables enhanced high-speed program processing.

In September 1990, Fujitsu announced the M-1800 Model Group of large-scale computers, which consists of five models. This was the first product introduction within the framework of MISSION/DC. Fujitsu plans to have the MISSION/DC be a major influence on its future product introductions.

According to Dataquest, in the worldwide business supercomputer market, Fujitsu ranks first with a 56.03 percent market share for 1990; in the worldwide technical supercomputer market, it ranks fourth with a 9.39 percent market share. In the worldwide business mainframe market, Fujitsu ranks fourth, with a 5.01 percent market share. In the worldwide technical mainframe market, it also ranks fourth with a 7.44 percent market share. Finally, in the worldwide business midrange market, Fujitsu ranks fifth with 5.56 percent of the market share.

Office Automation

Within the office automation product line, Fujitsu offers small business computers, workstations, word processors, and personal computers, including business, hypermedia, desktop, portable, and laptop. In the worldwide personal computer market, including desktop, portable, laptop, and notebooks, Fujitsu had less than 1 percent of the market share in each of these categories.

VAN Services

Within the VAN services product line, Fujitsu offers industry VANs, local VANs, corporate VANs, and personal communications services. During fiscal 1991, Fujitsu expanded the FENICS VAN service network, enhanced database services, and started FENICS-INS packet-switched services. To respond to the expansion of international VAN services in Asia, Fujitsu started a data switching service between Japan and Singapore. In addition, the NIFTY-Serve personal computer communications service was expanded to include English-to-Japanese machine translation, electronic mail, facsimile, and other services. As of March 31, 1991, this service has more than 260,000 subscribers.

Computer Storage

Fujitsu built its reputation in the rigid disk drive market with solutions for high-end computers. The company produces rigid disk drives in a variety of sizes from 2.5-inch to 14-inch. According to Dataquest, during 1990 Fujitsu ranked eighth in the worldwide overall total rigid disk drive market with a 2.9 percent market share. In the 8- to 14-inch worldwide rigid disk drive market, it ranked fourth with a 13.8 percent market share.

In September 1990, Fujitsu announced the M2671P, an 8-inch disk drive that provides 2.6GB of storage and offers a data transfer rate of 4.78 MB/sec. and a seek time of less than 12ms.

In September 1991, Fujitsu introduced a line of high-capacity, low-profile, 2.5-inch rigid disk drives. This product line consists of three disk drives all backed by a 150,000 hour mean time between failures rating, a comprehensive warranty program, and capacities of 45MB, 67MB, and 90MB. All four drives feature an average seek time of 18ms, burst data transfer rates of up to 6 MB/sec., and an average latency of 8.3ms.

Fujitsu also produces tape drives in 1/2-inch reel-to-reel, start-stop, and streaming. During calendar 1990, according to Dataquest, Fujitsu ranked fourth in the 1/2-inch worldwide tape drive market with a 9.0 percent market share. It also ranked fifth in the 1/2-inch worldwide reel-to-reel worldwide tape drive market with a 7.3 percent market share.

Electronic Printers

The company manufactures and markets line-impacted, fully formed printers, serial impact dot matrix printers, baud printers, and laser printers. According to Dataquest, during 1990 the company had less than 1 percent of the total worldwide printer market.

Software

Within the software product line, Fujitsu offers operating system software, application software, translation support systems, and architectures. In May 1991, MESSAGE 90s was introduced as a new approach to system construction. Its function is to help organizations process information effectively and set up systems quickly through linked software products. This product line allows the use of hardware and software from other vendors to be used in Fujitsu systems. For example, NEC or IBM PCs can run LOTUS 1-2-3 seamlessly in a Fujitsu-based network.

During fiscal 1991, Fujitsu strengthened System Development Architecture and Support facilities, with the SDEM90 standard method of system development and the C-NAP II/CASE technical support tool for analyzing system requirements. Also, to expand the computer-integrated manufacturing business, the company started consulting and basic planning services to support system structuring in the fields of production and product distribution.

Telecommunications

The Telecommunications Division's product line is ISDN systems, COINS, mobile communication, switching systems, and transmission systems. In fiscal 1991, the division recorded net sales of $3.1 billion, an increase of approximately 13 percent over fiscal 1990. Net sales of the division accounted for 15 percent of total net sales.

ISDN

NTT's new ISDN service INS net 64/1500 is achieving acceptance, and many users are applying the network to fit their applications. In fiscal 1991, the packet communications mode in INS net was approved and the new INS-P service was started. In addition, demand increased for the ISDN-compatible systems, which support the entire scope of these ISDN services.

COINS

COINS is a corporate information network system that is receiving significant interest from companies as a multimedia network with excellent economy and extendability. It integrates data, voice, and images. By the end of March 1991, Fujitsu had strengthened COINS to implement ISDN communications forms by adding 1.5Mb line-switching and packet-switching functions to conventional private ISDN functions.

Mobile Communication

Demand increased sharply for small, lightweight cellular telephones in the field of mobile communication. NTT is promoting development of very small and lightweight cellular telephones. Fujitsu is participating in this development under contract with NTT. In the U.S. cellular telephone handset market, Fujitsu ranked sixth with a 7.2 percent market share.

Switching Systems

Within the switching systems product line, Fujitsu offers central office switching systems and digital PBX switching systems. During fiscal 1991, Fujitsu developed and delivered a prototype of the next-generation node system for the D-70. For digital PBXs, the company added application packages to the series. Fujitsu also released the cost-effective E-100 Series of information switching systems. In the U.S. PBX systems market, with 1,000 plus lines (new), Fujitsu ranked sixth with a 2.5 percent market share. In the 101 to 400 lines (new) segment, the company ranked eighth with a market share of 2.5 percent.

Transmission Systems

Within the transmission systems product line, Fujitsu offers digital communications equipment and earth station systems for satellite communication. The company implemented SDH, an international standard that will open communications environments and enable ISDN and other new services to be used more efficiently. In Japan, NTT is actively promoting the conversion to SDH, while Fujitsu is delivering many transmission systems and radio equipment that comply with SDH.

Electronic Devices

The Electronic Devices Division includes IC memories, ASICs, compound semiconductors, and other electronic devices. Dataquest estimates that Fujitsu ranked sixth in the worldwide semiconductor market, with 4.9 percent of the market share and revenue totaling $2.9 billion during calendar year 1990. This includes captive sales, which are excluded from the Electronic Devices Division's sales, as reported in the annual report. Net sales within this division decreased by 1.0 percent from $2.49 billion to $2.47 billion. The division accounted for 12.0 percent of total net sales. The semiconductor product line can be segmented into IC memories (MOS and bipolar technology), ASICs (MOS and bipolar technology), large-scale integrations (LSIs), and electronic components.

IC Memories

In fiscal 1991, Fujitsu increased its production of 4Mb DRAMs. The company also started delivering samples of 16Mb DRAMs, which will be the next generation of computer memory. In February 1991, Fujitsu announced a prototype of a 64Mb DRAM that uses new photo lithography exposure technology. This new technology will make mass production possible. Also, in February 1991, Fujitsu announced the 4Mb BiCMOS ECL SRAM, with an access time of 7ns.

ASICs

In fiscal 1991, demand rose for faster and larger-scale CMOS gate arrays. To meet this demand, Fujitsu released 15 new products, 7 of which feature a gate delay of 0.5ns and contain up to 14,000 gates. The remaining eight feature a gate delay of 0.35ns and contain up to 102,000 gates. In the worldwide total ASIC market, Fujitsu ranked number one with a market share of 13.0 percent.

Compound Semiconductors

During fiscal 1991, the compound semiconductor market developed a strong demand for low-noise high electron mobility transistors (HEMTs) for satellite broadcasting receivers. Fujitsu developed and released a super HEMT that can capture very weak signals because of dramatic improvements in gain and signal-to-noise ratio. Fujitsu also developed and released a GaAs gate array that features high-speed, large-scale integration and low power consumption. To respond to future increases in demand for HEMTs, GaAs FETs, and GaAs ICs, Fujitsu constructed a plant targeted for GaAs products.

Other Electronic Devices

In fiscal 1991, in response to rising use in home electrical appliances, telephones, and office machines, Fujitsu added application specific microcontrollers to its market offerings. Fujitsu also developed a 16-bit microcontroller that performs full 16-bit processing with an instruction cycle of 100ns. In addition, significant releases included a 16-inch plasma display with a resolution of 1280 × 1024 pixels and a membrane keyboard with a small footprint and low profile.

Other Operations

Other operations range from products such as car stereos to automatic vehicle monitors. Although in fiscal 1991, this division accounted for only 4 percent of total net sales, it increased approximately 16 percent to $885.

Further Information

For further information pertaining to the company's business segments, please contact the appropriate Dataquest industry service.

Table 1
Five-Year Corporate Highlights (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Five-Year Revenue	11,218	14,830	18,616	17,839	21,043
Percent Change	46.71	32.19	25.53	(4.17)	17.96
Capital Expenditure	814	1,209	1,825	2,105	2,231
Percent of Revenue	7.25	8.16	9.81	11.80	10.60
R&D Expenditure	1,043	1,378	1,925	2,093	2,336
Percent of Revenue	9.30	9.29	10.34	11.73	11.10
Number of Employees	89,293	94,825	104,503	115,000	145,000
Revenue ($K)/Employee	126	156	178	155	145
Net Income	135	305	545	607	585
Percent Change	(23.00)	125.24	78.74	11.29	(3.55)
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

1991 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	NA	NA	NA	NA
Quarterly Profit	NA	NA	NA	NA

NA = Not available

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

Table 2
Revenue by Geographic Region (Percent)

Region	1987	1988	1989	1990	1991
Japan	78.06	77.89	77.87	76.13	75.17
International	21.94	22.11	22.13	23.87	24.83

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

1991 SALES OFFICE LOCATIONS

North America—3
Europe—4
Asia/Pacific—90
  Japan—82
ROW—3

MANUFACTURING LOCATIONS

North America

Fujitsu America
  Communications and information processing equipment, development of software
Fujitsu Business Communications Systems
  Communications equipment
Fujitsu Microelectronics
  Semiconductor devices
Intellistor Inc.
  Development of information processing equipment

Europe

Fujitsu Espana (Spain)
  Communications and information processing equipment
Fujitsu Microelectronics (Ireland)
  Semiconductor devices
Fujitsu Microelectronics (United Kingdom)
  Development of ASICs

Asia/Pacific

FKL-Dongwa (South Korea)
  Magnetic floppy disk drive heads
Fuji Electrochemical (Japan)
  Ferrites, electronic equipment, dry batteries
Fuji Facom (Japan)
  Development of computer systems for control
Fujitsu (Singapore)
  Electronic parts (digital switching systems)
Fujitsu Australia (Australia)
  Digital key telephones, digital PBXs
Fujitsu Automation (Japan)
  Automation equipment
Fujitsu Buhin (Japan)
  Electronic parts
Fujitsu Component (Malaysia)
  Electronic parts (relays, keyboards, connectors)
Fujitsu Computer Technology (Japan)
  Development of LSIs, software for information processing equipment
Fujitsu Denso (Japan)
  Communications/electronic equipment
Fujitsu General (Japan)
  Home electric appliances, communications equipment, data processing equipment
Fujitsu Isotec (Japan)
  Printers
Fujitsu Kasei (Japan)
  Plastic products for communications equipment
Fujitsu Kiden (Japan)
  Data processing equipment, indicators, molds
Fujitsu Microelectronics Asia (Singapore)
  Semiconductor devices
Fujitsu Microelectronics (Malaysia)
  Semiconductor devices
Fujitsu Miyagi Electronics (Japan)
  Semiconductor devices
Fujitsu Peripherals (Japan)
  Peripherals
Fujitsu TEN (Japan)
  Car radios, stereos
Fujitsu Thailand (Thailand)
  Magnetic disk drive heads, magnetic heads for printers
Fujitsu Tohoku Electronics (Japan)
  Semiconductor devices
Fujitsu VLSI (Japan)
  Development of semiconductor devices
Fujitsu Yamanashi Electronics (Japan)
  Semiconductor devices
Hasegawa Electric (Japan)
  Communications equipment
Kyushu Fujitsu Electronics (Japan)
  Semiconductor devices
Nihon Dengyon (Japan)
  Radio and digital communications equipment
PFU Ltd. (Japan)
  Microcomputers, peripherals
Shinano Fujitsu (Japan)
  Electronic parts
Shinko Electric Industries (Japan)
  Semiconductor parts
Takamisawa Electric (Japan)
  Switching systems, parts
Towa Electron (Japan)
  Capacitors, hybrid ICs
Yamagata Fujitsu (Japan)
  Magnetic disk drives

SUBSIDIARIES

North America

Fujitsu America Inc. (United States)
Fujitsu Business Communications Systems Inc. (United States)
Fujitsu Canada Inc. (Canada)
Fujitsu Component of America Inc. (United States)
Fujitsu Computer Packaging Technologies Inc. (United States)
Fujitsu Computer Products of America Inc. (United States)
Fujitsu Customer Service of America Inc. (United States)
Fujitsu Imaging Systems of America Inc. (United States)
Fujitsu Microelectronics Inc. (United States)
Fujitsu Network Switching of America Inc. (United States)
Fujitsu Network Transmission Systems Inc. (United States)
Fujitsu Systems of America Inc. (United States)
Fujitsu Systems Business of America Inc. (United States)
Intellistor Inc. (United States)
Poqet Computer Corp. (United States)

Europe

Fujitsu Deutschland GmbH (Germany)
Fujitsu Espana S.A. (Spain)
Fujitsu Europe Ltd. (England)
Fujitsu Europe Telecom R&D Centre Limited (United Kingdom)
Fujitsu Finance (U.K.) plc (United Kingdom)
Fujitsu International Finance (Netherlands) B.V. (Netherlands)
Fujitsu Italia S.p.A. (Italy)
Fujitsu Microelectronics Ireland Ltd. (Ireland)
Fujitsu Microelectronics Italia S.r.l. (Italy)
Fujitsu Microelectronics Ltd. (England)
Fujitsu Mikroelektronik GmbH (Germany)
Fujitsu Nordic AB (Sweden)
Fulcrum Communications Limited (United Kingdom)

Asia/Pacific

Beijing Fujitsu Systems Ltd. (China)
Fuji Electrochemical Co. Ltd. (Japan)
Fujitsu Advanced Printing and Publishing Co. Ltd. (Japan)
Fujitsu Aichi Engineering Limited (Japan)
Fujitsu Australia Ltd. (Australia)
Fujitsu Australia Software Technology Pty. Ltd. (Australia)
Fujitsu Australia Wholesale Pty. Ltd. (Australia)
Fujitsu Automation Limited (Japan)
Fujitsu Basic Software Corporation (Japan)
Fujitsu Business Systems (Japan) Ltd. (Japan)
Fujitsu Communications Systems (Japan)
Fujitsu Component (Malaysia) Sdn. Bhd. (Malaysia)
Fujitsu Computer Technologies (Japan)
Fujitsu Dai-ichi Communication Software Limited (Japan)
Fujitsu Dai-ichi System Engineering Limited (Japan)
Fujitsu Denso Ltd. (Japan)
Fujitsu Devices Inc. (Japan)
Fujitsu Digital Technology Limited (Japan)
Fujitsu Distribution Systems Engineering Limited (Japan)
Fujitsu Documents Service Limited (Japan)
Fujitsu Electronics (Singapore) Pte. Ltd. (Singapore)
Fujitsu FACOM Information Processing Corporation (Japan)
Fujitsu Financial Information Systems Limited (Japan)
Fujitsu Fudosan Ltd. (Japan)
Fujitsu Hong Kong Ltd. (Hong Kong)
Fujitsu Isotec Limited (Japan)
Fujitsu Kansai Communication Systems Limited (Japan)
Fujitsu Kansai System Engineering Limited (Japan)
Fujitsu Kasei Ltd. (Japan)
Fujitsu Keihin Systems Engineering Limited (Japan)
Fujitsu Kiden Ltd. (Japan)
Fujitsu Korea Ltd. (Korea)
Fujitsu Kosan Limited (Japan)
Fujitsu Kyushu Communication Systems Limited (Japan)
Fujitsu Kyushu Systems Engineering Ltd. (Japan)
Fujitsu Laboratories Ltd. (Japan)
Fujitsu Lease (Japan)
Fujitsu Logistics Limited (Japan)
Fujitsu Microelectronics Asia Pte. Ltd. (Singapore)
Fujitsu Microelectronics (Malaysia) Sdn. Bhd. (Malaysia)
Fujitsu Microelectronics Pacific Asia Ltd. (Hong Kong)
Fujitsu Minami-Kyushu Systems Engineering Limited (Japan)
Fujitsu Miyagi Electronics Ltd. (Japan)
Fujitsu Nagano Systems Engineering Limited (Japan)
Fujitsu Network Engineering Limited (Japan)
Fujitsu New Zealand Holdings Ltd. (New Zealand)
Fujitsu New Zealand Ltd. (New Zealand)
Fujitsu OA Limited (Japan)
Fujitsu Office Machines Limited (Japan)

Fujitsu Oita Software Laboratories Limited (Japan)
Fujitsu Peripherals Limited (Japan)
Fujitsu Program Laboratories Limited (Japan)
Fujitsu Shikoku Infortec Limited (Japan)
Fujitsu Shizuoka Engineering Limited (Japan)
Fujitsu (Singapore) Pte. Ltd. (Singapore)
Fujitsu Sinter Limited (Japan)
Fujitsu Social Science Laboratory Limited (Japan)
Fujitsu Social Systems Engineering Limited (Japan)
Fujitsu Supplies Limited (Japan)
Fujitsu System Integration Laboratories Ltd. (Japan)
Fujitsu Systems Construction (Japan)
Fujitsu Systems Consulting (Japan)
Fujitsu Technosystems Limited (Japan)
Fujitsu TEN Limited (Japan)
Fujitsu (Thailand) Co. Ltd (Thailand)
Fujitsu Tohoku Electronics Ltd. (Japan)
Fujitsu Tohoku Systems Engineering Limited (Japan)
Fujitsu Tokia Systems Engineering Limited (Japan)
Fujitsu Trading Ltd. (Japan)
Fujitsu VLSI Limited (Japan)
Fujitsu Quantum Devices Ltd. (Japan)
Gunma Fujitsu Limited (Japan)
Hasegawa Electric Co. Ltd. (Japan)
Ishikawa Fujitsu Software Limited (Japan)
Iwaka Densi Ltd. (Japan)
Kyushu Fujitsu Electronics Ltd. (Japan)
Nihon Dengyo Limited (Japan)
Okinawa Fujitsu Systems Engineering Limited (Japan)
PFU Limited (Japan)
Shimane Fujitsu (Japan)
Shinano Fujitsu Ltd. (Japan)
Shin-Etsu Fujitsu (Japan)
Shinko Electric Industries Co. Ltd. (Japan)
Ten Onkyo Ltd. (Japan)
Totalizator Engineering Limited (Japan)
Toyama Fujitsu (Japan)
Yamagata Fujitsu Limited (Japan)
Yonago Fujitsu (Japan)

ROW

Fujitsu de Brasil Limitada (Brazil)
Fujitsu Vitonia Computadores e Servicos Ltda (Brazil)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

EPWING Consortium

The EPWING Consortium was created with Sony Corporation and several publishing houses to establish a standard for CD-ROM electronic books.

Hitachi Ltd., Sony Corporation, Texas Instruments Japan Ltd.

Fujitsu Ltd., Hitachi Ltd., Sony Corporation, and Texas Instruments Japan Ltd. signed an agreement to codevelop the MUSE decoder integrated circuits. MUSE is the standard high-definition television format in Japan. The cooperative efforts by the four companies is expected to accelerate the development of a small, low-cost, next generation MUSE decoder.

Texas Instruments

Fujitsu and Texas Instruments signed a five-year global semiconductor patent cross-licensing agreement. The deal encompasses most of the semiconductor patents by the two firms except the Texas Instruments Kilby patent.

Cadence Design Systems

Cadence Design Systems and Fujitsu have signed a joint development agreement to produce ASIC software tools.

Quotient plc

Quotient plc and Fujitsu signed a joint development agreement to produce financial software systems.

KBS2 Corp.

KBS2 Corp. and Fujitsu signed a joint development agreement to develop crashworthiness software.

Rodime plc

Rodime plc entered into a nonexclusive royalty-free patent cross-licensing agreement with Fujitsu Ltd. The agreement is for the use of Rodime patents that apply to 3.5-inch drives.

Cincom Systems

Cincom Systems and Fujitsu will combine business efforts in the Canadian market to offer high-performance software.

McDonnell Douglas Information Systems International (MDISI)

MDISI and Fujitsu have made an agreeement to port the PRO-IV 4GL software package developed by MDISI to Fujitsu's K Series office computers. The two firms will then market the software.

1990

Novell K.K.

A joint marketing venture to sell Netware products in Japan was formed with Novell and six partners, Fujitsu being one of them.

Isuzu
The two companies have formed an automotive electronics venture and currently are attempting to get General Motors to join.

Matsushita Electric Industrial
The two companies plan to strengthen their business relationship by mutually supplying their computers on an OEM basis. Fujitsu will supply Matsushita with its high-end laptop and desktop 32-bit PCs; Matsushita will supply Fujitsu with the M550 and M600 series of 32-bit desktop personal computers.

Poqet Computer
Fujitsu will produce and market Poqet Computer's pocket-size computer under license. Fujitsu's stake in Poqet Computer has grown gradually over the last two years because of mutual agreement and investments into R&D and manufacture of Poqet's product lineup.

Nokia Data Systems Oy
An agreement has been made whereby Nokia will act as an OEM of digital PBX systems (the F-620 and F-640) for Fujitsu.

Matsushita Electric Industrial
The two companies plan to strengthen their business relationship by mutually supplying their computers on an OEM basis.

UNIX International
Fujitsu has joined a new marketing group comprising 21 other high-tech companies. The group will promote UNIX's System V release 4 and further standard developments.

Molecular Design Ltd. and IBM
Fujitsu has formed a relationship with the two companies to ensure that Molecular Design software for managing and communicating scientific information will run on their computers.

Mitsui Bank Research Institute
The two companies have agreed to establish a system consulting service.

MEDIAGENIC
MEDIAGENIC has agreed to develop entertainment software for the Fujitsu FM TOWNS.

Daisy/Cadnetix Inc.
The companies jointly produced an ASIC design kit developed for the DAZIX design environment on the Sun-4 family of workstations running on UNIX.

Vitesse Semiconductor Corporation
The companies have entered into an alternate source agreement with regard to Vitesse's Fury gallium arsenide (GaAs) VLSI gate-array family.

1989

Japan Tobacco Inc.
Fujitsu formed a tie-up agreement with Japan Tobacco whereby Fujitsu will market two of Japan Tobacco's software modules.

The Australian National University in Canberra
The two organizations signed an R&D agreement for two three-year projects. One project is to develop a small image processing system; the other is to develop software for parallel processors.

Vitesse Semiconductor
The two companies agreed to jointly develop GaAs gate arrays.

Southern New England Telecommunications Systems
Southern New England Telecommunications agreed to market Fujitsu's ISDN telecommunications equipment in the United States on an exclusive basis. The list of products includes digital telephones and terminal adapters.

NTT Data Communications Systems
The two companies will jointly market their respective logic chip design software products as a total CAE design system.

Sony Corporation
The two companies jointly developed a trial common rule to develop CD-ROM XA software for their personal computers.

Bell Atlantic Optical Network (SONET)
Fujitsu agreed to sell Bell Atlantic's transmission products under a two-year, $2 million contract. Fujitsu will provide its FLM 50/150 Fiber LOOP Multiplexer for deployment in Bell Atlantic areas.

Poqet Computer Corporate
An agreement provides Poqet with funding and credit guarantees; the companies made a cooperative technology agreement allowing for mutual adaptation of technologies and joint development of new technology.

Sun Microsystems Inc.
Sun and Fujitsu will jointly develop a high-speed RISC chip.

1988

Telecom Australia
Telecom Australia agreed to sell Fujitsu's digital PBXs in Australia; the companies established a sales joint-venture, Information Switching Technology.

Daisy Systems
Fujitsu's FAME was made available on Daisy's Advansys Series of CAD/CAE systems.

Hitachi Ltd.
The two companies agreed to cooperate on the development of a 32-bit MPU and peripheral LSI family based on TRON architecture.

ICL plc
Fujitsu purchased 80 percent of ICL, a subsidiary of STC plc. The merger increases Fujitsu's global presence and makes it the second largest computer manufacturer in the world.

MERGERS AND ACQUISITIONS

Fulcrum Communications Ltd.
British Telecommunications plc sold the manufacturing division of Fulcrum Communications to Fujitsu Ltd. but will retain a 25.1 percent interest in the new company. The company makes and markets public switched telephone network equipment such as call monitoring and logging products, call queueing, exchange monitoring, and fiber-optic tools.

Nokia Data
Nokia Data, which is one of Europe's largest computer companies, was purchased by ICL Ltd. (80 percent owned by Fujitsu). ICL Ltd. will pay $402.3 million for the company and will assume about $174.9 million of Nokia's debt. Nokia's parent corporation, Nokia Corporation, will receive a 5 percent stake in ICL Ltd.

Poqet Computer Corporation
Fujitsu increased its stake to 85 percent in Poqet Computer Corporation for $37 million. In 1988, Fujitsu had purchased a 28 percent equity stake in the firm. Fujitsu has been working with Poqet Computer to develop Japanese versions of pocket computers.

Softway
Fujitsu acquired a 40 percent interest in Softway, an Australian software company. Both companies will collaborate on UNIX systems development. Continental Venture Capital, Softway, and Techway staff also hold a 20 percent interest in the company.

Hal Computer Systems Inc.
Fujitsu Ltd. acquired a 44 percent interest totaling $40.2 million in Hal Computer Systems. The company is developing a family of high-performance open systems based on the SPARC architecture and UNIX System V Release 4.

KEY OFFICERS

Takuma Yamamoto
Chairman and representative director

Matami Yasufuku
Vice chairman and representative director

Tadashi Sekizawa
President and representative director

Kazuo Watanabe
Vice president and representative director

Mikio Ohtsuki
Executive vice president

Motojiro Shiromizu
Executive director

Mamoru Mitsugi
Executive director

Tokio Tatsuta
Executive director

Eigo Kato
Executive director

Matsuro Umezu
Executive director

Ryoichi Sugioka
Executive director

PRINCIPAL INVESTORS

Fuji Electric Co. Ltd.—13.5 percent
Asahi Mutual Life Insurance Company—6.5 percent

FOUNDERS

Information is not available.

Table 3
Balance Sheet
Fiscal Year Ending March 31
(Millions of U.S. Dollars)

Balance Sheet	1987	1988	1989	1990	1991
Cash	1,125	1,764	2,379	1,833	2,906
Receivables	2,904	3,645	4,615	5,104	6,025
Marketable Securities	137	648	189	225	159
Inventory	2,562	3,354	3,734	4,097	5,038
Other Current Assets	307	408	452	265	599
Total Current Assets	7,035	9,818	11,369	11,523	14,726
Net Property, Plants	3,424	4,289	5,481	5,777	6,947
Other Assets	2,067	2,678	3,617	3,489	4,792
Total Assets	12,527	16,784	20,467	20,789	26,465
Total Current Liabilities	4,991	7,059	8,581	8,979	11,939
Long-Term Debt	2,117	2,185	2,467	2,368	4,091
Other Liabilities	1,153	1,548	1,924	1,849	2,225
Total Liabilities	8,261	10,792	12,973	13,197	18,256
Converted Preferred Stock	NA	NA	NA	NA	NA
Common Stock	2,115	3,364	4,252	4,219	4,350
Other Equity	71	92	110	110	123
Retained Earnings	2,080	2,536	3,133	3,264	3,737
Total Shareholders' Equity	4,266	5,992	7,495	7,592	8,210
Total Liabilities and Shareholders' Equity	12,527	16,784	20,467	20,789	26,465
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

NA = Not available

Source: Fujitsu Limited Annual Reports
Dataquest (December 1991)

Table 4
Consolidated Income Statement
Fiscal Year Ending March 31
(Millions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	11,218	14,830	18,616	17,839	21,043
Domestic	8,757	11,551	14,496	13,581	15,818
Overseas	2,461	3,279	4,120	4,258	5,225
Cost of Sales	7,728	9,703	11,914	11,043	12,893
R&D Expense	1,043	1,378	1,925	2,093	2,336
SG&A Expense	2,057	2,883	3,328	3,337	4,298
Capital Expense	814	1,209	1,825	2,105	2,231
Pretax Income	301	768	1,210	1,191	1,088
Pretax Margin (%)	2.68	5.18	6.50	6.68	5.17
Net Income	135	305	545	607	585
Shares Outstanding, Millions	1,593.3	1,710.0	1,760.1	1,760.1	1,760.1
Per Share Data					
Earnings	13.40	23.50	36.80	36.80	$36.80
Dividend	8.00	8.00	9.00	9.00	9.00
Book Value	2.68	3.50	4.26	4.31	4.66
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

Table 5
Balance Sheet
Fiscal Year Ending March 31
(Millions of Yen)

Balance Sheet	1987	1988	1989	1990	1991
Cash	179,409	243,492	305,166	261,928	410,365
Receivables	463,150	503,035	591,815	729,471	850,761
Marketable Securities	21,863	89,402	24,219	32,154	22,413
Inventory	408,718	462,869	478,840	585,546	711,392
Other Current Assets	49,035	56,326	58,017	37,867	84,579
Total Current Assets	1,122,175	1,355,124	1,458,057	1,646,975	2,079,510
Net Property, Plants	546,233	591,921	702,988	825,757	980,961
Other Assets	329,779	369,549	463,882	498,633	676,699
Total Assets	1,998,187	2,316,594	2,624,927	2,971,365	3,737,170
Total Current Liabilities	796,143	974,268	1,100,577	1,283,409	1,685,950
Long-Term Debt	337,660	301,618	316,395	338,481	577,700
Other Liabilities	183,980	213,685	246,778	264,347	314,221
Total Liabilities	1,317,783	1,489,571	1,663,750	1,886,237	2,577,871
Converted Preferred Stock	NA	NA	NA	NA	NA
Common Stock	337,308	464,365	545,369	602,980	614,205
Other Equity	11,359	12,659	14,050	15,658	17,381
Retained Earnings	311,737	349,999	401,758	466,490	527,713
Total Shareholders' Equity	680,404	827,023	961,177	1,085,128	1,159,299
Total Liabilities and Shareholders' Equity	1,998,187	2,316,594	2,624,927	2,971,365	3,737,170
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

NA = Not available

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

Table 6
Consolidated Income Statement
Fiscal Year Ending March 31
(Millions of Yen, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	1,789,417	2,046,802	2,387,442	2,549,773	2,971,462
Domestic	1,396,876	1,594,193	1,859,129	1,941,075	2,233,493
Overseas	392,541	452,609	528,313	608,698	737,969
Cost of Sales	1,232,722	1,339,183	1,527,908	1,578,343	1,820,554
R&D Expense	166,342	190,130	246,906	299,107	329,823
SG&A Expense	328,184	397,968	426,779	476,979	606,890
Capital Expense	129,822	166,924	234,113	300,822	315,109
Pretax Income	48,012	106,048	155,152	170,216	153,573
Pretax Margin (%)	2.68	5.18	6.50	6.68	5.17
Net Income	21,609	42,115	69,948	86,758	82,673
Shares Outstanding, Millions	1,593.3	1,710.0	1,760.1	1,802.4	1,812.1
Per Share Data					
Earnings	13.40	23.50	36.80	45.40	42.20
Dividend	8.00	8.00	9.00	9.00	10.00
Book Value	427.04	483.64	546.09	602.05	639.75
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

Table 7
Key Financial Ratios
Fiscal Year Ending March 31

Key Financial Ratios	1987	1988	1989	1990	1991
Liquidity					
Current (Times)	1.41	1.39	1.32	1.28	1.23
Total Assets/Equity (%)	293.68	280.11	273.10	273.83	322.36
Current Liabilities/Equity (%)	117.01	117.80	114.50	118.27	145.43
Total Liabilities/Equity (%)	193.68	180.11	173.10	173.83	222.36
Profitability (%)					
Return on Assets	1.08	1.82	2.66	2.92	2.21
Return on Equity	3.40	6.19	8.46	9.03	7.62
Profit Margin	1.21	2.06	2.93	3.40	2.78
Other Key Ratios					
R&D Spending % of Revenue	9.30	9.29	10.34	11.73	11.10
Capital Spending % of Revenue	7.25	8.16	9.81	11.80	10.60
Employees	89,293	94,825	104,503	115,000	145,000
Revenue (¥)/Employee	20,040	21,585	22,846	22,172	20,493
Capital Spending % of Assets	6.50	7.21	8.92	10.12	8.43
Exchange Rate (U.S.$1=¥)	159.51	138.02	128.25	142.93	141.21

Source: Fujitsu Limited
Annual Reports
Dataquest (December 1991)

Hitachi Ltd.

6, Kanda-Surugadai
4-chome, Chiyuoda-ku
Tokyo 101, Japan
Telephone: (03) 258-1111
Fax: (03) 253-2186
Dun's Number: 69-054-1503

Date Founded: 1910

CORPORATE STRATEGIC DIRECTION

Hitachi Ltd. was founded to develop indigenous Japanese electrical power equipment manufacturing technology. Initially, the company emphasized the development of heavy electrical equipment and industrial machinery. After World War II, Hitachi expanded into the consumer product area and in the 1950s entered the electronics field, producing computers, semiconductors, and other electronic devices.

Over the years, most of Hitachi's business operations involved large equipment such as power plants and industrial machinery. The plant-as-profit-center concept was the basis of the management system. Today, however, a large percentage of Hitachi's business relates to electric and electronic consumer goods, office automation equipment, and other mass-market products.

Under the new system, the business divisions make the decisions regarding product development and coordinate the work of the laboratory, plant, and sales division in all phases of the development process, from R&D to marketing. This new system created the Semiconductor Design and Development Center and the Institute of Advanced Business Systems, as well as a system for promoting the development and marketing of new products in new business fields. During 1990, the office computer system design operations, which had been split between two works, were consolidated under the newly established Center for Small-Scale Processors and Workstations Development. Thus, a new profit center was created under the wing of the computer division.

Hitachi also consolidated the operations of its subsidiaries in each of the three major regions—United States, Europe, and Asia—where the company has production and marketing bases. Hitachi also made an effort to expand production at overseas sites. As part of this expansion, a company was set up in France for manufacturing computer products. Hitachi also increased the production capacity of a number of bases in other parts of the world.

During fiscal year 1991, operating income was held back by the high value of the yen, the economic slowdown in the United States and Europe, and the transition to a new generation of products in key computer and semiconductor sectors. In order to offset these factors, Hitachi increased its plant and equipment investment by 19 percent to ¥781,488 million (U.S.$55.6 million). (Percentage changes refer only to ¥ amounts; U.S.$ percentage changes will differ because of fluctuations in Dataquest exchange rates.) Most of these funds were used to strengthen and consolidate the computer and semiconductor operations.

Hitachi's consolidated revenue of ¥7,737.0 billion (U.S.$54.8 billion) for fiscal 1991 was an increase of 10.65 percent from ¥7,077.8 billion (U.S.$49.5 billion) during fiscal 1990.

Hitachi is divided into four separate segments: Information Systems and Electronics, Power and Industrial Systems, Consumer Products, and Materials and Others. Information Systems and Electronics was the largest contributor of revenue with 34 percent or ¥2,781,351 million (U.S.$19,798 million); Power and Industrial Systems contributed 28 percent or ¥2,357,892 million (U.S.$16,783 million); Materials and Others contributed 25 percent or ¥2,100,870 million (U.S.$14,953 million); and Consumer Products contributed 13 percent or ¥1,107,388 million (U.S.$7,882 million).

Net income increased by 10.4 percent to ¥230.2 billion (U.S.$1.6 billion) for fiscal 1991, compared with ¥211.0 billion (U.S.$1.5 billion) in fiscal 1990. The improved results were attributed to the company's steady expansion on a worldwide scale. Hitachi employs more than 290,000 people worldwide.

Research and development expenditure increased to ¥490.7 billion (U.S.$3.5 billion) and represented 6.3 percent of total revenue for the period. Over 60 percent of this expenditure was channeled into the Information Systems and Electronics division. During 1990, Advanced Research Laboratory was relocated to Saitama Prefecture, Japan. This laboratory concentrates on long-term research projects with a duration of 10 to 20 years. It is currently engaged in research in the areas of quantum measurement, software science, biotechnology, and materials science.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7 at the end of this backgrounder provide comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Semiconductors

During calendar year 1990, Hitachi was the third largest worldwide semiconductor manufacturer with U.S.$3,893 million, representing a 6.7 percent market share. Dataquest estimates the company's single largest market to be Japan, which generated approximately U.S.$2.8 million, representing 12.1 percent of the semiconductor market during 1990. Dataquest ranks Hitachi third of all Japanese companies in this market. Hitachi's next largest market is North America, where Hitachi's sales were U.S.$517 million in calendar 1990, ranking eighth, with a 3.0 percent market share.

Hitachi was the third largest worldwide supplier of MOS memory in 1990, accounting for approximately U.S.$1,366 million in revenue worldwide. This represented a 10 percent share of the worldwide market, which is an increase of about 10 percent over 1989.

In the second half of 1990, the supply of MOS memories exceeded demand, increasing the downward pressure on prices. Therefore, as a result of industry cutbacks in the production of 1Mb DRAMs implemented in fall 1990, prices stabilized. During the latter half of 1990, there was a growing demand for 4Mb DRAMs for use in new workstations and 32-bit personal computers. According to Dataquest estimates, Hitachi increased its DRAM market share from 8.5 percent in 1989 to 9.7 percent in 1990, and the company ranked fourth worldwide in DRAM production, accounting for U.S.$697 million in revenue.

Computers

During fiscal 1990, Hitachi introduced the large-scale general-purpose HITACHI M-880 Processor Group. This system will become a mainstay product in Hitachi's computer operations. In addition, the technology involved will be applied extensively in other products. During 1990, in the business computer market, Hitachi had a 12.45 percent worldwide market share and ranked third in supercomputers. In mainframes, it ranked second with a 7.40 percent worldwide market share. In the technical computer market, Hitachi had a 2.09 percent worldwide market share and ranked tenth in supercomputers. In mainframes, it ranked third with a 7.79 percent worldwide market share. In the personal computer market, Hitachi had less than one percent of the market.

Computer Storage

In addition to introducing the HITACHI M-880, the company also introduced the H-6587 series of mass-storage magnetic disk storage subsystems for large computers. Dataquest estimates that Hitachi ranks third in the worldwide total optical disk drive market with 11.5 percent of the market and U.S.$23.4 million in 1990 revenue. In the CD-ROM optical disk drive market, Hitachi ranks second worldwide with revenue of U.S.$10.4 million and a market share of 17.5 percent. Hitachi also ranks third in the worldwide 12-inch WORM optical disk drive market with a 20 percent market share and U.S.$13 million in revenue.

Other Products

Hitachi's Power and Industrial Systems witnessed a 5 percent increase in fiscal 1990 sales over 1989. The main contributing factors were a higher level of industrial demand accompanying the continuing expansion of the domestic economy. Sales in Hitachi's Consumer Products division grew 10 percent in 1990 from 1989. In Japan, sales were derived from air conditioners, washing machines, and 8mm camera/recorders. Although overseas sales were severely affected by the depressed state of the U.S. market, there was a recovery in exports of color television sets and VCRs to China and brisk exports to the USSR and Eastern Europe. The Materials and Others division posted an increase of 12 percent over 1989. Hitachi Cable Ltd. achieved an increase in sales based on a combination of strong domestic demand, mostly from the electric equipment and construction industries and brisk exports. At Hitachi Metals Ltd., sales were pushed up by demand from the automobile and electronics-related industries. Active business in the electronics equipment and industries, plus a high level of new housing starts, led to increased sales for Hitachi Chemical Co. Ltd. The major part of the service sector business was derived from Hitachi Transport System. The continuing driving pace of the Japanese economy generated strong demand for freight-hauling services and produced an increase in company sales.

Further Information

For further information pertaining to the company's business segments, please contact the appropriate Dataquest industry service.

Table 1
Five-Year Corporate Highlights (Billions of U.S. Dollars)

	1987	1988	1989	1990	1991
Five-Year Revenue	30.4	36.0	49.9	49.5	54.8
Percent Change	34.19	18.61	38.48	(0.79)	10.65
Capital Expenditure	4.1	2.7	4.0	3.6	5.3
Percent of Revenue	13.56	7.49	8.04	7.27	9.61
R&D Expenditure	1.9	2.3	2.9	3.0	3.5
Percent of Revenue	6.34	6.51	5.83	6.07	6.34
Number of Employees	161,325	159,910	274,508	290,000	310,000
Revenue ($K)/Employee	0.19	0.23	0.18	0.17	0.18
Net Income	0.6	1.0	1.4	1.5	1.6
Percent Change	38.67	60.22	46.02	2.01	10.43
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports
Dataquest (November 1991)

Table 2
Revenue by Geographic Region (Percent)

Region	1987	1988	1989	1990	1991
Japan	73.82	76.00	77.05	76.58	76.02
International	26.18	24.00	22.95	23.42	23.98

Source: Hitachi, Ltd.
Annual Reports
Dataquest (November 1991)

1991 SALES OFFICE LOCATIONS

North America—2
Europe—2
Asia/Pacific—61
Japan—50
ROW—9

MANUFACTURING LOCATIONS

North America

High Voltage Breakers, Norcross, Georgia
SF6 gas breakers
Hitachi Automotive Products, Farmingtonhills, Michigan
Electronic auto parts
Hitachi Cable Manchester Inc., Manchester, New Hampshire
Cables
Hitachi Cable Manchester Inc., New Albany, Indiana
Automobile brake hose
Hitachi Computer Products (America), Norman, Oklahoma
Computer products (magnetic disk devices, magnetic tape cartridges)
Hitachi Construction Machinery Corp., Brampton, Ontario
Excavators, cranes, tunnel shield machines
Hitachi Electronic Devices USA Inc., Greenville, South Carolina
Color picture tubes
Hitachi Home Electronics of America, Anaheim, California
Color TVs, VCRs
Hitachi Denshi (Canada) Ltd., Scarborough, Ontario
Broadcast and professional video, CCTV equipment, test and instrumentation
Hitachi (HSC) Canada Inc., Pointe Claire, Quebec
TVs, VCRs, and household electric appliances
Hitachi Instruments Inc.
Medical instruments
Hitachi Semiconductor (America), Irving, Texas
Semiconductors
Hitachi Telecom, Norcross, Georgia
Digital PBXs

Europe

Hitachi Consumer Products (Europe), Germany
VCRs
Hitachi Consumer Products (U.K.), United Kingdom
Color TVs
Hitachi Semiconductor Europe, Germany
Semiconductors

Asia/Pacific

Akita Electronic Co., Akita, Japan
MOS, bipolar IC
Hanshi Electric, Japan
Ignition coils for automobiles
Haramachi Semiconductor Ltd., Ibaraga, Japan
Diodes, thyristors
Hitachi Computer Engineering, Japan
Development of automatic designing systems
Hitachi Consumer Products, Malaysia
TV parts
Hitachi Consumer Products, Singapore
Color TVs, audio equipment, vacuum cleaners
Hitachi Consumer Products, Thailand
Electric fans, refrigerators, TVs, motors, air conditioners, electric rice cookers
Hitachi Cubu Electric, Japan
Switchboards
Hitachi Denshi, Japan
Communications equipment, measuring instruments, information equipment
Hitachi Electronic Devices, Singapore
Color CRTs
Hitachi Electronics Engineering, Japan
Information equipment, semiconductor devices, energy-saving equipment
Hitachi Elevator Engineering, Singapore
Elevators, escalators
Hitachi Engineering, Japan
Electric/electronic equipment, plant engineering
Hitachi Haramachi Semiconductor, Japan
Semiconductor parts
Hitachi Kiden Kogyo, Japan
Cranes, water treatment equipment, FA-related equipment
Hitachi Kyowa Kogyo, Japan
Electric equipment
Hitachi Maxell, Japan
Dry batteries, magnetic tapes, electronic devices
Hitachi Medical, Japan
Medical equipment
Hitachi Microcomputer Engineering, Tokyo, Japan
MPUs, ASICs
Hitachi Mizusawa, Japan
Transformers for TVs
Hitachi Naka Seiki, Japan
Chromatographic equipment, scientific instruments
Hitachi Nissin Electronics, Japan
Electronic parts

Hitachi Ohira Industrial, Japan
Parts for refrigerators, air conditioners
Hitachi Process Computer Engineering, Japan
Process computers
Hitachi Semiconductor, Malaysia
Semiconductors
Hitachi Setsubi Engineering, Japan
FA equipment
Hitachi Techno Engineering, Japan
Electronic part manufacturing equipment
Hitachi Telecom Technologies, Japan
Switching systems
Hitachi Television, Taiwan
Color TVs, audio equipment, displays
Hitachi Video Engineering, Japan
Development of video equipment
Hitachi Works, Ibaraga, Japan
Discrete devices
Hitachi Yomezawa Electronic, Japan
Semiconductor elements
Hokkai Semiconductor, Hokkaido, Japan
SRAMs
Horiba Ltd., Japan
Electric measuring instruments
Japan Servo, Japan
Precision motors
Jidosha Denki Kogyo, Japan
Electrical auto parts
Kaohsiung Hitachi Electronics, Taiwan
Electronic parts, transistors, LCDs
Kokusai Electric, Japan
Electric communications equipment
Kokusan Denki, Japan
Electrical auto parts, generators, motors
Komoro Works, Nagano, Japan
Photo devices, hybrid ICs
Mobara Works, Chiba, Japan
DRAMs, CMOS logic, LCDs
Musashi Works, Tokyo, Japan
MPUs, diodes, DRAMs, SRAMs
Naka Works, Ibaraga, Japan
Semiconductor sensors, DRAMs, SRAMs
Nakayo Telecommunications, Japan
Telephone and switching systems
Nigata Works, Nigata, Japan
Linear, bipolar digital ICs
Nippon Columbia, Japan
Records, stereos, and other audio equipment
Nissin Electronics Ltd., Ibaraga, Japan
MOS
Taga Sangyo, Japan
Electric equipment
Taiwan Hitachi, Taiwan
Room air conditioners
Takasaki Works, Gunma, Japan
Bipolar and MOS ICs, EPROMs, CMOS logic
Tobu Semiconductor Ltd., Aomari, Japan
Bipolar ICs
Tobu Semiconductor Ltd., Saitama, Japan
Transistor, hybrid ICs
Tokico Ltd., Japan
Electrical auto parts and equipment
Tokyo Electronics Co., Yamanashi, Japan
Diodes, bipolar ICs
Yagi Antenna, Japan
Antennas
Yomezawa Electronic Co., Yamagata, Japan
MOS

ROW

Industrias Hitachi, Brazil
Distribution equipment, air conditioners, electronic parts, transformers, switches
Hitachi Consumer Products de Mexico, Mexico
Televisions

SUBSIDIARIES

North America

Hitachi America Ltd. (United States)
Hitachi Automotive Products (USA) Inc. (United States)
Hitachi (Canadian) Ltd. (Canada)
Hitachi Computer Products (America) Inc. (United States)
Hitachi Electronic Devices (United States)
Hitachi Farmington Technical Center (United States)
Hitachi Home Electronics of America Inc. (United States)
Hitachi Micro Systems Inc. (United States)
Hitachi Semiconductor (America) Inc. (United States)
Hitachi Telecom (USA) Inc. (United States)

Europe

Hitachi Consumer Products Europe Ltd. (United Kingdom)
Hitachi Semiconductor Europe (Germany)
Hitachi Consumer Products (Europe) (Germany)

Asia/Pacific

Asahi Kogyo Co. Ltd. (Japan)
Babcock-Hitachi K.K. (Japan)
Chuo Shoji Ltd. (Japan)

Hitachi Air Conditioning & Refrigeration Co. Ltd. (Japan)
Hitachi Australia Ltd. (Australia)
Hitachi Automobile Appliances Sales Co. Ltd. (Japan)
Hitachi Cable Ltd. (Japan)
Hitachi Chemical Co. Ltd. (Japan)
Hitachi Construction Machinery Co. Ltd. (Japan)
Hitachi Consumer Products (Malaysia) Sdn. Bhd. (Malaysia)
Hitachi Consumer Products Pte. Ltd.
Hitachi Credit Corporation (Japan)
Hitachi Electronic Components (Asia) Ltd. (Hong Kong)
Hitachi Electronic Devices (Singapore) Pte. Ltd. (Singapore)
Hitachi Denshi Ltd. (Japan)
Hitachi Electronics Engineering Co. Ltd. (Japan)
Hitachi Electronics Service Co. Ltd. (Japan)
Hitachi Elevator Engineering and Service Co. Ltd. (Japan)
Hitachi Engineering Co. Ltd. (Japan)
Hitachi Heating Appliances Co. Ltd. (Japan)
Hitachi Higashi Shohin Engineering Ltd. (Japan)
Hitachi Hokkai Semiconductor Ltd. (Japan)
Hitachi Kiden Kogyo Ltd. (Japan)
Hitachi Lighting Ltd. (Japan)
Hitachi Machinery and Engineering Ltd. (Japan)
Hitachi Maxell Ltd. (Japan)
Hitachi Medical Corporation (Japan)
Hitachi Metals Ltd. (Japan)
Hitachi Mokuzai Jisho Ltd. (Japan)
Hitachi Nishi Shohin Engineering Ltd. (Japan)
Hitachi Plant Engineering & Construction Co. Ltd. (Japan)
Hitachi Power Engineering Co. Ltd. (Japan)
Hitachi Printing Co. Ltd. (Japan)
Hitachi Sales Corporation (Japan)
Hitachi Seiko Ltd. (Japan)
Hitachi Semiconductor (Malaysia) Sdn. Bhd. (Malaysia)
Hitachi Service Engineering Co. Ltd. (Japan)
Hitachi Software Engineering Co. Ltd. (Japan)
Hitachi Techno Engineering Co. Ltd. (Japan)
Hitachi Telecom Technologie Ltd. (Japan)
Hitachi Television Ltd. (Taiwan)
Hitachi Tochigi Electronics Co. Ltd. (Japan)
Hitachi Tohbu Semiconductor Ltd. (Japan)
Hitachi Tokyo Electronics Co. Ltd. (Japan)
Hitachi Transport System Ltd. (Japan)
Hitachi Welfare Service Ltd. (Japan)
Japan Servo Co. Ltd. (Japan)
Nippon Business Consultant Co. Ltd. (Japan)
Nissei Sangyo Co. Ltd. (Japan)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Texas Instruments Inc., Fujitsu Ltd., and Sony Corporation

Texas Instruments, Fujitsu, and Sony, along with Hitachi Ltd., have agreed to collaborate on HDTV chip development. Texas Instruments will be doing the frame memory store, Fujitsu the signal processors, Sony the analog components, and Hitachi the audio circuits. The full Muse chip set is scheduled for completion during the first quarter of 1992.

Bull CP8 S.A.

Bull CP8 S.A., a subsidiary of Groupe Bull, located in Trappes France, has signed Hitachi Ltd. as the first Japanese licensee of its self-programmable one-chip microcomputer (SPOM) patent. Hitachi's chips for microcomputer cards will be made available in Japan through Tokyo-based SPOM Japan KK, a joint venture between Bull CP8 and Dai Nippon Printing Co. Ltd, and worldwide through Hitachi's overseas sales office.

Dongfang Power Corp.

Hitachi Ltd. is planning to supply thermal power plant construction technology to Dongfang Power Corp., a Chinese company located in Sichuan Province. Under a 10-year agreement with the Chinese company, Hitachi will provide technology relating to steam turbines and generator for use in 600,000kw class thermal power stations. The two companies will then jointly construct four power plants.

TRW Inc.

Hitachi Ltd. and TRW Inc. formed a 15-year strategic alliance to jointly pursue opportunities in space systems and related ground systems and technologies. The two companies signed an agreement to set up a management team that will meet periodically to review future space programs, market opportunities, and technology requirements.

Ultra-Network Technologies

Ultra-Network Technologies, a U.S. network system manufacturer, and Hitachi Ltd. have formed a software agreement. The agreement will allow Hitachi to port ULTRANET software, a high-speed network software package developed by Ultra-Network, to its mainframe computers. The new version of ULTRANET will run under Hitachi's VOS3 operating system.

Hewlett-Packard Company
Hewlett-Packard Company (HP) and Hitachi Ltd. have agreed to jointly develop an artificial intelligence software product based on Hitachi's ES/Kernel expert systems technology. The new software will run on HP 9000 UNIX workstation as well as on Hitachi workstations.

National Semiconductor Corporation
National Semiconductor Corporation and Hitachi Ltd. have signed a 10-year patent cross-licensing agreement that covers all semiconductor products and technologies developed by either company in the past and during the course of the agreement. The new agreement expands and replaces a previous cross-licensing agreement between the two companies concerning FACT logic products.

Goldstar Electron Company Ltd.
Hitachi Ltd. licensed Lucky Goldstar Group's Goldstar Electron Company Ltd. to fabricate 4Mb memory chips to Hitachi's design. Part of the output will be sold back to Hitachi.

1990

Comparex Information Systems GmbH
Comparex Information Systems GmbH agreed to ship Hitachi's new Integrated Vector Feature for its 8/9X series of processors.

VLSI Technology Inc.
Hitachi plans to supply SRAMs to VLSI Technology on an OEM basis. The SRAMs have been jointly developed by the two companies.

Kansai Electric Power Co., Matsushita Electric Industrial Co. Ltd., Toshiba Corporation, Mitsubishi Electronics Corporation, Sumitomo Electric Industries Ltd., Kawasaki Heavy Industries Ltd., and Kobe Steel Ltd.
Hitachi agreed to set up a new company, which will perform research and development for free electron lasers with the preceding companies.

Sears, Roebuck and Company
Hitachi agreed to let Sears market its VY15A video printer.

1989

Sun Microsystems Inc.
Hitachi licensed Sun's Open Network Computing/Network File System technology for implementation on Hitachi's mainframe computers.

Zuken Inc.
Hitachi agreed to allow Zuken to develop CAD/CAM/CAE software packages for the 2050G Series of engineering workstations made by Hitachi.

Adaptive Information Systems (AIS)
AIS has been formed by Hitachi to market document image processing systems using optical storage technology.

Hewlett-Packard
Hewlett-Packard is licensing its proprietary Precision Architecture to Hitachi. The two companies also agreed to jointly develop a new set of chips using HP's proprietary Precision Architecture RISC MPU technology.

Texas Instruments Inc.
Texas Instruments supplied SRAMs to Hitachi on an OEM basis.

GoldStar
Hitachi signed a major pact with South Korea's GoldStar Company covering 1Mb DRAMs, for which Hitachi will provide technical consultations and manufacturing technology. Hitachi will get royalty payments from GoldStar and eventually will buy chips to sell under its own label.

Cray
This agreement gives each company the right to make use of the other's patents in designing computer hardware.

National Semiconductor
Under this production agreement for FACT logic devices, both companies can mutually produce independently defined and independently developed new functions.

MERGERS AND ACQUISITIONS

1991

Hitachi has made no merger or acquisition in 1991.

1990

Dataproducts Corporation
Two Hitachi affiliates, Hitachi Koki and Nissei Sangyo, acquired Dataproducts Corporation for approximately $160 million. Dataproducts

manufactures a broad range of band, dot matrix, laser, solid ink, and thermal printers, and a wide range of printer supplies. Dataproducts is counting on solid ink jet printers to play a significant role in the printer industry and is investing heavily to finance this strategically important technology. The 1988 acquisition of Imaging Solutions Inc. gave Dataproducts 100 percent ownership of this new technology. Dataproducts had sales of $353 million in fiscal 1989.

National Advanced Systems
Hitachi purchased National Advanced Systems from National Semiconductor Corporation. The name of the company was changed to Hitachi Data Systems. The company markets and services mainframe computers and peripheral subsystems.

KEY OFFICERS

Katsushige Mita
Chairman and representative director

Tsutomu Kanai
President and representative director

Yutaka Sonoyama
Executive vice president and representative director

Sutezo Hata
Executive vice president and representative director

Takeo Miura
Executive vice president and representative director

Toshi Kitamura
Executive vice president and representative director

Tadashi Okita
Executive vice president and representative director

Iwao Matsuoka
Executive vice president and representative director

PRINCIPAL INVESTORS

Nippon Life Insurance—3.8 percent
Sumitomo Trust—2.7 percent
Mitsubishi Trust—2.7 percent
Dai-ichi Life Insurance—2.6 percent

FOUNDERS

Namihei Odaira

Table 3
Balance Sheet
Fiscal Year Ending in March
(Billions of U.S. Dollars)

Balance Sheet	1987	1988	1989	1990	1991
Cash	5.6	8.0	12.8	13.0	11.7
Receivables	6.3	7.8	10.7	11.2	13.0
Marketable Securities	2.9	3.0	3.0	2.3	2.7
Inventory	5.6	7.0	9.7	9.5	11.3
Other Current Assets	1.1	1.4	1.7	1.8	2.0
Total Current Assets	21.6	27.2	38.0	37.7	40.7
Net Property, Plants	7.4	8.2	11.5	12.0	14.1
Other Assets	4.4	5.3	4.6	4.9	5.6
Total Assets	33.4	40.7	54.1	54.6	60.4
Total Current Liabilities	14.3	17.4	24.8	23.2	26.2
Long-Term Debt	3.1	3.1	4.1	6.2	6.3
Other Liabilities	2.2	2.8	3.8	3.5	3.7
Total Liabilities	19.6	23.3	32.6	32.9	36.2
Converted Preferred Stock	0	0	0	0	0
Common Stock	0.9	1.3	1.7	1.7	1.9
Other Equity	1.3	1.8	2.5	2.5	2.9
Retained Earnings	9.3	11.5	13.6	13.7	15.1
Total Shareholders' Equity	11.4	14.6	17.8	17.9	19.9
Minority Interests	2.3	2.8	3.7	3.8	4.3
Total Liabilities and Shareholders' Equity	33.4	40.7	54.1	54.6	60.4
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports
Dataquest (November 1991)

Table 4
Consolidated Income Statement
Fiscal Year Ending in March
(Billions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	30.4	36.0	49.9	49.5	54.8
Japanese Revenue	22.4	27.3	38.4	38.1	40.8
Non-Japanese Revenue	8.0	8.7	11.5	11.6	13.1
Cost of Sales	23.0	28.7	35.5	35.1	38.4
R&D Expense	1.9	2.3	2.9	3.0	3.5
SG&A Expense	6.0	7.5	11.0	10.7	12.8
Capital Expense	4.1	2.7	4.0	3.6	5.3
Pretax Income	1.6	2.4	3.8	3.7	4.0
Pretax Margin (%)	5.33	6.66	7.67	7.49	7.27
Effective Tax Rate (%)	57.50	56.10	56.10	53.90	51.20
Net Income	0.6	1.0	1.4	1.5	1.6
Shares Outstanding, Millions	2,816.3	2,921.7	3,017.7	3,072.8	3,273.7
Per Share Data					
Earnings	0.21	0.32	0.46	0.43	0.44
Dividend	0.06	0.07	0.07	0.06	0.06
Book Value	0	0.01	0.01	0.01	0.01
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports
Dataquest (November 1991)

Table 5
Balance Sheet
Fiscal Year Ending in March
(Billions of Yen)

Balance Sheet	1987	1988	1989	1990	1991
Cash	892.9	1,103.9	1,638.3	1,853.7	1,648.5
Receivables	1,010.6	1,080.7	1,372.2	1,594.3	1,833.9
Marketable Securities	470.6	412.3	385.1	324.8	384.9
Inventory	898.5	960.6	1,250.0	1,355.0	1,597.1
Other Current Assets	172.2	199.9	224.4	263.1	286.6
Total Current Assets	3,444.8	3,757.4	4,870.0	5,390.9	5,751.0
Net Property, Plants	1,179.1	1,133.0	1,473.1	1,708.9	1,985.7
Other Assets	704.1	730.7	594.4	705.3	789.3
Total Assets	5,327.9	5,621.1	6,937.5	7,805.1	8,526.0
Total Current Liabilities	2,288.5	2,399.0	3,183.5	3,314.9	3,694.3
Long-Term Debt	488.9	432.8	520.9	886.8	891.0
Other Liabilities	352.3	381.9	481.0	494.0	520.1
Total Liabilities	3,129.7	3,213.7	4,185.4	4,695.7	5,105.4
Converted Preferred Stock	0	0	0	0	0
Common Stock	141.2	180.3	219.4	246.9	269.7
Other Equity	199.6	244.4	322.0	357.8	410.4
Retained Earnings	1,485.0	1,593.9	1,740.3	1,956.1	2,131.0
Total Shareholders' Equity	1,825.8	2,018.6	2,281.7	2,560.8	2,811.1
Minority Interests	372.4	388.8	470.4	548.6	609.5
Total Liabilities and Shareholders' Equity	5,327.9	5,621.1	6,937.5	7,805.1	8,526.0
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports and
Dataquest (November 1991)

Table 6
Consolidated Income Statement
Fiscal Year Ending in March
(Billions of Yen, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	4,848.7	4,975.0	6,401.4	7,077.8	7,737.0
Japanese Revenue	3,579.3	3,781.0	4,932.3	5,420.1	5,881.6
Non-Japanese Revenue	1,269.4	1,194.0	1,469.1	1,657.7	1,855.4
Cost of Sales	3,675.0	3,961.9	4,552.1	5,023.5	5,417.2
R&D Expense	307.6	324.0	373.5	429.4	490.7
SG&A Expense	958.8	1,032.4	1,416.1	1,533.2	1,813.4
Capital Expense	657.4	320.4	532.4	514.9	743.4
Pretax Income	258.3	331.1	491.1	530.0	562.1
Pretax Margin (%)	5.33	6.66	7.67	7.49	7.27
Effective Tax Rate (%)	57.50	56.10	55.50	53.10	51.70
Net Income	98.7	136.8	185.6	211.0	230.2
Shares Outstanding, Millions	2,816.3	2,921.7	3,017.7	3,072.8	3,273.7
Per Share Data					
Earnings	33.45	44.14	58.94	61.71	65.96
Dividend	9.00	9.00	9.00	9.00	9.00
Book Value	0.65	0.69	0.76	0.83	0.86
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports
Dataquest (November 1991)

Table 7
Key Financial Ratios
Fiscal Year Ending in March

Key Financial Ratios	1987	1988	1989	1990	1991
Liquidity					
Current (Times)	1.51	1.57	1.53	1.63	1.56
Total Assets/Equity (%)	291.81	278.47	304.05	304.79	303.30
Current Liabilities/Equity (%)	125.34	118.84	139.52	129.45	131.42
Total Liabilities/Equity (%)	171.42	159.20	183.43	183.37	181.62
Profitability (%)					
Return on Assets	1.85	2.43	2.68	2.70	2.70
Return on Equity	5.41	6.78	8.13	8.24	8.19
Profit Margin	2.04	2.75	2.90	2.98	2.98
Other Key Ratios					
R&D Spending % of Revenue	6.34	6.51	5.83	6.07	6.34
Capital Spending % of Revenue	13.56	6.44	8.32	7.27	9.61
Employees	161,325	159,910	274,508	290,000	290,000
Revenue (¥K)/Employee	30.06	31.11	23.32	24.41	26.68
Capital Spending % of Assets	12.34	5.70	7.67	6.60	8.72
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Hitachi Ltd.
Annual Reports
Dataquest (November 1991)

Matsushita Electric Industrial Co. Ltd.

1006 Kadoma, Kadoma City
Osaka 571, Japan
Telephone: (06) 908-1121
Fax: (06) 906-1762
Dun's Number: 69-053-6552

Date Founded: 1918

CORPORATE STRATEGIC DIRECTION

Matsushita Electric Industrial Co. Ltd. was founded as a family business in 1918 by Konosuke Matsushita to produce and market an electric adapter plug for consumer products. Today, Matsushita is a worldwide electric and electronics manufacturer with products that range from consumer electronics equipment, home appliances, and housing-related products through sophisticated industrial and communications equipment, including electronic components.

Matsushita is currently divided into four major business segments. These segments are discussed below:

Audiovisual (AV) Products and Home Appliances

The audiovisual products and home appliances segment is Matsushita's core business. Matsushita strengthened its position as a digital video industry leader by introducing its composite digital 1/2-inch tape VCR system (D3) for broadcast use. This system will be used as the official system for the 1992 Barcelona Olympic Games.

Further advances in intelligent products are expected in home appliances. With Matsushita's success of appliances employing fuzzy logic and neuro-fuzzy logic, the company is working to develop next-generation technologies. It is pursuing basic R&D into artificial intelligence and home-use robots.

Information and Communications Equipment

In systems and networks, Matsushita has made advances in urban cable TV (CATV) systems, as well as in airport traffic control systems and subway information management systems that use optical fiber LANs. The company is also increasing installations of AV information networks employing satellite signals. To meet emerging markets, such as integrated services digital network (ISDN)-related products and systems and intraorganizational information systems, the company is currently constructing the Tokyo Information and Communications Development Center.

Construction Electronics

Matsushita is a major manufacturer of virtually all of the key equipment needed in homes, offices, and other buildings, including air-conditioning equipment, gas water-heating equipment, kitchen-related products, lighting fixtures and elevators, as well as appliances and communications equipment used in the home. Drawing on its capabilities as a manufacturer of a comprehensive range of products, Matsushita is using this approach to develop a totally integrated package concept and proposing it to the construction industry. To foster this concept, the company established the Construction Electronics Business Group.

Components and Industrial Goods

Matsushita supplies a vast array of electronic components including semiconductors. The company is also one of Japan's leading suppliers of factory automation equipment. It plans to continue developing a well-balanced semiconductor business, stressing not only memory devices but also bipolar ICs, microprocessors, logic ICs and charge-coupled devices.

Within the four major segments, Matsushita has six major product categories: video equipment, communications and industrial equipment, electronic components, home appliances, audio equipment, and batteries and kitchen-related products.

Matsushita's products are sold in more than 160 countries under the brand names National, Panasonic, Technics, and Quasar and under other trade names including JVC.

The company reported consolidated sales of $46.7 billion* for the fiscal year ended March 31, 1991. Net income for the year increased over 13 percent, to $1.8 billion, versus $1.6 billion in fiscal 1990. International sales accounted for 45 percent of revenue in fiscal 1991. Within the major product categories, video equipment sales increased 9 percent; audio equipment sales rose 8 percent; home appliances sales increased 13 percent; communications and industrial equipment had a sales growth of 14 percent; electronic components' sales grew 9 percent; and batteries and kitchen-related products had sales gains of 13 percent. (Note: Percentage growth figures apply to U.S. dollar-based growth.)

In December 1990, Matsushita acquired MCA Inc. for approximately $6.1 billion. MCA Inc. is a leading U.S. entertainment company, which includes Universal Pictures Production. It engages primarily in the film, music, and publishing business. MCA's strength in the production of film and music software will widen Matsushita's business scope in the audiovisual field.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7 at the end of this backgrounder provide comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Video Equipment

The video equipment category remains Matsushita's largest revenue producer, accounting for 26 percent of fiscal 1991 revenue. Sales totaled $12,144 million for this period. This category includes VCRs, camcorders and related equipment; color, projection, and liquid crystal display televisions; videodisc players; and satellite broadcast receivers.

*All dollar amounts are in U.S. dollars.

Communications and Industrial Equipment

The second-largest revenue-producing category for the company is communications and industrial equipment. This category accounted for 24 percent of fiscal 1991 revenue. Total sales increased 14 percent over the previous period to $11.0 billion and include Matsushita's targeted growth areas of information/communication and factory automation. Products include facsimile and copier equipment, PCs and workstations, printers, telephones and private branch exchange systems, industrial robots, electronic parts mounting equipment, welding machines, air conditioners, and compressors.

Computers

Matsushita has expanded its desktop and laptop PC lines, resuming exports to Europe and North America, which were curtailed in 1987. The company is manufacturing 8-, 16-, and 32-bit IBM-compatible laptops in Japan, under the Panasonic label, for sale in Europe. In the U.S. market, the company is selling 16- and 32-bit models made by Tandy Corporation on an OEM basis. According to Dataquest, Matsushita had less than 1 percent of the worldwide market share for desktop and laptop PCs during 1990.

Facsimiles

During 1989, Matsushita merged its Panafax Corporation into the larger Office Automation Group of Panasonic Communications & Systems Company. The company intends to expand its presence across the entire spectrum of facsimile product markets through the merger of the two groups. According to Dataquest, Panasonic facsimile sales in the North American market during 1990 were more than 95,000 units, placing Panasonic/Matsushita among the top five vendors in the market with a 6.8 percent market share.

In addition to sales by its Panasonic subsidiary, Matsushita manufactures facsimile equipment sold by Pitney Bowes Inc. and several models sold by Fujitsu, Tandy, and Telautograph.

In April 1990, Matsushita's Quasar subsidiary announced a facsimile model for sale in the U.S. market, manufactured by Matsushita in Japan.

Copiers

Selling copiers under the Panasonic label, Matsushita continued to gain market share during 1990. Panasonic copiers compete in segments 1 through 4 of the six Dataquest copier segments. Based on plain paper copier placements, Dataquest ranked Panasonic thirteenth in 1990, with 30.7 thousand units. In the Western European copier market, Panasonic's 1990 sales rose to a total of 24.9 thousand units, up from 23.1 for 1989.

In addition to copier sales under the Panasonic label, Matsushita manufactures several models sold under the Lanier label in the United States and under the Adler-Royal label in Europe.

Printers

Matsushita also manufactures and markets its printers under the Panasonic label. Its product line focus is primarily on the serial printer market. According to Dataquest, Panasonic ranked fourth among page printer vendors in North America during 1990, with 75.5 thousand units and a market share of 3.6 percent. In the serial printer market, the company had unit shipments of 1.2 million with a market share of 20.8 percent.

Electronic Components

The electronic components category accounted for 13 percent of Matsushita's fiscal 1991 revenue, with sales of $5,961 million. In the general components field, sales gains domestically as well as overseas were led by surface-mounted components and microwave parts used in audiovisual and mobile communications equipment, as well as parts for office automation equipment.

Semiconductors

Matsushita's 1990 worldwide semiconductor ranking went from ninth in worldwide semiconductor sales to tenth, based on revenue of $1,942 million. Its semiconductor sales include MOS digital ICs, analog devices, discrete devices, optoelectronics, and bipolar digital ICs. The total revenue and worldwide market share breakdown is as follows: MOS digital, $819 million with a 2.5 percent market share; MOS memory, $284 million with a 2.2 percent market share; MOS microcomponents, $250 million with a 2.5 percent market share; MOS logic, $285 million with a 3.1 percent market share; analog devices, $410 million with a 3.9 percent market share; discrete devices, $374 million with a 4.5 percent market share; and optoelectronics, $325 million with a 12.1 percent market share.

Home Appliances

The home appliances category accounted for 14 percent of total revenue during the 1991 fiscal year. Sales for the period were $6,370 million, up 13 percent from $5,614 million for the previous period.

Products in the home appliances category include refrigerators, room air conditioners, laundry equipment, vacuum cleaners, electric irons, microwave ovens, electric fans, electric blankets, and cooking appliances. Appliances using fuzzy or neuro-fuzzy logic and air conditioners with heating and cooling capabilities sold especially well.

Audio Equipment

Matsushita's audio equipment category accounted for 9 percent of the company's revenue, with sales of $4,234 million for the period ended March 31, 1991. Although audio equipment in Japan was generally slow during this fiscal year, compact discs (CDs), radio/cassette recorders, and portable headphone cassette players continued as sales leaders in this segment.

Other products under the audio equipment category are radios, tape recorders, stereo hi-fi and related equipment, car audio products, and electronic musical instruments.

Batteries and Kitchen-Related Products

The batteries and kitchen-related products category accounted for 5 percent of Matsushita's revenue, $2,474 million for the fiscal year 1991. Batteries include compact batteries such as nickel-cadmium batteries. These batteries are used in video camcorders, portable phones, notebook-size personal computers, and other portable electronic products. Lithium batteries are also produced and used in cameras and for office automation equipment memory backups.

Others

The balance of Matsushita's business includes sales of bicycles, cameras and flash units, prerecorded tapes and discs, water purifiers, and imported materials and products such as nonferrous metals, lumber, paper, medical equipment, and cabin cruisers. This category accounted for 10 percent of the company's total revenue for fiscal 1991, with total sales of $4,551 million.

Further Information

For further information on the company's business segments, please contact the appropriate Dataquest industry service.

Table 1
Four-Year Corporate Highlights (Millions of U.S. Dollars)

	1988*	1989	1990	1991
Four-Year Revenue	36,710.8	42,918.1	41,998.1	46,733.9
Percent Change	NA	16.91	-2.14	11.28
Capital Expenditure	1,679.8	2,537.5	2,482.0	3,377.9
Percent of Revenue	4.58	5.91	5.91	7.23
R&D Expenditure	2,022.7	2,488.1	2,418.5	2,718.6
Percent of Revenue	5.51	5.80	5.76	5.82
Number of Employees	134,186	193,088	198,299	210,848
Revenue ($K)/Employee	273.58	222.27	211.79	221.65
Net Income	1,192.7	1,664.4	1,648.1	1,833.4
Percent Change	NA	39.56	-0.98	11.25
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

1991 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	11,162.8	11,831.9	12,635.8	11,103.5
Quarterly Profit	413.02	486.13	596.03	338.36

NA = Not applicable
*In 1987, Matsushita changed its fiscal year-end from November to March 31.
Fiscal 1987 represents only four months from November 1986 to March 31, 1987.
Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd.
Annual Reports
Dataquest (January 1992)

Table 2
Revenue by Geographic Region (Percent)

Region	1988*	1989	1990	1991
Japan	59	58	56	55
International	41	42	44	45

*In 1987, Matsushita changed its fiscal year-end from November to March 31.
Fiscal 1987 represents only four months from November 1986 to March 31, 1987.
Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd.
Annual Reports
Dataquest (January 1992)

1991 SALES OFFICE LOCATIONS

North America—9
Europe—15
Asia/Pacific—142
Japan—132
ROW—12

MANUFACTURING LOCATIONS

North America

America Kotobuki Electronics Industries (United States)
VCRs
American Matsushita Electronics Corporation (United States)
Color TV picture tubes
Kyushu Matsushita Electric Corporation of America (United States)
Deflection yokes
Matsushita Communication Industrial Corporation of America (United States)
Car telephones, pagers, point-of-sale electronic cash register systems
Matsushita Compressor Corporation of America (United States)
Air conditioning compressors
Matsushita Computer Company (United States)
Personal computers, workstations
Matsushita Electronic Components Corporation of America (United States)
Electrolytic capacitors, car audio speakers, filters, switchers
Matsushita Industrial Canada (Canada)
Color TVs, speaker boxes, TV cabinets, AV racks
Matsushita Industrial de Baja California S.A. de C.V. (United States)
TV chassis, color TVs
Matsushita Refrigeration Co. of America (United States)
Refrigerators
Matsushita Semiconductor Corporation of America (United States)
Semiconductors
Matsushita-Ultra Tech. Battery Corp. (United States)
Batteries
Panasonic Technologies (United States)
R&D

Europe

Kyushu Matsushita Electric (United Kingdom)
Electronic typewriters, printers
Matsushita Business Machine (Germany)
Plain paper copiers
Matsushita Communication Deutschland (Germany)
Car radios/stereos
Matsushita Communication Industrial (United Kingdom)
Car telephones
Matsushita Electric (United Kingdom)
Color TVs, microwave ovens
Matsushita Electric Motor (Germany)
Motors
Matsushita Electronic Components (Germany)
Electronic parts, materials
Matsushita Electronic Components (United Kingdom)
Transformers, LC filters
Matsushita Electronic Magnetron Corp. (United Kingdom)
Magnetrons for microwave ovens
Matsushita Graphic Communication Systems Ltd. (United Kingdom)
Fax machines
Matsushita Video Manufacturing (Germany)
VCR mechanisms
MB Video (Germany)
VCRs, CD players
Panasonic Espana (Spain)
Electric equipment
Panasonic France S.A. (France)
Consumer electronics

Asia/Pacific

A.P. National (Thailand)
Home electrical appliances
Asahi Kogyo (Japan)
Tape recorders
Beijing-Matsushita Color CRT (China)
Color CRTs
International Fan Manufacturing (Hong Kong)
Electric fans
Katano Matsushita (Japan)
Audio equipment
Kibi Matsushita (Japan)
Video equipment
Kyushu Matsushita Electric (Japan)
Data processing, business machines, magnetic heads
Matsue Matsushita Denki (Japan)
Capacitors
Matsusaka Seimitsu (Japan)
Assembly of motors
Matsushita Air-Conditioning Corporation (Malaysia)
Air conditioners

Matsushita Communication Industrial (Japan)
Data processing, communication, control, video equipment
Matsushita Communication Industrial Corp. of the Philippines (Philippines)
FDDs, ECM
Matsushita Compressor & Motor (Malaysia)
Compressors, fan motors
Matsushita Denshi (Singapore)
IC production, large-scale integration (LSI) design
Matsushita Electric (Australia)
TVs, audio equipment
Matsushita Electric (Malaysia)
Home electrical appliances
Matsushita Electric (Taiwan)
Electrical appliances
Matsushita Electric Institute of Technology (Taiwan)
R&D
Matsushita Electric Works (Japan)
Electrical housing equipment
Matsushita Electronic Components (Japan)
Electronic equipment parts
Matsushita Electronic Components (Malaysia)
Electronic parts
Matsushita Electronic Components (Singapore)
Electronic parts
Matsushita Electronic Motor (Malaysia)
Electronic motors
Matsushita Electronic Motor (Singapore)
Precision motors, applied equipment
Matsushita Electronics (Japan)
Semiconductors, electron tubes, lighting equipment
Matsushita Electronics (Singapore)
Audio equipment
Matsushita Graphic Communication Systems (Japan)
Facsimiles, graphics equipment
Matsushita Graphic Communications Systems (Singapore)
Fax machines
Matsushita Industrial (Malaysia)
Air conditioners, compressors
Matsushita Industrial Equipment (Japan)
Industrial equipment
Matsushita-Kotobuki Electronics (Japan)
Video equipment, TVs, tape recorders
Matsushita Precision Industrial (Malaysia)
Flyback transformers, coils
Matsushita Refrigeration (Japan)
Refrigerators, air conditioners
Matsushita Refrigeration Industries (Malaysia)
Refrigerator/freezers
Matsushita Refrigeration Industries (Singapore)
Compressors
Matsushita Refrigeration Industries (Thailand)
Refrigerator/freezers
Matsushita Research Institute (Japan)
Electronics research
Matsushita Seiko (Japan)
Electric fans, ventilators, air conditioners
Matsushita Seiko Hong Kong International Manufacturing Co. Ltd. (Hong Kong)
Air conditioners
Matsushita Technical Center (Singapore)
Production equipment
Matsushita Television (Malaysia)
Color TVs
Miyazaki Matsushita Denki (Japan)
Ceramics, magnetic materials, resistant materials
National Micromotor (Japan)
Microprecision motors
National Thai (Thailand)
Home electrical appliances
PFU Ltd. (Japan)
Minicomputers
Precision Electronics (Philippines)
Home electrical appliances
P.T. Matsushita Gobel Battery Industry (Indonesia)
Batteries
P.T. National Gobel (Indonesia)
Home electrical appliances
Takefu Matsushita Electric (Japan)
Micromotors
Victor Company of Japan (Japan)
Video/audio equipment, TVs
Wakayama Precision (Japan)
Refrigerators, air conditioners

ROW

Matsushita Electric (East Africa)
Radios, radio cassette recorders, dry batteries
Matsushita Electrica de Guatemala (Guatemala)
Audio equipment
Matsushita Electric de El Salvador (El Salvador)
Audio equipment
Matsushita Industrial de Baja California (Mexico)
Color TV chassis
National Centroamericana
Dry batteries, audio equipment
National Componentes Electronicos do Brazil (Brazil)
Electronic parts
National do Brazil (Brazil)
Matsushita group products
National Electric Cote d'Ivoire (Ivory Coast)
TVs, radio cassette recorders
National Panasonic Fueguina
Color TVs, radio cassette recorders
National Peruana (Peru)
Home electrical appliances
Panasonic de Mexico (Mexico)
Audio equipment, electronic parts
Panasonic Industrial de Venezuela C.A. (Venezuela)
Consumer electronic products

Springer National Componentes (Brazil)
  Assembly of micromotors, CRT sockets, PC boards
Springer National da Amazonia (Brazil)
  Color TVs, audio equipment

SUBSIDIARIES

North America

Matsushita Electric Corporation of America (United States)
Solbourne Computer (United States)

Europe

Matsushita Electric (U.K.) Ltd. (United Kingdom)
Matsushita Electronic Magnetron Corp. (United Kingdom)
Matsushita Graphic Communication Systems U.K. Ltd. (United Kingdom)
Panasonic Espana S.A. (Spain)
Panasonic France S.A. (France)

Asia/Pacific

Kyushu Matsushita Electric Co. Ltd. (Japan)
Matsushita Battery Industrial Co. Ltd. (Japan)
Matsushita Communications Industrial Co. Ltd. (Japan)
Matsushita Electric (Taiwan) Co. Ltd. (Taiwan)
Matsushita Electronic Components Co. Ltd. (Japan)
Matsushita Electronics Corporation (Japan)
Matsushita Electronics (S) Pte. Ltd. (Singapore)
Matsushita Graphic Communications Systems Inc. (Japan)
Matsushita Housing Products Co. Ltd. (Japan)
Matsushita Industrial Equipment Co. Ltd. (Japan)
Matsushita Industrial Corporation Sdn. Bhd. (Malaysia)
Matsushita Kotobuki Electronics Industries Ltd. (Japan)
Matsushita Refrigeration Company (Japan)
Matsushita Refrigeration Industries (S) Pte. Ltd. (Singapore)
Matsushita Seiko Co. Ltd. (Japan)
Victor Company of Japan Ltd. (Japan)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Digital Tape Licensing
  Matsushita will share its digital compact cassette tape technology, which was jointly developed with Philips, with third parties. The aim is to make the digital tape format, which competes against digital audio tape, a standard in the industry.

Tandy Corporation
  Tandy Corporation and Matsushita have signed a joint venture to manufacture laptop and notebook computers. Both companies will be equal partners and share in the technology of the new company called PTCC Inc.

Texas Instruments Inc. (TI)
  TI and Matsushita signed a cross-licensing agreement. This five-year agreement replaced the previous agreement that expired in 1990. TI will continue to receive royalty payments from Matsushita based on worldwide sales of chips by the two Japanese firms.

Energy Conversion Devices Co. (ECD)
  ECD and Matsushita have signed a patent licensing agreement for ECD's patented phase transformation optical disk system. With this agreement Matsushita will be able to sell optical disks worldwide.

Siemens Nixdorf Information Systems (SNI)
  SNI and Matsushita have signed an agreement to develop PC peripherals. The development will include an expansion unit for 16-bit and 32-bit notebook-size PCs. The unit will contain extra memory and space for an additional battery unit. Matsushita will produce the expansion unit. The company will market it in Europe and will also supply the device to SNI on an OEM basis.

Sun Microsystems Inc.
  Sun Microsystems Inc. has signed an agreement with Matsushita, Fujitsu, and Toshiba whereby Sun will exchange information with the other firms on image-processing techniques for multimedia workstations.

1990

The Santa Cruz Operation
The Santa Cruz Operation and Matsushita have signed an agreement to codevelop a Japanese version of a UNIX operating system. Matsushita will manufacture the new product on an OEM basis, while The Santa Cruz Operation will be responsible for marketing efforts through a new branch office to be established in Japan.

SNI
SNI and Matsushita signed an agreement to have SNI supply desktop PCs to Matsushita. In return, Matsushita will supply laptop PCs to SNI on an OEM basis.

1989

Signetics Company
Signetics and Matsushita entered a sales agency agreement for memory products.

Weitek Corporation
Weitek and Matsushita are jointly developing a microprocessor product.

Siemens
Matsushita and Siemens formed a joint venture for producing passive electronic components.

Office Workstations Ltd.
Matsushita and Office Workstations of Scotland formed a joint venture for development of office automation software products.

1988

Hewlett-Packard Company, IBM Corporation, Intel
Matsushita agreed to supply these companies with a total of more than 1 million 1Mb DRAMs per month.

Intel Corporation
Matsushita agreed to subcontract production of Intel's 8-bit microcontrollers for the Japanese market. The companies also agreed to jointly develop a sub-0.5-micron 16Mb DRAM process.

Sun Microsystems
The SPARC RISC chip was licensed for use in workstations being developed by Solbourne Computer, a Matsushita subsidiary.

Tosoh
The companies agreed to jointly develop conductive electron-beam resist that completely solves the electrification problem occurring with direct-write e-beams.

Motorola
Matsushita agreed to purchase Motorola semiconductors for use in videocassette recorders.

1987

NEC Corporation
NEC and Matsushita agreed to develop the next generation of steppers for very large scale integration (VLSI) manufacturing.

SAE Inc.
SAE and Matsushita agreed to jointly develop a 64-bit microprocessor with plans for a 64-bit engineering workstation in 1989.

Philips
Philips and Matsushita renewed a business cooperation agreement for the next ten years in which Matsushita Electric will continue to own 65 percent of Matsushita Electronics and Philips will own 35 percent. Matsushita agreed to supply LSIs for compact discs to Philips, and the companies made a second-source agreement for 8-bit CMOS microcontrollers.

Intel
Matsushita obtained a license from Intel for the 8051 and three other 8-bit microcontrollers.

TRW
The companies agreed to jointly develop a 0.8-micron-wavelength GaAlAs semiconductor laser for space communications.

Nikon Corporation
The companies jointly developed advanced i-line steppers and excimer lasers for next-generation VLSIs.

MERGERS AND ACQUISITIONS

1991

Matsushita made no mergers or acquisitions in 1991.

1990

MCA Inc.
MCA Inc. was acquired by Matsushita for approximately $6.1 billion. MCA is primarily engaged in the production and distribution of motion pictures and musical recordings, theme parks, book publishing, retailing, and real estate development.

1989

Matsushita made no mergers or acquisitions in 1989.

1988

Matsushita Electric Trading Co. Ltd. (MET)
MET, a 51.24 percent owned consolidated subsidiary, was merged into the company in exchange for 73.4 million shares of Matsushita common stock having a fair market value of $1.1 billion.

KEY OFFICERS

Masaharu Matsushita
Chairman of the board

Akio Tanii
President

Shoji Sakuma
Executive vice president

Masahiko Hirata
Executive vice president

Keiya Toyonaga
Senior managing director

Hiroyuki Mizuno
Senior managing director

Tsuzo Murase
Senior managing director

PRINCIPAL INVESTORS

Sumitomo Bank—4.4 percent
Sumitomo Life Insurance—4.4 percent
Nippon Life Insurance—4.0 percent
Matsushita Investment and Development—3.2 percent
Mitsubishi Trust—3.0 percent
Sumitomo Trust—2.9 percent
Konosuke Matsushita—2.6 percent
Toyo Trust—2.0 percent
Kyowa Bank—2.0 percent

FOUNDERS

Konosuke Matsushita

Table 3
Balance Sheet
Fiscal Year Ending March 31
(Millions of U.S. Dollars)

Balance Sheet	1988*	1989	1990	1991
Cash	10,016.4	11,229.2	14,068.8	11,737.8
Receivables	4,915.5	6,137.8	7,782.4	9,062.4
Marketable Securities	2,562.6	1,652.8	2,346.6	1,294.5
Inventory	4,857.9	6,210.6	5,919.0	6,593.7
Other Current Assets	1,967.2	2,303.0	2,157.4	2,491.3
Total Current Assets	24,319.6	27,533.4	32,274.3	31,179.8
Net Property, Plants	5,056.0	6,426.6	6,700.1	8,202.7
Investments	8,971.7	11,828.3	11,527.1	17,420.9
Other Assets	3,149.8	4,128.9	4,429.0	5,239.7
Total Assets	41,497.2	49,917.3	54,930.5	62,043.1
Total Current Liabilities	13,359.1	16,717.6	18,208.2	22,500.5
Long-Term Debt	4,093.6	4,849.1	8,375.3	8,665.8
Other Liabilities	6,005.4	5,999.5	5,952.1	6,553.4
Total Liabilities	23,458.1	27,566.3	32,535.6	37,719.7
Common Stock	1,048.2	1,280.7	1,293.9	1,383.0
Other Equity	1,815.8	3,266.7	3,700.2	3,688.8
Retained Earnings	15,175.1	17,803.6	17,400.8	19,251.5
Total Shareholders' Equity	18,039.1	22,351.0	22,394.9	24,323.3
Total Liabilities and Shareholders' Equity	41,497.2	49,917.3	54,930.5	62,043.1
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

*In 1987, Matsushita changed its fiscal year-end from November to March 31. Fiscal 1987 represents only four months from November 1986 to March 31, 1987. Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Inc. Annual Reports
Dataquest (January 1992)

Table 4
Consolidated Income Statement
Fiscal Year Ending March 31
(Millions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1988*	1989	1990	1991
Revenue	36,710.8	42,918.1	41,998.1	46,733.9
Cost of Sales	24,223.1	28,622.9	28,052.8	31,113.2
R&D Expense	2,022.7	2,488.1	2,418.5	2,718.6
SG&A Expense	9,880.5	11,042.3	10,777.8	12,273.9
Capital Expense	1,679.8	2,537.5	2,482.0	3,377.9
Pretax Income	3,283.6	4,128.2	4,000.1	4,230.6
Pretax Margin (%)	8.94	9.62	9.52	9.05
Effective Tax Rate (%)	55.50	54.20	52.60	51.10
Net Income	1,192.7	1,664.4	1,648.1	1,833.4
Shares Outstanding, Millions	1,861.8	1,955.6	2,080.2	2,093.4
Per Share Data				
Earnings	0.67	0.76	0.68	0.83
Dividend	0.80	0.90	0.63	0.89
Book Value	9.69	11.43	10.77	11.62
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

*In 1987, Matsushita changed its fiscal year-end from November to March 31. Fiscal 1987 represents only four months from November 1986 to March 31, 1987. Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd. Annual Reports
Dataquest (January 1992)

Table 5
Balance Sheet
Fiscal Year Ending March 31
(Billions of Yen)

Balance Sheet	1988*	1989	1990	1991
Cash	1,382.6	1,440.1	2,010.8	1,657.5
Receivables	678.5	787.2	1,112.3	1,279.7
Marketable Securities	353.7	212.0	335.4	182.8
Inventory	670.5	796.5	846.0	931.1
Other Current Assets	271.5	295.4	308.4	351.8
Total Current Assets	3,356.8	3,531.2	4,612.9	4,402.9
Net Property, Plants	697.9	824.2	957.6	1,158.3
Investments	1,238.4	1,516.9	1,647.6	2,460.0
Other Assets	434.8	529.6	633.0	739.9
Total Assets	5,727.9	6,401.9	7,851.1	8,761.1
Total Current Liabilities	1,843.9	2,144.0	2,602.5	3,177.3
Long-Term Debt	565.0	621.9	1,197.1	1,223.7
Other Liabilities	828.9	769.4	850.7	925.4
Total Liabilities	3,237.8	3,535.3	4,650.3	5,326.4
Common Stock	144.7	164.3	184.9	195.3
Other Equity	250.7	419.0	528.9	520.9
Retained Earnings	2,094.7	2,283.3	2,487.1	2,718.5
Total Shareholders' Equity	2,490.1	2,866.6	3,200.9	3,434.7
Total Liabilities and Shareholders' Equity	5,727.9	6,401.9	7,851.2	8,761.1
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

*In 1987, Matsushita changed its fiscal year-end from November to March 31. Fiscal 1987 represents only four months from November 1986 to March 31, 1987. Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd. Annual Reports
Dataquest (January 1992)

Table 6
Consolidated Income Statement
Fiscal Year Ending March 31
(Billions of Yen, except Per Share Data)

Income Statement	1988*	1989	1990	1991
Revenue	5,067.2	5,504.3	6,002.8	6,599.3
Cost of Sales	3,343.5	3,670.9	4,009.6	4,393.5
R&D Expense	279.2	319.1	345.7	383.9
SG&A Expense	1,363.8	1,416.2	1,540.5	1,733.2
Capital Expense	231.9	325.4	354.8	477.0
Pretax Income	453.2	529.4	571.7	597.4
Pretax Margin (%)	8.94	9.62	9.52	9.05
Effective Tax Rate (%)	55.50	54.20	52.60	51.10
Net Income	164.6	213.5	235.6	258.9
Shares Outstanding, Millions	1,861.8	1,955.6	2,080.2	2,093.4
Per Share Data				
Earnings	80.34	99.94	108.34	117.12
Dividend	9.52	11.90	10.00	12.50
Book Value	1.34	1.47	1.54	1.64
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

*In 1987, Matsushita changed its fiscal year-end from November to March 31. Fiscal 1987 represents only four months from November 1986 to March 31, 1987. Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd. Annual Reports
Dataquest (January 1992)

Table 7
Key Financial Ratios
Fiscal Year Ending March 31

Key Financial Ratios	1988*	1989	1990	1991
Liquidity				
Current (Times)	1.82	1.65	1.77	1.39
Fixed Assets/Equity (%)	230.03	223.33	245.28	255.08
Current Liabilities/Equity (%)	74.05	74.79	81.31	92.51
Total Liabilities/Equity (%)	130.03	123.33	145.28	155.08
Profitability (%)				
Return on Assets	2.87	3.33	3.00	2.96
Return on Equity	6.61	7.45	7.36	7.54
Profit Margin	3.25	3.88	3.92	3.92
Other Key Ratios				
R&D Spending % of Revenue	5.51	5.80	5.76	5.82
Capital Spending % of Revenue	4.58	5.91	5.91	7.23
Employees	134,186	193,088	198,299	210,848
Revenue (¥M)/Employee	37.76	28.51	30.27	31.30
Capital Spending % of Assets	4.05	5.08	4.52	5.44
Exchange Rate (U.S.$1=¥)	138.03	128.25	142.93	141.21

*In 1987, Matsushita changed its fiscal year-end from November to March 31. Fiscal 1987 represents only four months from November 1986 to March 31, 1987. Because of these changes, no information is included for 1987.

Source: Matsushita Electric Industrial Co. Ltd. Annual Reports
Dataquest (January 1992)

Siemens AG

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Federal Republic of Germany
Telephone: 011 49 89 234-0
Fax: 234-42 42
Dun's Number: 31-606-7164

Date Founded: 1847

CORPORATE STRATEGIC DIRECTION

Siemens AG provides a comprehensive range of products from electronic components to office and telecommunication systems, and from production equipment, power, and medical engineering to transportation systems and automotive electronics. Siemens has positioned itself as a global company with sales to its domestic German market accounting for 45 percent and sales to the rest of world accounting for 55 percent of total worldwide sales in fiscal 1990. Currently, Siemens' operations in the United States exceed 10 percent of total sales.

Siemens AG is one of the world's major electrical engineering and electronics companies with 1990 sales of DM 63.1 billion (U.S.$39.2 billion). (Percentage changes refer only to DM amounts; U.S.$ percentage changes will differ because of fluctuations in Dataquest exchange rates.) According to Dataquest, in 1990 semiconductor sales totaled DM 2.0 billion (U.S.$1.1 billion). This ranks Siemens as Europe's third-largest semiconductor company. Its data and information systems sales of DM 7.7 billion (U.S.$4.8 billion) rank the company as one of the world's largest information systems vendors. And with public and private telecommunication equipment sales of DM 13.8 billion (U.S.$8.6 billion), Siemens is one of the world's largest telecommunication vendors.

In April 1990, Siemens acquired a majority interest of common stock in Nixdorf Computer AG. On October 1, 1990, the Data and Information Systems Group was integrated into Nixdorf to form Siemens Nixdorf Informationssysteme AG (SNI). The integration of Siemens and Nixdorf represents a major expansion of the company. Although the company planned to increase business volume by nearly DM 6 billion (U.S.$3.7 billion), in April 1991, Siemens AG announced that Siemens Nixdorf Informationssysteme AG had a loss of DM 348 million (U.S.$216 million) worldwide.

In October 1990, the activities of Dr.-Ing Rudolf Hell GmbH were transferred to Linotype AG. Siemens, which was the parent company of Hell, holds a minority interest in the company, which has been renamed Linotype-Hell AG. The two companies together will have an estimated annual revenue of approximately DM 500 million (U.S.$310.4 million). This makes the company one of the largest electronic prepress companies in the industry.

In October 1990, Siemens acquired 49 percent interest in Mannesmann Tally GmbH, a computer printer manufacturer. This places Europe's printer industry in a very strong position. Mannesmann Tally was quick to maximize on the broadened range of products by introducing a new printer that was designed by Siemens AG.

In November 1990, Siemens acquired a 50 percent stake in Stromberg-Carlson Corporation, a U.S. telephone exchange business from GEC Plessey Telecommunications Ltd. (GPT). Siemens merged its Siemens Private Communication Systems Inc. with Stromberg-Carlson to create Siemens Stromberg-Carlson and became one of the largest U.S. public network equipment suppliers.

In addition, several structural changes took place within the company. The former Peripherals and Terminals Group was dissolved as of April 1, 1990; its fields of operation were assigned to units involved in related product lines.

Currently, Siemens AG has 13 business groups, 2 special divisions, and 1 legally independent unit. The 13 business groups include: Industrial and Building

Systems, Drives and Standard Products, Automation, Automotive Systems, Power Generation (KWU), Power Transmission and Distribution, Semiconductors, Medical Engineering, Public Communication Networks, Passive Components and Electron Tubes, Private Communication Systems, Defense Electronics, and Transportation Systems. The two special divisions are Audio and Video Systems and Electromechanical Components; the legally independent unit is Osram GmbH.

Siemens' strategy is to further enhance its position in Europe in all important sectors of electrical engineering and electronics while continuing to build a broad business base in the United States. Siemens' goal in the new German states is to achieve the same market position that it enjoys in the western part of the country. Over the next few years, Siemens plans to invest more than DM 1 billion in the new German states and to employ locally some 25,000 to 30,000 people in research and development, production, distribution, installation, and service. During 1990, Siemens employed 373,000 people worldwide, which is a 2 percent increase from 1989.

Siemens' sales by business segment, excluding intersegment sales, were as follows for fiscal 1990: Power Generation, 5.8 percent; Power Transmission and Distribution, 5.0 percent; Industrial and Building Systems, 7.6 percent; Drives and Standard Products, 6.3 percent; Automation, 5.5 percent; Data and Information Systems, 7.7 percent; Private Communication Systems, 4.8 percent; Defense Electronics, 1.1 percent; Transportation Systems, 1.2 percent; Automotive Systems, 1.8 percent; Medical Engineering, 6.6 percent; Public Communication Networks, 9.1 percent; Semiconductors, 2.0 percent; Passive Components and Electron Tubes, 1.7 percent; Electromechanical Components, 0.8 percent; Audio and Video Systems, 0.1 percent; Osram, 2.6 percent; Hell, 1.0 percent.

Total revenue increased by 20.7 percent to DM 63 billion (U.S.$39.2 billion) in fiscal 1990 from DM 61 billion (U.S.$32.5 billion) in fiscal 1989. Net income increased 23.5 percent to DM 1.7 billion (U.S.$1.1 billion) in fiscal 1990 from DM 1.5 billion (U.S.$931 million) in fiscal 1989.

Research and development expenditure totaled DM 7.0 billion (U.S.$4.3 billion) in fiscal 1990, representing 6.9 percent of revenue. Capital spending totaled DM 7.0 billion (U.S.$4.4 billion) in fiscal 1990, representing 7.0 percent of revenue. In fiscal 1990, approximately 43,000 employees worldwide were engaged in R&D activities. About 90 percent of the R&D work was carried out by the operating groups, while the remaining 10 percent was done by the Corporate Research and Development and the Corporate Production and Logistics Division.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information is not available on revenue by distribution channel. Tables 3 through 7 at the end of this backgrounder present comprehensive financial information. The financial information does not include Nixdorf Computer AG because its consolidation will not be completed until the 1990 to 1991 fiscal year.

BUSINESS SEGMENT STRATEGIC DIRECTION

Data and Information Systems

The activities of Data and Information Systems were transferred to Siemens Nixdorf Informationssysteme AG in October 1990. With a spectrum ranging from notebook PCs to advanced mainframes, from organizational solutions for offices and plants to networks for large companies with global operations, Siemens Nixdorf Informationssysteme AG is the largest European computer manufacturer.

The Data and Information Systems segment contributed significantly to Siemens' overall growth in 1990. New orders increased 15 percent to DM 7.5 billion (U.S.$4.7 billion) and sales increased 28 percent to DM 7.7 billion (U.S.$4.8 billion) from 1989. This growth was significantly higher than the industry average and increases were registered in both domestic and international markets. Siemens believes that a major share of this favorable business was attributable to BS2000-driven, general-purpose computers. For the third straight year, the MX300 and MX500 Sinix computer families led both German and European markets for multiuser computers using the UNIX operating system. The company's market position for special systems, such as point-of-sale terminals, also continued to grow.

Mainframes

The 7500 Series of general-purpose computers using the BS2000 operating system offers a broad spectrum ranging in performance from 1 to 100 mips, covering desktop units to large general-purpose computers. The BS2000, with its high degree of upward compatibility, is seen as a main foundation for development and has been merged with BASF's plug-compatible marketing arm to form Comparex. Siemens is attempting to gain more market share in the IBM mainframe market.

Midrange

Growth in the MX300 and MX500 Sinix computer families led both German and European markets for multiuser computers using UNIX operating systems. The MX300 and MX500 systems can connect up to 24 and 64 terminals, respectively. During 1990, the WX200 Sinix workstation was one of the new products introduced. Siemens supplied one of the largest suppliers of UNIX-based multiterminal systems in Europe.

Personal Computers

MS-DOS PC sales almost doubled during fiscal 1990. Growth was especially high in the high-performance category. This was, in part, the result of developing a highly regarded line of fully MS-DOS-compatible PC models. The two main lines are the PC D-2, which is based on the Intel 80286 processor, and the PC D-3, which is based on the 80386 processor.

Industry Standards

Siemens strongly supports European data processing standards and was a founding member of the X Open group of European Companies working on development of a common applications environment.

Peripherals and Terminals

Although the peripherals and terminals accounted for about one-fifth of the Peripherals and Terminals Group business in 1989, the activities were transferred to Data and Information Systems of Siemens Nixdorf Informationssysteme during 1990. The strongest growth was in personal computers, fax machines, office printers, and telephone terminals, especially digital feature phones.

Telecommunication

In the telecommunication business, Siemens has a global presence as a participant or leader in all of the crucial standards-making committees of the CCITT. It is strongly entrenched in Europe and has a solid reputation for well-engineered and well-manufactured products. It also has developed an expertise in ISDN. Siemens plans to install 200,000 lines in the former East Germany and to acquire a large share of this market.

In 1990, ROLM Systems, which develops and manufactures communications systems, was integrated into Siemens Private Communication Systems Inc. (SPCS). ROLM Company, however, is a joint venture that is equally owned by IBM Corporation and Siemens. It distributes the communications systems in the United States manufactured by ROLM Systems.

PBX

In October 1990, Siemens reorganized its PBX-related communications businesses in the United States. This created a new company called Siemens Private Communication Systems Inc. This new company includes ROLM Systems, Tel Plus Communications and Siemens' interest in ROLM Company, a 50-50 joint venture with IBM. ROLM is the third largest PBX supplier in the United States, with 14.0 percent market share, while Siemens ranks sixth with 3.9 percent. SPCS will include a PBX development division, a manufacturing plant, and the Gold Seal Dealer marketing and government sales units. Part of the new company will also include such support functions as financial controls, strategic planning, market research, and marketing communications. During 1990, the company's business in Spain and the Netherlands developed particularly well.

ISDN

This business is expected to grow because of the computer-aided telephony access to ISDN. Smaller systems and worldwide networking are examples of services that offer additional benefits. In an effort to avoid problems, including interoperability, that have stood in the way of the acceptance of ISDN, an agreement was made between AT&T, Northern Telecom, Inc., and Siemens Stromberg-Carlson to implement key ISDN standards. The companies hope that the service may be extended to millions of users by the end of 1992.

Digital Public Telephone Switching System

Siemens entered into alliances in eastern Germany with former state-owned businesses, including a

Leipzig plant that will manufacture public telephone switching systems (EWSD). The merger of Stromberg-Carlson with U.S.-based Siemens Communication Systems Inc. provided additional market share in the United States. During fiscal 1990, 107 telecommunication administrators worldwide ordered EWSD exchanges. A total of approximately 28 million lines were ordered or delivered, which is an increase of approximately 50 percent over fiscal 1989. In addition, the first contract for the installation of a digital telephone network was signed in the new German states.

Defense

In the defense sector, the acquisition of Plessey operations strengthened its competitive position. The integration of two British companies, Siemens Plessey Defence Systems Ltd. and Siemens Plessey Radar Ltd., provided Siemens with local production facilities in two of Europe's key regional markets—Great Britain and Germany.

Higher sales volumes were generated primarily by the Patriot air defense missile system. Siemens is the general contractor in charge of adapting Patriot for German defense requirements. Current political developments are expected to cause substantial changes in the structures of NATO and the German Federal Armed Forces and will, therefore, affect previously planned development and procurement projects.

Semiconductors

Siemens reached a technological level equal to that of its major competitors with the Mega Project, its megabit DRAM development project. Although shipments of 4Mb DRAMs doubled during 1990, revenue dropped because of falling prices. During fiscal 1990, the semiconductor business was marked by a dramatic fall in memory prices and fierce competition, precipitated by excess capacity on the world market and the declining exchange rates of the dollar and the yen.

In fiscal 1990, the Semiconductor group's new orders decreased 12 percent to DM 2.1 billion (U.S.$1.2 billion) and sales decreased 12 percent to DM 2.0 billion (U.S.$1.1 billion). Siemens attributes this drop in revenue to the dramatic fall in semiconductor prices, fierce competition, and the declining exchange rates of the dollar and the yen.

In addition, IBM and Siemens signed an agreement to manufacture 16Mb DRAM chips at IBM's facility in Corbeil-Essonnes, France. Production is to begin at the end of 1991, with output set for the second half of 1992.

Further Information

For further information about the company's business segments, please contact the appropriate Dataquest industry service.

Table 1
Five-Year Corporate Highlights (Millions of U.S. Dollars)

	1986	1987	1988	1989	1990
Five-Year Revenue	21,669.6	28,572.8	33,356.2	32,514.9	39,245.3
Percent Change	1.17	31.86	16.74	(2.52)	20.70
Capital Expenditure	3,155.8	2,951.7	2,927.0	4,187.4	4,388.8
Percent of Revenue	6.71	5.74	4.93	6.85	6.95
R&D Expenditure	2,488.9	3,450.6	3,640.4	3,656.9	4,335.4
Percent of Revenue	5.29	6.71	6.13	5.98	6.86
Number of Employees	359,000	359,000	353,000	365,000	373,000
Revenue ($K)/Employee	60.36	79.59	94.49	89.08	105.22
Net Income	679.3	708.3	781.5.1	838.8	1,036.0
Percent Change	30.71	4.28	10.32	7.34	23.51
Exchange Rate (U.S.$1=DM)	2.17	1.80	1.78	1.88	1.61

1990 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	NA	NA	NA	NA
Quarterly Profit	NA	NA	NA	NA

NA = Not available

Source: Siemens AG
Annual Reports
Dataquest (November 1991)

Table 2
Revenue by Geographic Region (Percent)

Region	1986	1987	1988	1989	1990
Germany	45	49	52	47	45
International	55	51	48	53	55

Source: Siemens AG
Annual Reports
Dataquest (November 1991)

1990 SALES OFFICE LOCATIONS

North America—70
Europe—88
Asia/Pacific—25
  Japan—2
ROW—60

MANUFACTURING LOCATIONS

Information is not available.

SUBSIDIARIES

North America

Nixdorf Computer Corporation
Siemens Automotive Ltd. (Canada)
Siemens Electric Ltd. (Canada)
Siemens Automotive L.P. (United States)
ROLM Systems (United States)
Siemens Private Communication Systems Inc. (United States)
Siemens Components Inc. (United States)
Siemens Energy & Automation Inc. (United States)
Siemens Information Systems (United States)
Siemens KWU Inc. (United States)
Siemens Medical Systems Inc. (United States)

Europe

ATEA N.V. (Belgium)
Dr.-Ing Rudolf Hell GmbH (Germany)
Duewag Aktiengesellschaft
Heimann GmbH (Germany)
Interatom GmbH (Germany)
Nixdorf AG (Switzerland)
Nixdorf Computer AG (Germany)
Nixdorf Computer France S.A. (France)
Nixdorf Computer Ges.m.b.H. (Austria)
Nixdorf Computer Ltd. (England)
Nixdorf Computer S.A (Spain)
Nixdorf Computer A.G. (Switzerland)
NRG Nuklearrohr-Gesellschaft GmbH (Germany)
Osram GmbH (Germany)
Ostram Ltd. (England)
Osram S.A. (France)
Osram S.A. (Spain)
Osram-GEC Ltd. (United Kingdom)
Osram Societa Ruinite Osram Edison-Clerici S.p.A. (Italy)
Rofin-Sinar Laser GmbH (Germany)
Siemens AB, Stockholm (Sweden)
Siemens A.E., Elektrotechnische Projekte und Erzeugnisse (Greece)
Siemens AG Osterreich (Austria)
Siemens-Albis AG (Switzerland)
Siemens A/S (Denmark)
Siemens A/S, Oslo (Norway)
Siemens Automotive S.A (France)
Siemens Beteiligungen AG (Switzerland)
Siemens-Elema AB (Sweden)
Siemens Finanzierungsgesellschaft furr Informationstechnik GmbH (Germany)
Siemens Ltd., Dublin (Ireland)
Siemens Ltd., London (United Kingdom)
Siemens Matsushita Components GmbH & Co. (Germany)
Siemens Miet- und Portfolio- GmbH & Co. OHG, (Germany)
Siemens Nederland N.V. (Netherlands)
Siemens Osakeyhtio (Finland)
Siemens plc (England)
Siemens Plessy Electronic Systems Ltd. (England)
Siemens S.A. (Belgium)
Siemens S.A. (France)
Siemens S.A., Lisbon (Portugal)
Siemens S.A., Madrid (Spain)
Siemens S.p.A. (Italy)
Siemens Telecomunicazioni S.p.A. (Italy)
Siemensstadt-Grundstucksverwaltung GmbH & Co. (Germany)
Sietec Siemens-Systemtechnik und Portfolio GmbH & Co. (Germany)
Simko Ticaret ve Sanayi (Turkey)
Turk Siemens Kablo ve Elektrik Sanayii A.S. (Turkey)
Vacuumschmelze GmbH (Germany)

Japan

Siemens K.K. (Japan)

ROW

Equitel S.A. (Argentina)
Osram Argentina S.A.C.I. (Argentina)
Osram do Brasil-Companhia de Lampadas Electricas S.A. (Brazil)

Osram S.A. de C.V. (Mexico)
Siemens Components (Pte.) Ltd. (Singapore)
Siemens Components Sdn. Bhd. (Malaysia)
Siemens Ltd. (Australia)
Siemens Ltd. (India)
Siemens Pakistan Engineering Co. Ltd. (Pakistan)
Siemens Ltd. (South Africa)
Siemens S.A. (Columbia)
Siemens S.A. (Venezuela)
Siemens S.A. de C.V. (Mexico)
Siemens S.A., Sao Paulo (Brazil)
Siemens S.A.I.C.F.I.yM. (Argentina)
Siemens Western Finance N.V. (Netherlands Antilles)
Taicom Systems Ltd. (Taipei)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Appian Technology

Appian Technology signed an agreement to supply Siemens with custom VGA graphics boards for a range of personal computers.

AT&T, Siemens Stromberg-Carlson, and Northern Telecom Inc.

An agreement was developed among AT&T, Siemens Stromberg-Carlson, and Northern Telecom Inc. These companies will begin to implement ISDN standards in order to extend the service to millions of users by 1992.

China Great Wall Industry

Siemens signed an agreement that allows two factories to build the Hicom 300 private branch exchange system. The agreement was signed with China Great Wall Industry and permits each of the factories to produce up to 100,000 subscriber lines per year within 4 years.

GPT Ltd.

GPT Ltd. and Siemens AG merged their British PABX distribution operations to create a joint venture. GPT Sales and Service and Siemens Communications Systems are being merged to form GPT Communications Systems. Siemens will have a 50 percent ownership.

Gandalf Technologies

Siemens and Gandalf Technologies have agreed to jointly market Gandalf's communications server and Siemen's PBX. Under the agreement, Gandalf's Starmaster server and Siemen's Hicom PBX will supply customers with ISDN-LAN connections.

IBM Corporation

IBM and Siemens signed a contract to build a factory that will manufacture 16Mb DRAM microprocessors at an estimated cost of $700 million. The facility is planned to be located in Corbeil-Essonnes. The agreement leaves room for additional partners providing the plant produces more microprocessors than the two companies need themselves. As part of the agreement Siemens will use the chips in specialized products, while IBM will use the chips in its own machines.

Matsushita Electric Industrial Company Ltd.

Matsushita and Siemens Nixdorf Informationssysteme AG signed an alliance to exchange personal computers in Europe. Siemens will sell Matsushita notebook computers under its own name, and Matsushita will sell Siemens machines under its Panasonic trade name in Europe. Under the agreement, the equipment will be jointly developed by both companies' R&D operations in their respective countries.

Motorola Incorporated

Motorola and Siemens agreed to jointly market equipment for contracts under a $30 billion European cellular network.

Nippon Telephone and Telegraph (NTT)

NTT selected Siemens to participate in the development of the Visual, Intelligent and Personal program. Fiber optic cables and the asynchronous transfer mode principle will be the technological basis of various services for speech, text, data, and pictures.

Storage Technology Corporation

Storage Technology and Siemens Nixdorf agreed to merge their nonimpact printer operations in the United States in a joint venture that became operational in January 1991. Siemens Nixdorf owns 51 percent, and Storage Technology owns 49 percent.

SynOptics Communications Inc.

Siemens signed a three-year OEM agreement with SynOptics Communications (Santa Clara, California) in which Siemens will market LAN products such as concentrators, ethernet, and token-ring connections in Europe.

1990

VEB Robotron

Siemens and VEB Robotron plan to enter into a joint venture. The software and computer systems company will be based in Dresden.

BB-Data Gesellschaft

Siemens and BB-Data Gesellschaft fuer Informations-und Kommunikationssysteme are to cooperate in marketing the BB-Data Domino CASE tool. The companies also will jointly market tools for Computer Reverse Engineering (CARE). Siemens will support BB-Data in the development of further Domino products.

Digital Equipment Corporation, Hewlett-Packard Company, IBM Corporation, Unisys Corporation

Siemens has established worldwide PBX and computer teaming alliances with Digital Equipment, Hewlett-Packard, IBM, and Unisys to provide voice/data solutions to end users.

SGS-Thompson

Siemens and SGS-Thompson agreed to cooperate in the field of high-performance microcontrollers. The objective is to provide a comprehensive and integrated common solution for high-end 8-bit and 16-bit MCU applications. Siemens and SGS-Thompson also entered into a cooperative agreement wherein both companies agreed to act as second sources for each other's high-performance microcontrollers in 8-bit and 16-bit applications.

Unitrode

Siemens and the Micro Networks Division of Unitrode entered into a licensing agreement. Under the agreement, Micro Networks will sell Siemens' high-speed flash A/D converters. The licensing agreement initially covers the purchase and repackaging of Siemens' 6-bit and 8-bit, 75-MHz to 300-MHz sampling A/Ds.

Chinon Industries Inc.

Siemens and Chinon Industries entered into an agreement to cooperate in the development, production, and marketing of peripherals for PCs and of communications devices. The companies also plan to cooperate in the development of facsimile machines and image scanners.

VEB Numerik Karl Mark, VEB Niles, WMV International Handelgesellschaft

Siemens, VEB Numerik Karl Mark, VEB Niles, and WMV International Handelgesellschaft will form a joint venture to produce electrical and electronic machine tool equipment.

Analogy Inc.

Siemens and Analogy entered into an OEM agreement. Under the terms of the agreement, Siemens will market and support Saber as an OEM product worldwide, integrated with its SIGRAPH-EL product line.

General Electric Aerospace, Thompson-CFS, Thorn EMI

Siemens, General Electric Aerospace, Thompson-CFS, and Thorn EMI signed a memorandum of understanding establishing a consortium known as Euro-Art. The consortium will develop an advanced ground-based weapons-locating radar for the armed forces of France, Germany, and the United Kingdom.

MAP Deutschland

Siemens and MAP Deutschland entered into a cross-licensing pact covering Siedcon connector and RV-100-4 transfer systems for the connectors. The products are produced by the Electromechanical Component Divisions of the respective companies with Siemens manufacturing the connectors and MAP producing the transfer system.

Rational

Siemens and Rational are to cooperate on the Ada programming language for computer-aided software engineering (CASE). The move is intended to help both companies expand in the CASE sector.

Corning

Siemens and Corning have agreed to jointly develop passive fiber-optic transmission components that will help bring optical communications technology to the home.

1988 to 1989

MIPS Corporation

Siemens bought MIPS' design for the newest 32-bit RISC microprocessor.

BASF (Comparex)

BASF agreed to manage Siemens' IBM-compatible, non-Fujitsu-based mainframes.

Iskra

The companies are manufacturing telecom equipment (EWSD).

ROLM Systems

Siemens acquired this telecom product marketing and servicing company.

Advanced Integrated Circuit Design Aids (AIDA)
AIDA is developing semiconductor technology.

AMD
The companies are developing a common chipsets for ISDN. AMD second sources Siemens' 80515 and 82258 DM A controllers.

JESSI
Siemens participates in JESSI to develop semiconductor technology with Philips and Thomson.

Megaproject
Siemens is developing DRAMs and SRAMs with Philips.

Open Software Foundation (OSF)
Siemens joined this UNIX development standards group.

Toshiba and General Electric
The companies are participating in the development of standard cell libraries.

Acer
The companies have an OEM agreement to resell the industrial PC 16-05.

Apollo
The companies have an OEM agreement covering the bottom end of midrange computers.

Fujitsu
The companies have an OEM agreement to resell the MX500 processor and VP Series of vector processors.

NEC
The companies have an OEM agreement to resell the NEAX2400 PBX.

Sequent
The companies have an OEM agreement to resell UNIX equipment and products.

Taylorix
Siemens manufactures PCs for resale.

Toshiba
Siemens is licensed to manufacture 1.2-micron CMOS 1Mb DRAMs.

Zenith
The companies have an OEM agreement to resell 80286-based laptops.

MERGERS AND ACQUISITIONS

1991

Anlagenbau Teltow
Siemens confirmed that it will buy Anlagenbau Teltow, the Berlin-based electrical components manufacturer.

Cardion Electronics Inc.
Siemens acquired Cardion Electronics Inc. from Ferranti International of England. The company manufactures and markets commercial and defense electronic navigation systems. The new name of the company is Cardion Inc.

EG&G Inc.
EG&G Inc. of Wellesley, Massachussetts, signed a letter of intent to acquire a majority interest in Heimann, subsidiary of Siemens AG. Heimann GmbH is a producer of optoelectronic devices based in Wiesbaden, Germany.

Ferranti Business Communications
Ferranti Business Communication was acquired by Siemens. Siemens will relocate the firm to its new site in Manchester.

GPT
Siemens Communications Systems and GPT Sales and Services, the largest UK telecommunications manufacturer, have agreed to merge their British distribution companies for computerized switchboards. Siemens and GEC will each indirectly own 17 percent of the venture directly with the remainder coming through its 40 percent stake of GPT. The venture will be financially consolidated into GPT, which will own 83 percent.

Relcon
Relcon, producer of electronic drive systems, has been acquired by ASI, a Siemens division that is involved in drive and switchboard technology. Via Relcon products, Siemens aims to increase it presence in the electronic drive systems markets in the United States and Mexico.

Texas Instruments Inc.
Texas Instruments Inc. signed a letter of intent to sell its Industrial Controls unit to Siemens Corp. Included in the sale are TI's products, facilities equipment, and sales/support activities.

1990

Dr.-Ing Rudolf Hell GmbH
Linotype AG acquired Dr.-Ing, parent company being Siemens. Siemens will be the largest shareholder, with 33 1/3 percent of the stock.

GPT Ltd.
GPT Ltd. and Siemens AG merged their U.S. operations. The new company is called Siemens Stromberg-Carlson. Siemens and GPT will each own 50 percent.

Mannesmann Tally GmbH
Siemens acquired Mannesmann, a computer printer manufacturer, and merged it into Siemens' Office Products Division. Mannesmann is now 51 percent owned by Mannesmann AG and 49 percent by Siemens AG.

Nixdorf Computer
Siemens AG acquired 78 percent of Nixdorf Computer. The new company, a majority-owned subsidiary of Siemens called Siemens-Nixdorf Informationssyteme AG, combines the Siemens data and information systems activities with those of Nixdorf.

1989

ROLM Company
Siemens acquired ROLM from IBM.

The Plessey Company
In partnership with Britain's General Electric Company (GEC), Siemens acquired The Plessey Company, an electronics firm based in Ilford, Essex, England.

1988

Allied Signal Inc.
Siemens AG acquired Bendix Electronics Group from Allied Signal Inc. to strengthen its position in the automotive electronics market.

KEY OFFICERS

Karlheinz Kaske, Dr.-Ing.
President and CEO

Karl-Hermann Baumann, Dr.rer.oec.
Executive vice president, Corporate Finance

Heinrich von Pierer, Dr. jur.
Vice chairman

Hermann Franz
Executive vice president, Corporate Planning and Development

Claus Kessler, Dr.-Ing
Executive vice president, Corporate Production and Logistics

Hans-Gerd Neglein
Executive vice president, regional administrator

Hans Baur, Dr.-Ing
Executive vice president

Klaus Barthelt, Dr.-Ing.E.h.
Executive vice president

Horst Langer, Dr.-Ing
Executive vice president

PRINCIPAL INVESTORS

Information is not available.

FOUNDERS

Information is not available.

Table 3
Balance Sheet
Fiscal Year Ending September 30
(Millions of U.S. Dollars)

Balance Sheet	1986	1987	1988	1989	1990
Cash*	0	0	0	0	00
Receivables	6,644.2	8,141.1	8,858.4	10,206.5	11,907.0
Marketable Securities	NA	NA	NA	10,364.5	9,743.1
Inventory	1,119.4	1,009.4	2,200.6	3,663.6	4,542.9
Other Current Assets	10,013.8	12,805.6	13,465.2	963.0	2,304.8
Total Current Assets	17,777.4	21,956.1	24,524.2	25,197.7	28,497.8
Net Property, Plants	5,701.4	7,467.2	7,653.4	7,394.3	8,978.9
Other Assets	741.5	1,067.8	1,315.2	1,661.4	2,554.3
Total Assets	24,220.3	30,491.1	33,492.7	34,253.3	40,031.1
Total Current Liabilities	1,914.9	1,958.9	2,193.5	2,248.3	2,520.6
Long-Term Debt	11,088.0	14,334.1	16,021.7	16,388.5	19,773.7
Other Liabilities	3,955.3	5,139.6	5,370.9	5,747.7	6,831.7
Total Liabilities	16,958.2	21,432.6	23,586.1	24,384.4	29,126.0
Converted Preferred Stock	21.3	25.7	26.0	24.6	28.7
Common Stock	1,085.5	1,324.4	1,349.0	1,299.8	1,591.4
Other Equity*	2,690.0	3,348.0	3,445.4	3,471.6	4,590.7
Retained Earnings	3,465.3	4,360.4	5,086.2	5,072.8	4,694.2
Total Shareholders' Equity	7,262.0	9,058.5	9,906.6	9,868.9	10,905.1
Total Liabilities and Shareholders' Equity	24,220.3	30,491.1	33,492.7	34,253.3	40,031.1
Exchange Rate (U.S.$1=DM)	2.17	1.80	1.78	1.88	1.61

*Other capital is paid-in capital.
NA = Not available

Source: Siemens AG
Annual Reports and Forms 10-K
Dataquest (November 1991)

Table 4
Consolidated Income Statement
Fiscal Year Ending September 30
(Millions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1986	1987	1988	1989	1990
Revenue	21,669.6	28,572.8	33,356.2	32,514.9	39,245.3
Domestic	10,184.3	13,896.1	17,278.1	15,132.4	17,609.9
International	11,485.3	14,676.7	16,111.8	17,382.4	21,635.4
Cost of Sales	25,508.3	20,478.9	23,552.8	13,409.6	16,618.0
R&D Expense	2,488.9	3,450.6	3,640.4	3,656.9	4,335.4
SG&A Expense	9,807.1	12,715.5	13,397.3	13,778.8	16,762.8
Capital Expense	3,155.8	2,951.7	2,927.0	4,187.4	4,388.8
Pretax Income	1,245.6	1,443.3	1,390.4	1,482.8	1,753.5
Pretax Margin (%)	5.75	5.05	4.17	4.56	4.47
Effective Tax Rate (%)	46.00	50.00	44.00	43.00	43.00
Net Income	679.3	708.3	718.5	838.8	1,036.0
Shares Outstanding, Millions	48.0	48.6	48.9	49.8	52.2
Per Share Data					
Earnings	14.01	13.94	15.11	15.74	18.45
Dividend	5.53	6.11	6.18	6.65	8.07
Book Value	143.59	177.56	193.48	190.74	199.94
Exchange Rate (U.S.$1=DM)	2.17	1.80	1.78	1.88	1.61

Source: Siemens AG
Annual Reports and Forms 10-K
Dataquest (November 1991)

Table 5
Balance Sheet
Fiscal Year Ending September 30
(Millions of Deutsche Marks)

Balance Sheet	1986	1987	1988	1989	1990
Cash*	0	0	0	0	0
Receivables	14,418.0	14,654.0	15,768.0	19,188.2	19,170.3
Marketable Securities	0	0	0	19,485.3	15,686.4
Inventory	2,429.0	1,817.0	3,917.0	6,887.6	7,314.1
Other Current Assets	21,730.0	23,050.0	23,968.0	1,810.5	3,710.7
Total Current Assets	38,577.0	23,050.0	43,653.0	47,371.6	45,881.5
Net Property, Plants	12,372.0	39,521.0	13,623.0	13,901.2	14,456.1
Other Assets	1,609.0	1,922.0	2,341.0	3,123.4	4,112.4
Total Assets	52,558.0	54,884.0	59,617.0	64,396.2	64,450.0
Total Current Liabilities	4,155.4	3,526.1	3,904.5	4,226.8	4,058.1
Long-Term Debt	24,060.9	25,801.3	28,518.6	30,810.3	31,835.7
Other Liabilities	8,583.0	9,251.3	9,560.2	10,805.6	10,999.0
Total Liabilities	36,799.4	38,578.7	41,983.3	45,842.7	46,892.8
Converted Preferred Stock	46.2	46.2	46.2	46.2	46.2
Common Stock	2,355.5	2,383.9	2,401.2	2,443.7	2,562.2
Other Equity*	5,837.3	6,026.4	6,132.9	6,526.7	7,391.1
Retained Earnings	7,519.6	7,848.8	9,053.4	9,536.9	7,557.7
Total Shareholders' Equity	15,758.6	16,305.3	17,633.7	18,553.5	17,557.2
Total Liabilities and Shareholders' Equity	52,558.0	54,884.0	59,617.0	64,396.2	64,450.0
Exchange Rate (U.S.$1=DM)	2.17	1.80	1.78	1.88	1.61

*Other capital is paid-in capital.

Source: Siemens AG
Annual Reports and Forms 10-K
Dataquest (November 1991)

Table 6
Consolidated Income Statement
Fiscal Year Ending September 30
(Millions of Deutsche Marks, except Per Share Data)

Consolidated Income Statement	1986	1987	1988	1989	1990
Revenue	47,023.0	51,431.0	59,374.0	61,128.0	63,185.0
Domestic	22,100.0	25,013.0	30,755.0	28,449.0	28,352.0
International	24,923.0	26,418.0	28,679.0	32,679.0	34,833.0
Cost of Sales	55,353.0	36,862.0	41,924.0	25,210.8	26,754.9
R&D Expense	5,401.0	6,211.0	6,480.0	6,875.0	6,980.0
SG&A Expense	21,281.3	22,887.9	23,847.2	25,904.2	26,988.1
Capital Expense	6,848.0	5,313.0	5,210.0	7,872.4	7,066.0
Pretax Income	2,703.0	2,598.0	2,475.0	2,787.6	2,823.1
Pretax Margin (%)	5.7	5.1	4.2	4.6	4.5
Effective Tax Rate (%)	46.00	50.00	44.00	43.00	0
Net Income	1,474.0	1,275.0	1,391.0	1,577.0	1,668.0
Shares Outstanding, Millions	48.0	48.6	48.9	49.8	52.2
Per Share Data					
Earnings	30.40	25.10	26.90	29.60	29.70
Dividend	12.00	11.00	11.00	12.50	13.00
Book Value	311.60	319.60	344.40	358.60	321.90
Exchange Rate (U.S.$1=DM)	2.17	1.8	1.78	1.88	1.61

Source: Siemens AG
Annual Reports and Forms 10-K
Dataquest (November 1991)

Table 7
Key Financial Ratios
Fiscal Year Ending September 30

Key Financial Ratios	1986	1987	1988	1989	1990
Liquidity					
Current (Times)	9.28	11.21	11.18	11.21	11.31
Total Assets/Equity (%)	333.52	336.60	338.09	347.08	367.09
Current Liabilities/Equity (%)	26.37	21.63	22.14	22.78	23.11
Total Liabilities/Equity (%)	233.52	236.60	238.09	247.78	26.09
Profitability (%)					
Return on Assets	0.06	0.04	0.04	0.05	0.04
Return on Equity	0.09	0.08	0.08	0.08	0.10
Profit Margin	3.13	2.48	2.34	2.58	2.64
Other Key Ratios					
R&D Spending % of Revenue	11.49	12.08	10.91	11.25	11.05
Capital Spending % of Revenue	14.56	10.33	8.77	12.88	11.18
Employees	359,000	359,000	353,000	365,000	373,000
Revenue (DM K)/Employee	130.98	143.26	168.20	167.47	169.40
Capital Spending % of Assets	28.27	17.42	15.56	22.98	17.65
Exchange Rate (U.S.$1=DM)		2.17	1.8	1.78	1.88

Source: Siemens AG
Annual Reports and Forms 10-K
Dataquest (November 1991)

Sony Corporation

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Shinagawa-ku
Tokyo 141, Japan
Telephone: (03) 448-2111
Fax: (03) 448-2244
Dun's Number: 04-065-3636

Date Founded: 1946

CORPORATE STRATEGIC DIRECTION

Sony Corporation, founded in Tokyo in 1946, is one of the world's leading manufacturers of video and audio equipment, televisions, displays, semiconductors, computers, computer peripherals, factory automation equipment, and engineering workstations.

Sony's business philosophy is to provide innovative and attractive products to its customers worldwide. Sony is one of Japan's leaders in global marketing; it had ¥3.6 trillion (U.S.$25.6 billion) in revenue for the fiscal year ended March 31, 1991. Because of its strong international customer base, the company is especially susceptible to fluctuations in international trade markets. The Gulf War, which occurred during fiscal 1991, had severe repercussions in the world economy and directly affected Sony's performance. The United States entered a recession in the second half of the year, the European economy evidenced sluggish performance, and the Japanese economy faced higher interest rates. Even with this difficult environment, Sony attained the highest sales and profit figures in the company's history. Sony points to strong growth in its electronics and entertainment industries as the key factors in its growth.

Sony's long-term strategy to improve product performance and meet customer expectations includes the following policies:

- In consumer electronics, Sony will strive to accelerate the development and marketing of attractive and original products. Expansion will occur in such areas as high-definition television (HDTV) products and information-related equipment for the home.
- In industrial electronics, Sony will seek to strengthen its operations in broadcast- and professional-use videocassette recorders and players (VTRs) and displays while addressing a varied spectrum of market needs. Other areas of targeted growth include recording media, semiconductors, electronic components, computer systems, information processing, and telecommunications.
- Sony will intensify its activities in the entertainment field by strengthening its music and image-based software operations, and by creating synergy with its electronics business. Efforts will be centered on Sony Music Entertainment Inc. (known before January 1, 1991, as CBS Records Inc.) and Columbia Pictures Entertainment Inc.
- Sony has committed to a companywide efficiency upgrade in all areas of business, as well as to the promotion of more efficient allocation of the company's capital, personnel, and management resources.
- Sony will seek to bring all facets of its overseas operations, including procurement of components, R&D, production, and marketing, in closer contact with local communities.

Sony's ¥3.6 trillion (U.S.$25.6 billion) total revenue for the year ended March 31, 1991, represents an increase of 27.11 percent over the year ended March 31, 1990. The increase in sales was led by a 178.4 percent increase in filmed entertainment revenue. Television sales increased 33.2 percent, video equipment sales grew 23.7 percent, and audio equipment sales increased 23.5 percent. Growth of 30.6 percent in the other products group can be attributed to the strong growth of information-related equipment. (Percentage changes refer to U.S. dollar amounts.)

Sony is an international company with 26.3 percent of its sales occurring in Japan, 29.2 percent in the United States, 28.1 in Europe, and 16.4 percent in all other regions. Europe posted the highest growth rate, increasing sales 43.9 percent, while the United States grew 24.4 percent and other international markets grew 37.3 percent. The Japanese market grew at a significantly lower rate of 10.9 percent.

Net income increased 13.7 percent to ¥116.9 billion (U.S.$829.3 million) in fiscal year 1991 from ¥102.8 billion (U.S.$654.8 million) for fiscal 1990. Sony employed approximately 112,900 people in 1990, an increase of 18.1 percent over the 1990 year-end total of 95,600 employees.

R&D expenditure increased 24.6 percent to ¥205.8 billion (U.S.$1.2 billion) for the year ended March 31, 1991, from ¥165.2 billion (U.S.$1.2 billion) in the year ended March 31, 1990. R&D represented 5.7 percent of revenue for the year ended March 31, 1991. Capital expenditure for the year ended March 31, 1991, increased 27.1 percent from the previous year's ¥323.8 billion (U.S.$2.3 billion) to ¥411.7 billion (U.S.$2.9 billion), representing 11.4 percent of total revenue. The increased expenditure primarily was used for expanding production facilities for semiconductors; image-based devices such as color picture tubes; magnetic products; and audio and video equipment. About 35 percent of the capital development expenses were appropriated for overseas facilities. Sony intends to maintain a high level of capital investment and expects next year's expenditure to exceed this year's figure.

Sony's policy is to base its manufacturing operations in markets where its products are sold. By doing this, Sony brings its products closer to customers and avoids trade problems and exchange rate variations. Accordingly, Sony maintains its principal manufacturing facilities in Japan, the United States, and Europe.

In January 1991, Sony Music Entertainment Inc. (SMEI) and a subsidiary of Time-Warner Inc. formed The Columbia House Company, a 50:50 partnership consisting of the former Columbia House Division of SMEI. Columbia House is a direct marketer of music and home video products in the United States and Canada.

In November 1989, Sony purchased Columbia Pictures Entertainment, adding image-based software to its software business. This purchase emphasized strengthening of the company's software operations primarily through the record and video business.

On January 5, 1988, Sony purchased CBS Records Inc. and now holds 100 percent of the shares. The U.S.$2 billion (¥256.5 billion) acquisition was based on Sony's belief in the important relationship between the software and hardware sides of the consumer electronics business.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7 at the end of this backgrounder present comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Lines of Business

Video Equipment

The video equipment product group revenue totaled ¥908 billion (U.S.$6.4 billion) for the year ended March 31, 1991, or 25.1 percent of sales. Products include VTRs, video cameras, camcorder systems, videotapes, optical videodisk players, and high-definition video systems.

Audio Equipment

The audio equipment product group revenue totaled ¥883 billion (U.S.$6.2 billion) for the year ended March 31, 1991, or 24.4 percent of total sales. Products include tape recorders, audiotapes, cassette players, car stereos, amplifiers, tuners, turntables, speaker systems, CD players, digital audiotape (DAT) recorders, headphones, microphones, and compact discs.

Music Entertainment

Sony's music entertainment business reported revenue of ¥474 billion (U.S.$3.4 billion) for the year ended March 31, 1991, or 13.1 percent of total revenue. Performers on the Sony label include Mariah Carey, New Kids on the Block, George Michael, Billy Joel, Michael Bolton, Gloria Estefan, the Vaughan Brothers, and Harry Connick, Jr.

TV Equipment

Sony's television product group reported revenue of ¥553.4 billion (U.S.$3.9 billion) for the year ended March 31, 1991, or 15.3 percent of total revenue. Key products include color TVs and monitors, projection TVs, JumboTRON, direct broadcasting satellite reception systems, and security systems.

Filmed Entertainment

Sony's filmed entertainment reported revenue of ¥257 billion (U.S.$1.8 billion), or 7.1 percent of sales for the year ended March 31, 1991. Fiscal 1991 film releases included *Total Recall, Look Who's Talking Too, Misery, Awakenings, Postcards from the Edge,* and *Flatliners.*

Other Products

The groups producing other products reported revenue of ¥543 billion (U.S.$3.8 billion) for the year ended March 31, 1991. Key products include the 3.5-inch microfloppy disk systems, microcomputers, workstations, CD-ROM systems, information processing systems, semiconductor devices, electronic components, dictating machines, word processors, induction cooking ranges, telephones, telecommunications systems, factory automation systems, batteries, accessories, and audio and video software.

Company Positioning

Computer Storage

Sony was one of the leading flexible disk drive (FDD) vendors in 1990. Dataquest estimates that Sony maintained its market leadership in the worldwide 3.5-inch FDD market with a 25 percent market share and $226.5 million in factory revenue. We estimate that Sony shipped 5 million 3.5-inch disk drives in 1989. In the worldwide overall FDD (3.5-inch and 5.25-inch) market, Sony dropped from third in 1989 to fourth in 1990, with a market share of 13.6 percent. Sony continues to emphasize the 3.5-inch market, beginning production of 3.5-inch drives in Malaysia in May 1990.

According to Dataquest estimates, Sony ranked first in the optical disk drive market in 1990 with $125.6 million in factory revenue and a 36.2 percent market share. Sony dominates the rewritable market in optical disk drives with 49.0 percent of the market, 39,200 units shipped, and $49 million in factory revenue. Sony also moved up to second in the 12-inch write-once, read-many (WORM) drive market with a 29.9 percent market share and $19.4 million in factory revenue.

Sony has entered the 3.5-inch rigid disk drive market. Dataquest expects Sony to offer a broad range of rigid drives with capacities between 40MB and 200MB and access times of less than 20ms.

Workstations

Sony Microsystems was formed in February 1988 to market Sony's NEWS workstation, a 32-bit UNIX workstation designed primarily for software development applications. Dataquest estimates that Sony had 6.6 percent of the worldwide workstation market share for calendar 1989. Dataquest estimates that Sony ranked fourth in the entry-level workstation market with U.S.$137.2 million in factory revenue for 1989. Dataquest also estimates that Sony ranked third in the Japanese workstation market, with a 9.8 percent market share and $133.7 million in factory revenue.

In May 1990, Sony introduced its laptop NEWS workstation to the European market and later to the Japanese market. Sony had two major design goals for its new workstation, as follows:

- The same level of performance and functionality as the NEWS desktop workstation
- Compatibility with NEWS software and hardware products

The laptop workstation is priced between $10,000 and $15,000 and is targeted toward the technical user with a requirement for a transportable, fully functional technical workstation.

In 1989, Sony introduced a RISC-based workstation using MIPS R3000 processors. Sony expanded its NEWS line to include lower-priced models, and high-performance 32-bit CPU versions. Sony added desktop publishing software to the NEWS line of workstations.

Personal Computers

In July 1991, Sony released a new PalmTop series of personal computers, featuring the ability to input characters with a light pen. The PTC-300, weighing in at 355g, offers significant improvements in portability. Sony does not market its computers in the United States and held less than 1 percent of the worldwide PC market, according to Dataquest estimates.

Semiconductors

Sony began marketing semiconductors in 1984 and currently produces a range of devices, including static random-access memory (SRAM) chips, charge-coupled devices (CCDs), and bipolar ICs for consumer audiovisual equipment. In capital expansion, Sony completed a new wing at Sony Nagasaki Corporation with a clean room for the manufacture of

SRAMs and other leading-edge semiconductor devices and a design center for large-scale integration (LSI) technologies. In addition, Sony began operations at its first overseas semiconductor manufacturing facility, Sony Semiconductor (Thailand) Company Ltd., which will center on the assembly of bipolar ICs.

In the area of research and development, Sony announced in October 1990 the successful development of the world's fastest large-scale gallium arsenide gate array. The device will be used in workstations, image-processing equipment, and other equipment requiring high-speed data processing capabilities.

Dataquest estimates that Sony's 1990 worldwide semiconductor market share was 1.9 percent, with U.S.$1.1 billion in revenue. Dataquest estimates that Sony ranks 19th in the total worldwide semiconductor market, while in Japan, Sony ranked 9th for the third year in a row, with a 4.0 percent market share. Japan represented 77.7 percent of Sony's semiconductor revenue for 1990.

Computer Software

Sony Computer Science Laboratory Inc. was established by Sony Corporation to develop distributed operating systems, programming languages, system architectures, and user interfaces.

Further Information

For further information about the company's business segments, please contact the appropriate Dataquest industry services.

Table 1
Five-Year Corporate Highlights (Billions of U.S. Dollars)

	1987	1988	1989	1990	1991
Five-Year Revenue	3.4	10.4	16.7	20.1	25.6
Percent Change	-42.67	202.02	41.94	20.84	27.11
Capital Expenditure	0.6	1.0	1.7	2.3	2.9
Percent of Revenue	18.55	9.33	10.05	11.25	11.38
R&D Expenditure	0.8	0.9	1.1	1.2	1.5
Percent of Revenue	9.27	8.91	6.62	5.74	5.69
Number of Employees	47,583	71,000	78,900	95,600	112,900
Revenue (U.S.$K)/Employee	72.15	146.04	212.01	210.76	226.84
Net Income	0.1	0.3	0.6	0.7	0.8
Percent Change	-55.98	218.98	112.61	27.23	15.10
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

1991 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	5.41	6.23	7.84	6.34
Quarterly Profit	0.16	0.19	0.39	0.11

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Table 2
Revenue by Geographic Region (Percent)

Region	1987	1988	1989	1990	1991
United States	27	28	27	30	29
Japan	35	35	34	30	26
Europe	24	23	23	25	28
All Other Regions	14	14	16	15	17

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

1990 SALES OFFICE LOCATIONS (Includes sales subsidiaries only)

Asia/Pacific—19
International—14

MANUFACTURING LOCATIONS

North America

Digital Audio Disc (United States)
CDs
Sony Engineering and Manufacturing of America (United States)
TVs, CRTs, 32-bit workstations, 3.5-inch FDDs, CD-ROM drives, monitors, audio speakers, factory automation equipment
Sony Magnetic Products Inc. (United States)
Magnetic tapes, flexible disks
Sony Microelectronics Corporation (United States)
Semiconductors
Sony Music Entertainment (United States)
Phonograph records, tapes, CDs
Sony Professional Products Company (United States)
Professional AV equipment
Sony USA (United States)
Electronic equipment

Europe

DADC Austria (Austria)
CDs
Sony (United Kingdom)
TVs, CRTs
Sony Espana (Spain)
TVs, VCRs
Sony France (France)
CD players, video cameras, VHS video decks
Sony-Wega Productions (United Kingdom)
TVs
Television Division Europe (France)
Development, design of TVs

Asia/Pacific

Aiwa Company (Japan)
High-fidelity audio systems, headphone stereos
Hagiwara Electronics (Japan)
TV/video equipment
Mac Precision Products (Japan)
Precision parts
Miyagi Video-Tech (Japan)
Magnetic tapes
Motomiya Denshi (Japan)
Trinitron gun, security systems, flat display tubes, TV parts
Nakada Magnetics (Japan)
Ferrites
Sony Akebono Denshi (Japan)
Printed circuit boards
Sony Audio (Japan)
Audio, video, camera, and optical systems
Sony Bonson (Japan)
Tape recorders, flat TVs, radios
Sony Chemicals (Japan)
Magnetic tapes, chemical products
Sony Computer Science Lab (Japan)
R&D of computer systems/software
Sony Denshi (Japan)
TVs and parts
Sony Electronics (Japan)
Radiocassette tape recorders
Sony Ichinomiya (Japan)
VCRs, color TVs
Sony Inazawa (Japan)
Color CRTs
Sony Itakura (Japan)
CD players, radiocassette recorders
Sony Kisarazu (Japan)
VCRs, CD players
Sony Kohda (Japan)
Video equipment
Sony Kokubu Semiconductor (Japan)
Bipolar ICs, CCDs
Sony Magnescale (Japan)
Electronic measuring instruments
Sony Magnetic Products (Japan)
Magnetic tapes, ferrites, videotapes
Sony Minokama (Japan)
Video equipment
Sony Mizunami (Japan)
Color CRTs
Sony Nagasaki (Japan)
Semiconductors
Sony Oita (Japan)
Semiconductors
Sony Precision Engineering (Japan)
Precision parts for audio equipment for Sony's subsidiaries worldwide
Sony Semiconductor (Japan)
Bipolar ICs

Sony Shiroishi Semiconductor (Japan)
Semiconductors
Sony Sound Tec (Japan)
Microphones, PA systems, furniture, hearing aids
Sony TV-Video (Japan)
Color TVs
Sony Tektronix (Japan)
Electronic measurements, displays, control instruments, computer graphics products
Sony Video Taiwan (Taiwan)
VCRs
Sound Magnetics (Japan)
Magnetic heads
Sound System (Japan)
VCRs, CD players
Taron Corporation (Japan)
Audio and video products
Tohkai Electronics (Japan)
PC boards
Toyo Radio (Japan)
Audio products
Video Magnetics (Japan)
Ferrites

ROW

Magneticos de Mexico (Mexico)
Magnetic tapes, floppy disks
Sony da Amazonia (Brazil)
VCRs
Sony de Venezuela (Venezuela)
Color TVs
Sony Videobras (Brazil)
Video cameras, video equipment
Videotec de Mexico (Mexico)
Video equipment

SUBSIDIARIES

As of March 31, 1991, Sony had 625 consolidated subsidiaries. The list below gives the company's principal subsidiaries and affiliated companies as of April 30, 1991.

North America

Digital Audio Disc Corporation (United States)
Materials Research Corporation (United States)
Sony Corporation of America (United States)
Sony Music Entertainment Inc. (United States)
Sony of Canada Ltd. (Canada)
Sony Pictures Entertainment (United States)
Sony Trans Com Systems Division (United States)
Sony USA Inc. (United States)

Europe

DADC Austria GesmbH (Austria)
Sony Belgium N.V. (Belgium)
Sony Broadcast & Communications Limited (United Kingdom)
Sony Communication Products B.V. (Netherlands)
Sony Deutschland GmbH (Germany)
Sony Espana S.A. (Spain)
Sony Euro-Finance B.V. (Netherlands)
Sony Europa GmbH (Germany)
Sony France S.A. (France)
Sony GesmbH (Austria)
Sony Italia S.p.A. (Italy)
Sony Nederland B.V. (Netherlands)
Sony Overseas S.A. (Switzerland)
Sony Portugal Lda. (Portugal)
Sony Scandinavia A/S (Denmark)
Sony (Schweiz) A.G. (Switzerland)
Sony Service Centre (Europe) N.V. (Belgium)
Sony (U.K.) Limited (United Kingdom)
Sony-Wega Productions GmbH (Germany)

Asia/Pacific

Aiwa Co. Ltd. (Japan)
Akebono Electronics Inc. (Japan)
CBS/Sony Group Inc. (Japan)
Hasso Electronics Corporation (Japan)
Korea Toyo Radio Co. Ltd. (South Korea)
Max Precision Products Corporation (Japan)
Motomiya Denshi Corporation (Japan)
Sony (Australia) Pty. Limited (Australia)
Sony Asco Inc. (Japan)
Sony Bonson Corporation (Japan)
Sony Broadcast Products Corporation (Japan)
Sony Chemicals Corporation (Japan)
Sony Corporation of Hong Kong Limited (Hong Kong)
Sony Creative Products Inc. (Japan)
Sony Denshi Corporation (Japan)
Sony Electronics (Malaysia) Sdn. Bhd. (Malaysia)
Sony Energytec Inc. (Japan)
Sony Engineering Corporation (Japan)
Sony Enterprise Co. Ltd. (Japan)
Sony Finance International Inc. (Japan)
Sony Ichinomiya Corporation (Japan)
Sony Inazawa Corporation (Japan)
Sony International (Singapore) Pte. Ltd. (Singapore)

Sony Kisarazu Corporation (Japan)
Sony Kohda Corporation (Japan)
Sony Kokubu Semiconductor Corporation (Japan)
Sony Logistics (Singapore) Pte. Ltd. (Singapore)
Sony Logistics Corporation (Japan)
Sony Magnescale Inc. (Japan)
Sony Magnetic Products Inc. (Japan)
Sony Magnetic Products (Thailand)
Sony Magnetic Tape Sales Corporation (Japan)
Sony Minokamo Corporation (Japan)
Sony Mizunami Corporation (Japan)
Sony Nagasaki Corporation (Japan)
Sony Oita Corporation (Japan)
Sony PCL Inc. (Japan)
Sony Plaza Co. Ltd. (Japan)
Sony Precision Engineering Center (Singapore) Pte. Ltd. (Singapore)
Sony Procurement Service Corporation (Japan)
Sony Pruco Life Insurance Co. Ltd. (Japan)
Sony Service Co. Ltd. (Japan)
Sony Shiroishi Semiconductor Inc. (Japan)
Sony Shoji Corporation (Japan)
Sony Singapore Pte. Ltd. (Singapore)
Sony Sound Tec Corporation (Japan)
Sony TV Video (Malaysia) Sdn. Bhd. (Malaysia)
Sony Trading Corporation (Japan)
Sony Tsukuba Corporation (Japan)
Sony Video Taiwan Co. Ltd. (Taiwan)
Sony/Tektronix Corporation (Japan)
Sound System Corporation (Japan)
Taron Corporation (Japan)
Tohkai Electronics Corporation (Japan)

ROW

Magneticos de Mexico, S.A. de C.V. (Mexico)
Sony CSA, S.A. (Panama)
Sony Chile Ltda. (Chile)
Sony Corporation of Panama S.A. (Panama)
Sony da Amazonia Ltda. (Brazil)
Sony de Venezuela S.A. (Venezuela)
Sony Saudi Arabian Company Ltd. (Saudi Arabia)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Advanced Micro Devices Inc. (AMD)
Sony and AMD signed a broad patent and copyright cross-licensing agreement covering wafer processes, design, and architectures for integrated circuits.

Apple Computer Inc.
Sony will manufacture major portions of the laptop Macintosh computer under development by Apple.

Bell Microproducts Inc.
Bell added Sony's read-write optical drives to its current franchise list.

Digital Equipment Corporation
Digital and Sony entered an agreement through which Digital will produce optical subsystems based on Sony optical disk drives.

Matsushita Electric Industrial
Matsushita Electric Industrial and seven other companies (Kyushu Matsushita Electric, Sega Enterprises, Chinon Industries, Casio Computer, Ricoh, Canon, and Sanyo Electric) will make CD-ROMs based on Sony specifications.

Nihon Silicon Graphics K.K. (NSG)
Sony and NSG signed a marketing agreement in which Sony will market a high-definition computer graphics system for NSG's Iris 4-D Power Vision graphics workstation.

Ricoh Company
Ricoh will provide its Design Base Jr. three-dimensional model-generation software package to Sony to be bundled with Sony's new NWB-236 processor.

SGS-Thomson Microelectronics
SGS-Thomson Microelectronics will second-source a chip set for high-speed serial digital video transmission developed by Sony.

Software Toolworks
Sony and Software Toolworks signed a licensing agreement allowing Sony to use special versions of Software Toolworks' CD-ROM software with Sony's CD-ROM optical disk player.

VideoLogic Inc.
Sony signed an agreement with VideoLogic allowing Sony to sell multimedia products through computer resellers and video dealers.

Wave Front Technologies
Wave Front will supply Sony with its TPV computer graphics software, to be bundled with Sony's latest three-dimensional computer graphics board, the NWB-256.

1990

Exabyte Corporation
Exabyte renewed a supply agreement with Sony under which Sony will supply Exabyte with 5.25-inch form factor tape drives.

Compression Labs Inc.
Sony entered into a reseller agreement with Compression Labs under which Sony will resell Compression Labs video coder/decoders. The agreement marks Sony's entry into the U.S. videoconferencing market.

Texas Instruments
Texas Instruments agreed to produce semiconductors in Europe for Sony on a consignment basis.

NJK Ltd.
NJK Ltd. signed as a distributor for Sony's NEWS workstations.

Fujitsu
Sony and Fujitsu jointly developed a trial common rule to develop CD-ROM XA software for their personal computers.

Oracle Corporation
Oracle agreed to supply the Oracle relational database management systems and applications development software products for the Sony NEWS family of UNIX workstations.

Novell K.K.
Novell K.K. was formed as a joint marketing venture to sell NetWare products in Japan. Novell and six partners—Canon, Fujitsu, NEC, Softbank, Sony, and Toshiba—helped fund the project.

Advanced Micro Devices (AMD)
AMD agreed to enter a joint manufacturing and educational pact with Sony to manufacture SRAMs.

Summus Computer Systems
Summus agreed to sell, distribute, and service 4mm DAT drives from Sony. Summus agreed to be an original equipment manufacturer (OEM) of Sony and to integrate hardware and software that offers turnkey storage subsystems for the Apple Macintosh, Digital, and Sun Microsystems Inc. PC markets.

1989

Parallex Graphics Inc.
Sony Microsystems agreed to incorporate Parallex's color graphics and video graphics controllers in Sony's workstations.

Matsushita Philips
Sony, Matsushita, and Philips agreed to develop, manufacture, and market interactive compact disk drives.

Apple Computer Inc.
Sony signed a contract with Apple to supply 40MB rigid disk drives for the Macintosh.

Hewlett-Packard Company (HP)
Sony agreed to supply 5.25-inch rewritable optical disk storage products to HP for the new HP C17QA Optical Disk Library System.

Pinnacle Micro
Sony announced plans to supply $1 million (¥128.3 million) worth of 5.25-inch rewritable optical disk storage products to Pinnacle Micro.

Advanced Micro Devices (AMD)
Sony and AMD entered a joint venture agreement for an SRAM memory product.

1988

Daewoo Electronics
Sony and Daewoo agreed to jointly develop 256K SRAMs, 64K SRAMs, 8- and 16-bit MPUs, and other microchips.

Engineering Mechanics Research (EMR)
Sony and EMR agreed to a joint venture in CAE software technology and sales. EMR is marketing Sony's engineering workstations (EWSs) that employ its software in the United States while Sony supports sales agents of EMR's software in Japan by supplying its EWS.

N.V. Philips Gloeilampenfabrieken
Sony and Philips agreed to a joint development of extended architecture CD-ROMs for audio use.

Motorola Inc.
Sony Microsystems agreed to incorporate dual Motorola 68030 MPUs in high-end models of Sony's NEWS UNIX workstation family.

Symbolics
Sony and Symbolics completed a sales agreement for Sony's workstations in the U.S. market. Sony Microsystems began supplying its workstations to Symbolics in May 1988 for sale in the United States under the Symbolics brand name. The two companies agreed to jointly develop a new model of workstation using Symbolics' A1 chips.

Texas Instruments Inc. (TI)
TI Japan and Sony jointly developed the CXD1144AP high-performance digital filter LSI for digital audio equipment.

Advanced Micro Devices (AMD)
Sony and AMD agreed to a sales tie-up for Sony's workstations in South Korea.

MERGERS AND ACQUISITIONS

1991

National Broadcasting Company
Sony purchased NBC's 50 percent stake in RCA/Columbia Home Video, resulting in Sony's complete ownership of the company.

1989

Trans Com Systems Division
Sony purchased all assets and liabilities of Trans Com Systems, a division of Sundstrand Corporation. Trans Com designed, manufactured, and installed in-flight AV entertainment systems in commercial aircraft worldwide.

Materials Research Corporation (MRC)
Sony acquired all of the outstanding shares of common stock of MRC and its affiliates. MRC manufactured and supplied sputtering and etching equipment, high-purity metals, and ceramics.

Columbia Pictures Entertainment
Sony acquired all of the outstanding shares of common stock of Columbia Pictures, which was primarily in the filmmaking business.

Guber-Peters Entertainment Company (GPEC)
Sony acquired GPEC, which was in the filmmaking business.

1988

CBS Records Inc.
Sony purchased CBS Records for U.S.$2 billion (¥256.5 billion) and held 100 percent of the shares. (The acquisition was made using U.S. currency.)

KEY OFFICERS

Akio Morita
Chairman and representative director

Norio Ohga
President and chief executive officer

Masaaki Morita
Deputy president

Nobuo Kanoi
Deputy president

Ken Iwaki
Deputy president

Tsunao Hashimoto
Deputy president

PRINCIPAL INVESTORS

Information is not available

FOUNDERS

Masaru Ilsuka
Akio Morita

Table 3
Balance Sheet
Fiscal Year Ending March 31
(Billions of U.S. Dollars)

Balance Sheet	1987*	1988	1989	1990	1991
Cash	1.0	1.6	2.3	3.2	3.1
Receivables	1.6	2.4	3.4	5.8	5.8
Marketable Securities	0.8	0.7	0.7	0.4	0.2
Inventory	1.9	2.4	3.8	4.8	5.2
Other Current Assets	0.5	0.7	1.0	1.2	1.5
Total Current Assets	5.8	7.8	11.2	15.4	15.8
Net Property, Plants	2.2	3.1	4.2	6.1	7.4
Other Assets	0.9	2.6	3.0	9.1	9.4
Total Assets	8.8	13.5	18.4	30.6	32.6
Total Current Liabilities	3.7	6.8	8.7	14.0	14.9
Long-Term Debt	0.9	1.4	1.7	4.5	4.9
Other Liabilities	0.5	0.6	0.8	2.0	2.3
Total Liabilities	5.0	8.8	11.2	20.5	22.1
Converted Preferred Stock	0	0	0	0	0
Common Stock	0.1	0.2	0.9	1.9	2.1
Other Equity	0.4	0.4	1.5	3.3	2.9
Retained Earnings	3.4	4.1	4.8	4.9	5.4
Total Shareholders' Equity	3.8	4.7	7.2	10.1	10.5
Total Liabilities and Shareholders' Equity	8.8	13.5	18.4	30.6	32.6
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

*For the five-month period ending March 31, 1987. Effective March 31, 1987, the parent company and almost all subsidiaries and affiliates changed their fiscal year-end from October 31 to March 31. Accordingly, the fiscal period ended March 31, 1987, included only 5 months of operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation Annual Reports
Dataquest (January 1992)

Table 4
Consolidated Income Statement
Fiscal Year Ending March 31
(Billions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1987*	1988	1989	1990	1991
Revenue	3.4	10.4	16.7	20.1	25.6
Japanese Revenue	1.1	3.5	5.7	6.1	6.7
Non-Japanese Revenue	2.3	6.9	11.0	14.1	18.9
Cost of Sales	2.6	7.7	11.5	13.6	17.7
R&D Expense	0.8	0.9	1.1	1.2	1.5
SG&A Expense	0.8	2.4	4.4	5.0	6.3
Capital Expense	0.6	1.0	1.7	2.3	2.9
Pretax Income	0.1	0.5	1.3	1.6	1.9
Pretax Margin (%)	4.36	5.14	7.71	7.90	7.32
Effective Tax Rate (%)	58.00	56.00	56.00	54.00	51.00
Net Income	0.1	0.3	0.6	0.7	0.8
Shares Outstanding, Thousands	231,236	238,769	282,603	331,929	338,593
Per Share Data					
Earnings	0.34	1.04	1.88	2.15	2.02
Dividend	0.12	0.32	0.28	0.32	0.32
Book Value	16.50	19.71	25.57	30.50	30.88
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

*For the five-month period ending March 31, 1987. Effective March 31, 1987, the parent company and almost all subsidiaries and affiliates changed their fiscal year-end from October 31 to March 31. Accordingly, the fiscal period ended March 31, 1987, included only 5 months of operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation Annual Reports
Dataquest (January 1992)

Table 5
Balance Sheet
Fiscal Year Ending March 31
(Billions of Yen)

Balance Sheet	1987*	1988	1989	1990	1991
Cash	152.9	218.0	297.9	451.7	442.9
Receivables	256.6	325.7	433.4	832.9	815.1
Marketable Securities	132.2	99.4	91.1	54.8	33.5
Inventory	302.9	334.7	483.7	693.0	731.7
Other Current Assets	77.6	99.1	127.7	169.2	211.2
Total Current Assets	922.2	1,076.9	1,433.8	2,201.6	2,234.4
Net Property, Plants	343.1	426.3	544.7	868.1	1,046.8
Other Assets	145.9	363.7	386.2	1,300.4	1,321.2
Total Assets	1,411.2	1,866.9	2,364.7	4,370.1	4,602.4
Total Current Liabilities	587.0	945.0	1,119.0	1,995.9	2,104.6
Long-Term Debt	143.4	196.0	220.8	646.0	694.5
Other Liabilities	72.1	76.3	98.2	281.3	327.0
Total Liabilities	802.5	1,217.3	1,438.0	2,923.2	3,126.1
Converted Preferred Stock	0	0	0	0	0
Common Stock	12.0	23.7	114.6	278.0	296.4
Other Equity	56.5	60.9	195.6	473.4	413.5
Retained Earnings	540.2	565.0	616.5	695.5	766.4
Total Shareholders' Equity	608.7	649.6	926.7	1,446.9	1,476.3
Total Liabilities and Shareholders' Equity	1,411.2	1,866.9	2,364.7	4,370.1	4,602.4
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.2[illegible]

Source: Sony Corporation
Annual Reports
Dataquest (January 199[illegible]

Table 6
Consolidated Income Statement
Fiscal Year Ending March 31
(Billions of Yen, except Per Share Data)

Consolidated Income Statement	1986	1987	1988	1989	1990
Revenue	547.8	1,431.2	2,145.3	2,879.9	3,616.5
Japanese Revenue	177.5	479.4	731.3	869.5	952.5
Non-Japanese Revenue	370.3	951.8	1,414.0	2,010.4	2,664.0
st of Sales	407.8	1,064.6	1,475.4	1,938.0	2,505.6
D Expense	131.2	127.5	142.1	165.2	205.8
&A Expense	131.0	336.3	565.6	712.0	887.8
tal Expense	101.6	133.5	215.6	324.0	411.7
x Income	23.6	73.5	165.5	227.4	264.6
Margin (%)	4.36	5.14	7.71	7.90	7.32
ve Tax Rate (%)	58.00	56.00	56.00	54.00	51.00
ome	13.3	36.7	72.5	102.8	116.9
Outstanding, Thousands	231,236	238,769	282,603	331,929	338,593
e Data					
s	54.2	143.8	219.7	279.0	285.9
d	18.5	44.6	40.5	45.5	45.5
lue	0	0	0	0	0
ate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

nth period ending March 31, 1987. Effective March 31, 1987, the parent ost all subsidiaries and affiliates changed their fiscal year-end from rch 31. Accordingly, the fiscal period ended March 31, 1987, included operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Ratios
ing March 31

tios	1987	1988	1989	1990	1991
	1.57	1.14	1.28	1.10	1.06
y (%)	231.85	287.39	255.17	302.03	311.75
Equity (%)	96.44	145.47	120.75	137.94	142.56
uity (%)	131.84	187.39	155.17	202.03	211.75
	0.94	2.24	3.43	3.05	2.23
	2.19	5.83	9.20	8.66	6.96
	2.43	2.56	3.38	3.57	2.84
evenue	23.95	8.91	6.62	5.74	4.57
Revenue	18.55	9.33	10.05	11.25	8.96
	47,583	71,000	78,900	95,600	112,900
	11.51	20.16	27.19	30.12	32.03
ssets	7.20	7.15	9.12	7.41	7.04
	159.56	138.03	128.25	142.93	141.21

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Toshiba Corporation

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Telephone: (03) 457-4511
Fax: (03) 456-1631
Dun's Number: 06-499-3082

Date Founded: 1875

CORPORATE STRATEGIC DIRECTION

Toshiba Corporation is one of the largest electronics companies worldwide. Its main business activity is the development, manufacturing, and marketing of electrical and electronics equipment and electronic components. The business is divided into the following segments: Information/Communication Systems and Electronic Devices, which accounts for 50 percent of net sales; Heavy Electrical Apparatus, which accounts for 19 percent of net sales; and Consumer Products, which accounts for 31 percent of net sales.

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

Total revenue for 1991 amounted to $33.3 billion,* an increase of 12 percent over 1990 revenue of $29.7 billion. Domestic sales decreased slightly from 60.73 percent in 1990 to 54.99 percent in 1991. International sales also dropped slightly from 31.62 percent to 30.98 percent. Fierce competition in the key semiconductor and computer markets led to a decrease in net income of 7.15 percent during 1991. Net income totaled $856.2 million, compared with $922.1 in 1990.

Toshiba has developed a "Sixth Medium-Term Plan." This plan will cover the period from 1991 through 1993. The focus of this plan is group, growth, and global. Group represents Toshiba's goal to strengthen its group of companies. This will be done by building on the synergies that exist among its lines of business and by making strategic alliances. For growth, Toshiba plans to increase total sales about 60 percent by 1993. This will be done by offering value-added products that unify the collective expertise of Toshiba's numerous divisions and group companies. In addition, the contribution of overseas sales is scheduled to rise from 35 to 39 percent of total sales. In order to meet this goal, Toshiba will need to build on its commitment to developing markets worldwide. Global represents how Toshiba will build on its global presence. Toshiba plans to raise overseas sales as a percentage of total sales by increasing overseas production and strengthening marketing operations in local markets.

R&D is structured by Toshiba to incorporate both long- and short-term planning by developing projects of varying time frames. Corporate level undertakes projects with a five- to ten-year time frame, division level operates under three-year time frames, division engineering level goes by one-year time frames, and division manufacturing strives for continuous day-to-day improvement. Therefore, Toshiba can take both long- and short-term perspectives.

R&D expenditure increased 13 percent from $1.86 billion in 1990 to $2.1 billion in 1991 and represented 6.37 percent of sales in 1991. This expenditure was concentrated primarily on 16Mb and 64Mb DRAMs, large color liquid crystal displays (LCDs), new high temperature superconducting materials for future electronic devices, and various equipment for train systems. A large share of activities was also focused on information and communications systems, such as broadband ISDN (BISDN) switching equipment. Toshiba plans to raise R&D expenditure 7 percent during the 1992 fiscal year.

Capital expenditure for the same period totaled $3.1 billion, a 35 percent increase over 1990,

*All dollar amounts are in U.S. dollars.

which totaled $2.3 billion. The rise in capital spending during fiscal 1990 and 1991 was primarily the result of development and production of 4Mb and 16Mb DRAMs. Over $1.4 billion was invested in the semiconductor group during the fiscal year; and several new factories are either currently under construction or already completed. During fiscal 1992, capital expenditure is expected to be approximately $3.5 billion.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7 at the end of this backgrounder present comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Information/Communication Systems and Electronic Devices

Fiscal 1991 sales in this segment were $16.7 billion and accounted for 50 percent of company sales.

A companywide program developed by Toshiba to strengthen its capabilities in information and communications systems contributed to the sale of notebook and laptop computers, which were up 40 percent during 1991. Although semiconductor memory sales were flat, sales of ASICs grew 6 percent in that product segment. Toshiba also introduced a second generation 4Mb DRAM that features a smaller chip size and faster access time.

Semiconductors

According to Dataquest, Toshiba remained the second-largest semiconductor supplier in 1990, with 8.3 percent of the worldwide market share and revenue of $4.8 billion. Toshiba also was the third-largest semiconductor supplier in Japan. Toshiba's diversified product portfolio emphasizes balance among analog, discrete, bipolar, MOS logic, memory devices, and ASICs.

Toshiba was also the largest worldwide supplier of discrete devices in 1988, 1989, and 1990. In 1990, Toshiba captured an 11.0 percent market share totaling $904 million in revenue. Toshiba has stated its goal to remain No. 1 in discretes. Toshiba ranked second, with a 9.2 percent market share and $838 million in revenue, in the MOS logic semiconductor segment and third in the MOS digital semiconductor segment with $2.9 billion in revenue. In the analog semiconductor industry Toshiba ranked third, capturing a 5.8 percent market share, according to Dataquest.

In the DRAM market, Toshiba is committed to increasing 4Mb DRAM production and has responded to demand by developing and producing a wide range of products. In October 1991, Toshiba announced a new series of 4Mb DRAMs with a 512K×9 structure. The device has the standard data capacity of 512K×8, plus an additional 512K×1 capacity for a parity bit. Dataquest believes that this is one of what will be many announcements for this type of product.

According to Dataquest, in 1990 Toshiba remained the largest supplier of 1Mb DRAMs to worldwide markets for the second consecutive year. It was second in the 4Mb product area, having held the top spot during 1989. However, during 1990 Toshiba adjusted to a 4Mb DRAM market shift, from a 350-mil-wide-device, the 4Mb part with which it started, to the now industry-standard 300-mil part. During 1991 and 1992, the company will emphasize the 4Mb DRAM density and de-emphasize the 256K DRAMs and 1Mb DRAMs. Toshiba should remain a leader in the DRAM market for the foreseeable future and a major player in the 4Mb video RAM (VRAM) segment as that market emerges. Toshiba ranked first in the MOS memory semiconductor arena with $1.6 billion in revenue and a 12.4 percent market share.

Dataquest ranked Toshiba third in the worldwide optoelectronic semiconductor industry, with an 11.6 percent share of the 1990 market.

During fiscal 1991, Toshiba invested approximately $226 million in its LCD business. Preparations for expansion into this market included the construction of LCD manufacturing facilities for the joint venture with IBM Japan, Display Technologies Inc.

Personal Computers

Toshiba is developing sophisticated, high-performance PC systems to position the company at the forefront of current and emerging high-growth fields. In 1990, according to Dataquest, Toshiba ranked tenth worldwide and captured 3.6 percent of the worldwide PC market. Dataquest believes that Toshiba is now the dominant player in the world market for laptops, with a 1990 market share of 29.4 percent in the worldwide laptop/DC market and a 21.6 percent market share in the worldwide laptop/AC market.

Workstations

Toshiba markets a line of UNIX engineering workstations incorporating original hardware and Japanese-version software. This line has done well in the Japanese market.

Telecommunications Equipment

Under a development contract with NTT, Toshiba is developing an asynchronous transfer mode (ATM) switching system for BISDN, the next-generation telecommunications network. Also, in a joint effort with Kokusai Denshin Denwa (KDD), Japan's international telephone service corporation, Toshiba has developed the first satellite communications system in Japan for installation in commercial airliners to enable air-to-ground telephone communication. Demand from the growing mobile portable and cordless telephone markets is being met, and an ultralight, ultracompact portable telephone that conforms to U.S. standards has been developed. According to Dataquest, in 1990 Toshiba ranked ninth in the United States in total PBX systems with a 2.5 percent market share.

Toshiba is a major supplier of facsimile products worldwide. Much of its success stems from the effective diversification of the product line to best suit the trends in market demand. Toshiba meets the high-end demand with products that will transmit a standard document in just 13 seconds. The products feature one-touch dialing and automatic Optical Mark Recognition (OMR) dialing. Toshiba also has models that offer an additional electronic memory, which adds such valuable functions as broadcasting, mailbox, and relay transmission. In addition, Toshiba offers compact, entry-level machines with one-touch dialing. In 1990, according to Dataquest, Toshiba ranked sixth worldwide with a 5.6 percent market share.

Toshiba is one of the top 10 suppliers of key telephone systems to the U.S. market. These systems are customer-premises telephone switching systems that allow telephones to interface to the public network without dialing access codes. Competition is stiff in this market segment because the top 10 suppliers account for 85 percent of the market, and there is very little differentiation among their technologies. For 1990, according to Dataquest, Toshiba ranked fifth in the key telephone systems area in the United States with a 5.7 percent market share.

Printers

Toshiba manufactures dot matrix, laser, and thermal transfer printers, with the overwhelming majority of business in the first two product areas. According to Dataquest, for 1990 Toshiba had less than a one percent share of the North America printer market.

Copiers

Toshiba sells and manufactures plain paper copiers (PPCs) on a global scale. According to Dataquest, Toshiba is one of the top 10 PPC manufacturers in the United States, placing 51.9 thousand PPCs during 1990.

Computer Storage

Toshiba is one of the leading optical drive suppliers. According to Dataquest, for 1990 Toshiba ranked fourth in the 12-inch worldwide write-once/read-many (WORM) market with a 10.0 percent market share. In the CD-ROM market it also ranked fourth with a 9.2 percent market share. Toshiba ranked fifth in the total optical disk drive market with a market share of 3.5 percent worldwide.

Heavy Electrical Apparatus

In fiscal 1991, Toshiba's Heavy Electrical Apparatus segment accounted for 19 percent of its net sales, totaling $6.4 billion compared with $618.6 million in 1990, reflecting a 14 percent increase over 1990. Domestic sales grew due to completion of large-scale nuclear power plants and high demand for electrical equipment stimulated by brisk capital investment. However, exports were down because of decreased plant deliveries.

Toshiba will continue to emphasize the development of its energy business, focusing on three systems. In the nuclear power generation sector, Toshiba is continuing to develop advanced, simplified systems that incorporate improvements in safety, reliability, and operability. The second system is thermal power plants. Toshiba is developing and refining a system that includes a combined cycle that will achieve new levels of turbine efficiency. The third system is fuel cells. According to Toshiba, the fuel cells show great promise as a superior next-generation source of clean energy.

Consumer Products

Fiscal 1991 sales of products in this segment rose 9 percent to $10.2 billion, accounting for 31 percent of Toshiba's net sales. The high added value of products in the domestic market and smooth expansion of overseas manufacturing operations both contributed to the gain. Domestic demand centered on air conditioners, large-screen TVs incorporating broadcast satellite tuners, lighting products, and materials.

The consumer products business has been restructured to reflect the continuing development of the information society and the personal and household use of information and communications devices. The Consumer Products Group has been separated into two business units, the Video & Electronics Media Group and the Airconditioners & Appliances Group. The Video & Electronics Media Group aims to position Toshiba as a major presence in multimedia.

Further Information

For further information about the company's business segments, please contact the appropriate Dataquest industry service.

Table 1
Five-Year Corporate Highlights (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Five-Year Revenue	20,734.7	25,881.3	29,636.6	29,748.8	33,251.2
Percent Change	36.01	24.82	14.51	0.38	11.77
Capital Expenditure	1,337.1	1,359.7	2,086.5	2,263.3	3,122.3
Percent of Revenue	6.45	5.25	7.04	7.61	9.39
R&D Expenditure	1,260.7	1,575.0	1,796.5	1,860.4	2,117.4
Percent of Revenue	6.08	6.09	6.06	6.25	6.37
Number of Employees	121,000	122,000	125,000	142,000	162,000
Revenue ($K)/Employee	171.36	212.14	237.09	209.50	205.25
Net Income	214.4	439.8	9,310.0	922.1	856.2
Percent Change	(20.15)	105.13	2,016.87	(90.10)	(7.15)
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

1991 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	NA	NA	NA	NA
Quarterly Profit	NA	NA	NA	NA

NA= Not available

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Table 2
Revenue by Geographic Region (Percent)

Region	1987	1988	1989	1990	1991
Japan	69.14	69.03	67.93	60.73	54.99
Overseas	30.86	30.97	32.07	31.62	30.98

Source: Toshiba Corporation
Annual Reports
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1991 SALES OFFICE LOCATIONS

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Asia/Pacific—77
Japan—67
ROW—11

MANUFACTURING LOCATIONS

North America

International Fuel Cells
A joint venture with United Technologies to produce fuel cells
Microelectronics Center
Semiconductors
Toshiba America Inc.
TVs, microwave ovens, VCRs, toners, telephones, medical equipment
Toshiba International
Motors, circuit boards, control equipment
Toshiba Westinghouse Electronics
A joint venture to produce color CRTs

Europe

Compagnie Europeen Pour La Fabrication D'Enceintes A Micro-Ondes (France)
A joint venture with Thomson of France to produce microwave ovens
Toshiba Consumer Products GmbH (Germany)
VCRs, TVs
Toshiba Consumer Products Ltd. (United Kingdom)
TVs, VCRs, microwave ovens
Toshiba Consumer Products S.A. (France)
Lamps for copiers
Toshiba Semiconductor GmbH (Germany)
Semiconductors
Toshiba Systemes S.A. (France)
A joint venture with ROHM Poulanc to produce plain paper copiers

Asia/Pacific

Amori Taic (Japan)
Radio cassette recorders, record players, component stereos
Buzen Toshiba Electronics Co. Ltd. (Japan)
Semiconductors
Hankook Tungsten (South Korea)
Tungsten, molybdenum wires and parts
Harison Denki (Japan)
Electric lamps
Himeji Toshiba Electronics (Japan)
ICs, lead frames for semiconductors
Hokuto Electronics (Japan)
CRTs
Iwate Toshiba Electronics Co. Ltd. (Japan)
Semiconductors
Kaga Toshiba Electronics (Japan)
Semiconductors
Kitashiba Electric Co. Ltd. (Japan)
Transformers, electric motors
Kitsuki Toshiba Electronics (Japan)
Semiconductors
Korea Electronics (South Korea)
Semiconductors, TVs
Kumdong Lighting (South Korea)
Fluorescent lamps
Leechun Electric Mfg. (South Korea)
Generators, motors, transformers, pumps
Marcon Electronics Co. Ltd. (Japan)
Capacitors, hybrid ICs
Nishishiba Electric Co. Ltd. (Japan)
Electric marine equipment
Nougata Toshiba Electronics (Japan)
Semiconductors
Olivetti Corporation of Japan (Japan)
Data communications equipment, computers, word processing systems, typewriters
Onkyo Corporation (Japan)
Audio equipment and parts
Shibaura Engineering Works Co. Ltd. (Japan)
Motors, electric tools
Sord Computer (Japan)
Microcomputer and peripherals
Tatung Co. (Taiwan)
TVs, refrigerators, transformers
Thai Toshiba Electric Industries Co. Ltd. (Thailand)
A joint venture with Siam Cement of Thailand to produce TVs, refrigerators, electric fans, electric rice cookers, motors
Thai Toshiba Fluorescent Lamp Co. Ltd. (Thailand)
Glass tubes for fluorescent lamps
Thai Toshiba Lighting Co. Ltd. (Thailand)
Fluorescent lamps
Tohoku Semiconductor (Japan)
Semiconductors
Toki Electric Industrial (Japan)
Electric lamps, lighting equipment

Tokyo Electric Co. Ltd. (Japan)
  Business machines, lighting equipment, home appliances
Tokyo Electronic Industry Co. Ltd. (Japan)
  Industrial video equipment, control equipment
Tokyo Optical (Japan)
  Optical instruments
Toshiba Battery (Japan)
  Dry batteries, battery applied products
Toshiba Ceramics (Japan)
  Ceramics
Toshiba Chemical Corporation (Japan)
  Plastic products, insulating materials
Toshiba Cold Chain (Japan)
  Freezers, vending machines
Toshiba Components Co. Ltd. (Japan)
  Semiconductors
Toshiba Electric Equipment Co. Ltd. (Japan)
  Lighting fixtures
Toshiba Electronics Malaysia Sdn. Bhd. (Malaysia)
  IC memories
Toshiba Electronic Systems Co. Ltd. (Japan)
  A joint venture with General Electric to produce and market electronic equipment
Toshiba Engineering & Construction Co. Ltd. (Japan)
  Electric facilities
Toshiba Glass Co. Ltd. (Japan)
  Glass products
Toshiba Heating Appliances (Japan)
  Oil heating equipment
Toshiba Kiki (Japan)
  Lighting equipment, etc.
Toshiba Machine (Japan)
  Machinery, machine tools
Toshiba Medical Systems Co. Ltd. (Japan)
  Medical electronic equipment
Toshiba Seiki (Japan)
  Automatic precision apparatus
Toshiba Singapore Pte. Ltd. (Singapore)
  Color TVs, TV parts, audio equipment
Toshiba Steel Tube Co. Ltd. (Japan)
  Steel tubes, electric conduit tubes
Toshiba Tungaloy (Japan)
  Special alloy tools

ROW

Industria Mexicana Toshiba S.A. (Mexico)
  Semiconductors
Semp Toshiba Amazonas S.A. (Brazil)
  TVs, audio equipment
Toshiba Electromex S.A. de C.V. (Mexico)
  Color TV parts for Toshiba America

SUBSIDIARIES

North America

GE Toshiba Lighting Corporation (United States)
Ottawa Design Center (Canada)
Toshiba America Consumer Products Inc. (United States)
Toshiba America Electronic Components Inc. (United States)
Toshiba America, Inc. (United States)
Toshiba America Information Systems Inc. (United States)
Toshiba America Medical Systems Inc. (United States)
Toshiba Display Devices Inc. (United States)
Toshiba Hawaii Inc. (United States)
Toshiba International Corporation (United States)
Toshiba of Canada Ltd. (Canada)

Europe

Compagnie European Pour La Fabrication D'Enceintes A Micro-Ondes (France)
Toshiba AG (Switzerland)
Toshiba Consumer Products GmbH (Germany)
Toshiba Consumer Products Ltd. (United Kingdom)
Toshiba Consumer Products S.A. (France)
Toshiba Deutschland GmbH (Germany)
Toshiba Electronics Espana S.A. (Spain)
Toshiba Electronics Europe GmbH (Germany)
Toshiba Electronics Italiana S.R.L. (Italy)
Toshiba Electronics Ltd. (United Kingdom)
Toshiba Electronics Scandinavia AB (Sweden)
Toshiba Europa GmbH (Germany)
Toshiba Information Systems (Belgium)
Toshiba Information Systems Ltd. (United Kingdom)
Toshiba Information Systems S.A. (Spain)
Toshiba Information Systems S.p.A. (Italy)
Toshiba Informationssyteme GmbH (Germany)
Toshiba International (Europe) Ltd. (United Kingdom)
Toshiba International Finance B.V. (Netherlands)
Toshiba International Finance Ltd. (United Kingdom)
Toshiba Ltd. (United Kingdom)
Toshiba Medical Systems Europe B.V. (Netherlands)
Toshiba Semiconductor GmbH (Germany)
Toshiba Systemes S.A. (France)

Asia/Pacific

Iwate Toshiba Electronics Co. Ltd. (Japan)
Kitashiba Electric Co. Ltd. (Japan)

Kyodo Building Corporation (Japan)
Man On Toshiba Ltd. (Hong Kong)
Marcon Electronics Co. Ltd. (Japan)
Minato Building Co. Ltd. (Japan)
Nikko Jitsdugyo Co. Ltd. (Japan)
Nishishiba Electric Co. Ltd. (Japan)
Onkyo Corporation (Japan)
Shibaura Engineering Works Co. Ltd. (Japan)
TDH, Inc. (Japan)
Thai Toshiba Electric Industries Co. Ltd. (Thailand)
Tokyo Electric Co. Ltd. (Japan)
Toshiba Automation Co. Ltd. (Japan)
Toshiba Battery Co. Ltd. (Japan)
Toshiba Builders Appliance Co. Ltd. (Japan)
Toshiba Building Corporation (Japan)
Toshiba Ceramics Co. Ltd. (Japan)
Toshiba Chemical Corporation (Japan)
Toshiba Components Co. Ltd. (Japan)
Toshiba Consumer Products Co. Ltd. (Thailand)
Toshiba Credit Corporation (Japan)
Toshiba Display Devices Co. Ltd. (Thailand)
Toshiba Electric Appliances Co. Ltd. (Japan)
Toshiba Electric Equipment Corp. (Japan)
Toshiba Electronic Systems Co. Ltd. (Japan)
Toshiba Electronics Asia, Ltd. (Hong Kong)
Toshiba Electronics Malaysia Sdn. Bhd. (Malaysia)
Toshiba Electronics Taiwan Corporation (Taiwan)
Toshiba Elevator & Escalator Service Co. Ltd. (Japan)
Toshiba Engineering & Construction Co. Ltd. (Japan)
Toshiba Engineering Co. Ltd. (Japan)
Toshiba Glass Co. Ltd. (Japan)
Toshiba Heating Appliances Co. Ltd. (Japan)
Toshiba Higashinihon Consumer Electronics Co. Ltd. (Japan)
Toshiba Information Equipment Co. Ltd. (Japan)
Toshiba International Corporation Pty. Ltd. (Australia)
Toshiba Lightec Corporation (Japan)
Toshiba Medical Systems Co. Ltd. (Japan)
Toshiba Physical Distribution Co. Ltd. (Japan)
Toshiba Pty. Ltd. (Australia)
Toshiba Sales and Services Sdn. Bhd. (Malaysia)
Toshiba Silicone Co. Ltd. (Japan)
Toshiba Singapore Pte. Ltd. (Singapore)
Toshiba Steel Tube Co. Ltd. (Japan)
Toshiba Thailand Co. Ltd. (Thailand)

ROW

Industria Mexicana Toshiba S.A. (Mexico)
Semp Toshiba Amazonas S.A. (Brazil)
T and S Servicos Industrias S/C Ltda. (Brazil)
Toshiba de Brasil S.A. (Brazil)
Toshiba de Panama S.A. (Panama)
Toshiba Electromex S.A. de C.V. (Mexico)
Toshiba Medical de Brasil Ltda. (Brazil)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Motorola Inc.

Motorola Inc.'s semiconductor products sector signed a joint-development agreement with Toshiba to design a MUSE (Multiple Sub-nyquist Encoding) decoder chip set for HDTV systems used in Japan. The chips are expected to be completed by the middle of 1992.

Sun Microsystems Inc.

Sun Microsystems Inc. and Toshiba will jointly develop the technology required to commercialize multimedia workstations, which will be compatible with the BISDN telecommunications service.

Synergy Semiconductor

Toshiba has acquired approximately a 10 percent minority stake in Synergy Semiconductor. This strategic alliance will provide for a joint-development effort to build libraries of high-speed ECL and E-BiCMOS ASIC designs. Under the agreement, Toshiba will build 6-inch submicron production lines in Japan for the to-be-designed ECL and E-BiCMOS ASICs.

Echelon Corporation

Echelon has licensed to Toshiba and Motorola the Neuron chip family, its local operating network (LON) product lines. The chip family comprises of two members: the 3210 and 3150.

TEC Electronics

Toshiba has licensed TEC Electronics, a subsidiary of its Tokyo Electric Corp. affiliate, to market its Dynabook notebook personal computers, along with the point-of-sale terminals that Toshiba manufactures.

Bull Micral of America

Toshiba entered into the PC logic chip set business with a chip set for 486-based Micro Channel systems licensed from Bull Micral of America, an affiliate of Groupe Bull.

Texas Instruments Inc.
Texas Instruments Inc. and Toshiba signed a 10-year patent cross-licensing agreement. Toshiba will pay Texas Instruments royalties for using the patented chip technology.

1990

IBM Japan Ltd.
Toshiba and IBM Japan are jointly constructing a plant that will have a production capability of 50,000 LCD panels a year.

Motorola Inc.
Toshiba and Motorola reportedly plan to sign an agreement to exchange gate array technology to allow the companies to act as mutual second sources. In the United States, Motorola will produce gate arrays designed and developed by Toshiba, which Motorola intends to market for use in workstations. In Japan, Tohoku Semiconductor Inc., a joint venture of the two companies, will produce gate arrays based on Motorola technology for supply to local companies. Toshiba and Motorola also plan to expand their technological cooperation to include discrete semiconductors.

Businessland
Businessland Japan will be formed by Businessland, Canon, Fujitsu, software distributor Softbank, Sony, and Toshiba to provide systems integration services for international firms. Businessland will have a 54 percent stake in the joint venture, Softbank will have 26 percent, and the other firms will have 5 percent each.

Spectrum Cellular Corp.
Toshiba will market Dallas-based Spectrum Cellular's new cellular/landline modem with its laptop computers as the T24D/X, and Spectrum will also develop five separate versions of its new SmartCable product for sale by Toshiba.

General Electric (GE)
GE and Toshiba have entered into a joint marketing agreement covering the sale of GE's CompuScene PT2000 in Japan. The visual simulation system and other Compu-Scene products will be distributed by Toshiba Electronics Systems, a GE/Toshiba joint venture company.

Echelon Systems Corp.
Motorola and Toshiba have become the first semiconductor makers to license the rights to a new generation of intelligent power-controller chips being developed by Echelon Systems. Under the terms of the agreement, Toshiba's Semiconductor Group will manufacture and market the Echelon-designed ICs. The agreement also permits Toshiba to design, manufacture, and market enhanced versions of the chips.

1989

EDA Systems Inc.
EDA signed a purchase agreement with Toshiba for its Powerframe product, a design management framework that integrates third-party CAD/CAE tools and speeds the overall electronic design process.

IBM Corporation
The two companies agreed to the joint development of a color flat panel display for computers that is larger and clearer than any demonstrated previously.

Digital Equipment Corporation
The companies have a technology exchange agreement that will ensure the integration of Toshiba's laptop personal computers into Digital's networking environment.

Weitek Corporation
Under a joint development agreement, Weitek will manufacture some of its semiconductors in Toshiba's plant; Toshiba will gain access to some of Weitek's floating-point product technology.

McDonnell Douglas
McDonnell Douglas has agreed to port its PRO-IV application development language to minicomputers manufactured by Toshiba.

Cummins Engine Co.
The companies have undertaken a joint venture to market silicon nitride ceramic components in North America.

Sun Microsystems Inc.
The companies signed a worldwide licensing agreement to bundle the SPARC MPU architecture, the SunOS operating system, and the Open Look Graphics interface into a series of small-footprint, low-cost computers.

Siemens
The companies extended their long-standing alliance in ASICs.

1988

Zoran
The companies agreed to a technology and manufacturing alliance.

Motorola Inc.
Under a joint venture, the companies formed Tohoku Semiconductor. Tohoku is using Toshiba's marketing channels to market Motorola's 68000 series MPUs in Japan.

Advanced Silicon Corporation
Toshiba agreed to provide Advanced Silicon Corporation with 6-inch CMOS wafers and jointly develop ASIC software.

Siemens and GE
The companies agreed to jointly develop a common cell library.

SGS-Thomson
The companies extended a six-year agreement to patent cross-licensing related to semiconductor technology.

1987

GRiD
Toshiba agreed to supply GRiD with an IBM PC AT-compatible kneetop computer.

Mitsui Petrochemical
The companies undertook the joint development of a magnetic tape emulator.

Viewlogic Systems
Viewlogic Systems is the principal worldwide supplier of CAE software for Toshiba.

Aida Corporation
Toshiba agreed to provide Aida with its TC17G gate array library models. Toshiba is gaining access to Aida's semicustom IC design equipment.

SGS-ATES
The companies made a five-year technical collaboration agreement allowing Toshiba to use SGS-ATES' semiconductor sales network in Europe and allowing SGS-ATES to receive LSI fab technology and technical training for its engineers from Toshiba.

SDA Systems
The companies undertook a five-year joint venture to cooperatively develop CAD systems for IC design.

MERGERS AND ACQUISITIONS

1991

UNIX System Laboratories
AT&T sold one-fifth of its UNIX System Laboratories to eleven computer companies, including Toshiba. The other computer companies involved are Motorola Inc., Novell Inc., Sun Microsystems Inc., NEC America Inc., England's ICL, Ing. C. Olivetti & Co. of Italy, the Institute for Information Industry of Taiwan, Fujitsu Ltd., and Oki Electric Industries Co. Ltd.

Vertex Semiconductor Corporation
Toshiba America Electronic Components Inc. acquired Vertex Semiconductor Corporation for approximately $20 million. Vertex is a designer and manufacturer of high-performance, multichip ASICs for high gate count, performance-driven electronic systems. Toshiba had already owned a 14 percent equity stake under a three-year agreement signed in 1989.

1990

Toshiba Display Devices Inc. and Toshiba America Electronic Components Inc.
These two Toshiba subsidiaries have been merged to complete the consolidation of all of Toshiba's North American components marketing, sales, and manufacturing operations.

Power and Design
Toshiba has acquired Power and Design, a Belgian distributor for Toshiba. The new subsidiary will be renamed Toshiba Information Systems and will deal with marketing and sales for Toshiba-made printers, photocopiers, personal computers, and fax machines. The subsidiary is the seventh sales outlet for Toshiba communications and information equipment in Europe.

Integrated CMOS Systems Inc. (ICS)
Toshiba has acquired equity stake in ICS. The acquisition will enable Toshiba to use the U.S. firm's design tools with existing customers, and, under its own name, Toshiba will market a new array family that will be developed using submicron CMOS technology. (Note: ICS subsequently changed its name to Vertex Semiconductor Corporation.)

KEY OFFICERS

Joichi Aoi
President and chief executive officer

Tsuyoshi Kawanishi
Senior executive vice president

Keiichi Komiya
Senior executive vice president

Kinichi Kadono
Senior executive vice president

Fumio Sato
Senior executive vice president

PRINCIPAL INVESTORS

The Dai-ichi Mutual Life Insurance Company—4.3 percent
Nippon Life Insurance Company—3.6 percent
The Mitsubishi Trust & Banking Corporation—3.1 percent
The Mitsui Bank Limited—3.1 percent

FOUNDERS

Information is not publicly available.

Table 3
Consolidated Balance Sheet
Fiscal Year Ending in March
(Millions of U.S. Dollars)

Balance Sheet	1987	1988	1989	1990	1991
Cash	1,279.5	3,681.8	4,964.5	7,127.3	5,998.9
Receivables	4212.6	5,223.5	6,885.8	7,131.5	8,288.4
Marketable Securities	1,284.5	1,409.8	1,334.1	1,323.7	1,373.8
Inventory	3,363.8	5,308.7	6,434.3	6,716.6	7,808.2
Other Current Assets	1,153.5	1,333.8	1,613.3	1,784.8	1,882.3
Total Current Assets	12,347.7	17,030.4	21,232.0	24,083.8	25,351.6
Net Property, Plants	4,666.5	5,346.6	6,158.3	6,336.0	7,915.2
Other Assets	3,573.2	4,399.8	5,402.7	5,830.8	5,896.9
Total Assets	20,587.4	26,776.8	32,793.0	36,250.6	39,163.7
Total Current Liabilities	11,500.1	15,018.5	19,002.7	19,287.1	20,713.1
Long-Term Debt	4,570.0	5,642.3	6,007.0	8,429.3	9,112.7
Other Liabilities	800.5	915.0	918.6	937.5	991.4
Total Liabilities	16,870.6	21,575.8	25,928.3	28,653.9	30,817.2
Common Stock	951.6	1,424.3	1,791.0	1,831.0	1,924.8
Other Equity	935.3	1,489.5	1,894.0	2,359.2	2,475.7
Retained Earnings	1,829.7	2,287.2	3,180.0	3,406.6	3,945.9
Total Shareholders' Equity	3,716.8	5,201.0	6,864.7	7,596.7	8,346.4
Total Liabilities and Shareholders' Equity	20,587.4	26,776.8	32,793.0	36,250.6	39,163.7
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Table 4
Consolidated Income Statement
Fiscal Year Ending in March
(Millions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	20,734.7	25,881.3	29,636.6	29,748.8	33,251.2
Japanese Revenue	14,336.8	17,865.7	20,133.3	18,065.5	18,285.5
Non-Japanese Revenue	6,397.9	8,015.6	9,503.3	9,405.3	10,302.4
Cost of Sales	15,223.8	18,640.2	20,150.0	20,037.8	22,509.0
R&D Expense	1,260.7	1,575.0	1,796.5	1,860.4	2,117.4
SG&A Expense	5,187.4	6,443.5	7,553.2	7,500.9	8,886.1
Capital Expense	1,337.1	1,359.7	2,086.5	2,263.3	3,122.3
Pretax Income	489.0	909.2	1,830.8	1,886.9	1,833.4
Pretax Margin (%)	2.36	3.51	6.18	6.3	5.5
Effective Tax Rate (%)	58.00	56.00	56.00	54.0	51.0
Net Income	214.4	439.8	922.1	922.1	856.2
Shares Outstanding, Millions	2,732.5	2,939.4	3,074.6	3,172.5	3,206.1
Per Share Data					
Earnings	0.07	0.15	0.29	0.28	0.25
Dividend	0.05	0.06	0.06	0.07	0.07
Book Value	1.36	1.77	2.23	1.68	1.82
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Table 5
Consolidated Balance Sheet
Fiscal Year Ending in March
(Billions of Yen)

Balance Sheet	1987	1988	1989	1990	1991
Cash	204.1	508.2	636.7	1,018.7	847.1
Receivables	671.9	721.0	883.1	1,019.3	1,170.4
Marketable Securities	204.9	194.6	171.1	189.2	194.0
Inventory	536.6	742.7	825.2	960.0	1,102.6
Other Current Assets	184.0	184.1	206.9	255.1	265.8
Total Current Assets	1,969.7	2,350.7	2,723.0	3,442.3	3,579.9
Net Property, Plants	744.5	737.9	789.8	905.6	1,117.7
Other Assets	569.9	607.4	692.9	833.4	832.7
Total Assets	3,284.1	3,696.0	4,205.7	5,181.3	5,530.3
Total Current Liabilities	1,834.5	2,073.0	2,437.1	2,756.7	2,924.9
Long-Term Debt	729.0	778.8	770.4	1,204.8	1,286.8
Other Liabilities	127.7	126.3	117.8	134.0	140.0
Total Liabilities	2,691.2	2,978.1	3,325.3	4,095.5	4,351.7
Converted Preferred Stock	0	0	0	0	0
Common Stock	151.8	196.6	229.7	261.7	271.8
Other Equity	149.2	205.6	242.9	337.2	349.6
Retained Earnings	291.9	315.7	407.8	486.9	557.2
Total Shareholders' Equity	592.9	717.9	880.4	1,085.8	1,178.6
Total Liabilities and Shareholders' Equity	3,284.1	3,696.0	4,205.7	5,181.3	5,530.3
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Table 6
Consolidated Income Statement
Fiscal Year Ending in March
(Billions of Yen, except Per Share Data)

Consolidated Income Statement	1987	1988	1989	1990	1991
Revenue	3,307.6	3,572.4	3,800.9	4,252.0	4,695.4
Japanese Revenue	2,287.0	2,466.0	2,582.1	2,582.1	2,582.1
Non-Japanese Revenue	1,020.6	1,106.4	1,218.8	1,344.3	1,454.8
Cost of Sales	2,428.5	2,572.9	2,584.2	2,864.0	3,178.5
R&D Expense	201.1	217.4	230.4	265.9	299.0
SG&A Expense	827.5	889.4	968.7	1,072.1	1,254.8
Capital Expense	213.3	187.7	267.6	323.5	440.9
Pretax Income	78.0	125.5	234.8	269.7	258.9
Pretax Margin (%)	2.4	3.5	6.2	6.3	5.5
Effective Tax Rate (%)	58.0	56.0	56.0	54.0	51.0
Net Income	34.2	60.7	119.4	131.8	120.9
Shares Outstanding, Millions	2,732.5	2,939.4	3,074.6	3,172.5	3,206.1
Per Share Data					
Earnings	11.86	20.37	37.27	40.11	35.72
Dividend	8.00	8.00	8.00	10.00	10.00
Book Value	216.98	244.23	286.35	342.3	367.6
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Table 7
Key Financial Ratios
Fiscal Year Ending in March

Key Financial Ratios	1987	1988	1989	1990	1991
Liquidity					
Current (Times)	1.07	1.13	1.12	1.25	1.22
Total Assets/Equity (%)	553.90	514.83	477.70	477.19	469.23
Current Liabilities/Equity (%)	309.41	288.76	276.82	253.89	248.17
Total Liabilities/Equity (%)	453.90	414.83	377.70	377.19	369.23
Profitability (%)					
Return on Assets	1.04	1.64	2.84	2.54	2.19
Return on Equity	5.77	8.46	13.56	12.14	10.26
Profit Margin	1.03	1.70	3.14	3.10	2.57
Other Key Ratios					
R&D Spending % of Revenue	6.08	6.09	6.06	6.25	6.37
Capital Spending % of Revenue	6.45	5.25	7.04	7.61	9.39
Employees	121,000	122,000	125,000	142,000	162,000
Revenue (¥M)/Employee	27.34	29.28	30.41	29.94	28.98
Capital Spending % of Assets	6.49	5.08	6.36	6.24	7.97
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Toshiba Corporation
Annual Reports
Dataquest (January 1992)

Semiconductor Procurement

Dataquest Perspective

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A series of multitopic publications that provide analysis on worldwide semiconductor procurement issues, regional pricing updates, and semiconductor news and views.

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Source: Dataquest
An annually updated collection of reference documents for the Semiconductor Procurement service. Worldwide and regional market statistics; *Company Backgrounders;* and several guides such as *How to Use Dataquest, Dataquest Research Methodology, Dataquest High-Technology Guide—Segmentation and Glossary* are contained in this binder.

Dataquest Perspective Index

Semiconductor Procurement

SPWW-SVC-IX-9201 April 30, 1992

How to Use This Index

This is a cumulative index of key industry terms, companies, and products for the first quarter 1992 issues of *Dataquest Perspective*. Entries are followed by the date of publication and the page number(s). Product names are listed under the company that manufactures/publishes the product. General information about a company itself is found under the full company name. Each citation indicates only the beginning page of a discussion of a topic (the range of page numbers is not cited). A Table of Contents for the first quarter 1992 issues of *Dataquest Perspective*—listing each issue number, date, and article title—is included at the end of the index.

Note: The *DQ Monday Report* Volume Mean Pricing table is not indexed.

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***Dataquest Perspective* issues covered in this index:**

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Dataquest Perspective

Semiconductor Procurement

Index

March-December 1991 **January 31, 1992**

How to Use This Index

This is a cumulative index of key industry terms, companies, and products for all 1991 issues of *Dataquest Perspective*. Entries are followed by the date of publication and the page number(s). Product names are listed under the company that manufactures/publishes the product. General information about a company itself is found under the full company name. Each citation indicates only the beginning page of a discussion of a topic (the range of page numbers is not cited). A Table of Contents for all 1991 issues of *Dataquest Perspective*—listing each issue number, date, and article title—is included at the end of the index.

Note: The *DQ Monday Report* Volume Mean Pricing table, which appears on page 2 of Semiconductor Procurement *Dataquest Perspective*, is not indexed.

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Semiconductor Procurement

Index

January-September 1991 **October 25, 1991**

How to Use This Index

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Note: The *DQ Monday Report* Volume Mean Pricing table, which appears on page 2 of Semiconductor Procurement *Dataquest Perspective*, is not indexed.

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 17 **December 23, 1991**

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.19	0.16	0.18	0.18	0.14
74AC138	0.32	0.33	0.26	0.31	0.34	0.21
74AC244	0.46	0.45	0.36	0.42	0.46	0.36
74AC74	0.25	0.26	0.22	0.23	0.24	0.17
Lead Time (Weeks):	2	3	8	4	5	5
4F00	0.11	0.12	0.09	0.11	0.10	0.09
4F138	0.15	0.19	0.16	0.18	0.19	0.14
4F244	0.22	0.27	0.22	0.27	0.29	0.23
4F74	0.12	0.13	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	4	4	5	5
7805-TO92	0.12	0.19	0.11	0.15	0.14	0.11
CODEC-FLTR 1	1.98	2.45	2.50	2.10	2.15	1.35
CODEC-FLTR 2	4.53	4.82	5.00	4.85	5.05	NA
Lead Time (Weeks)	4	3	6	3	4	NA
DRAM 1Mbx1-8	3.75	4.04	3.80	4.40	4.10	3.80
DRAM 1Mbx9-8	38.50	48.19	37.00	39.75	42.20	36.00
DRAM 256Kx1-8	1.75	1.69	1.70	1.43	1.45	1.10
DRAM 256Kx4-8	3.75	4.09	3.80	4.50	4.25	3.80
DRAM 4Mbx1-8	14.20	14.73	16.00	17.78	17.30	14.00
EPROM 1Mb, 170ns	3.85	4.52	3.55	4.75	3.90	3.80
EPROM 2Mb, 170ns	7.68	8.99	7.00	8.65	7.90	7.00
SRAM 1MB, 128Kx8	14.23	14.72	13.30	17.10	17.80	NA
SRAM 256K, 32Kx8	4.03	4.09	3.60	4.25	4.10	3.30
SRAM 64K, 8Kx8	2.13	1.57	1.90	1.60	1.40	1.20
Lead Time (Weeks)	2	4	8	4	7	3
68020-16	31.00	47.81	29.00	47.25	44.50	NA
80286-16	11.75	13.77	12.00	11.50	12.80	12.70
80386DX-25	147.50	169.79	160.00	184.00	186.00	NA
80386SX-16	48.50	63.86	55.00	58.50	60.40	55.00
R3000-25	125.00	144.93	132.00	NA	NA	NA
Lead Time (Weeks)	6	6	4	NA	NA	NA

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (December 1991)

Market Analysis

December Procurement Pulse: Order Rates and Lead Times Steady; Inventories Blip Upward

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to both semiconductor users and manufacturers.

Semiconductor Order Levels Expected to Slip Less Than 2 Percent

As seen in Figure 1, the monthly order level for semiconductors is expected to decline 1.7 percent from last month's level. Looking over the past six months, less than 10 percent difference exists between the high and low order index figures. This static level of semiconductor orders continues to highlight the fact that semiconductor bookings remain closely tied to system demand levels. The six-month system sales outlook for overall systems remains positive at 5.5 percent, which is slightly less than last month's 6.0 percent expectation. Although the computer segment respondents' sales dropped 1.5 percent last month, the six-month outlook is expected to be a positive 7.1 percent, up over last month's 5.5 level.

Figure 1
Averaged Monthly Semiconductor Orders

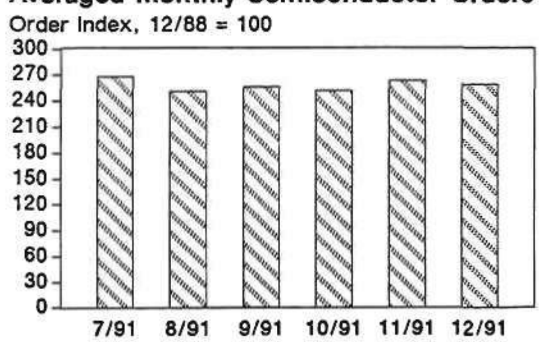


Figure 2
Averaged Semiconductor Lead Times

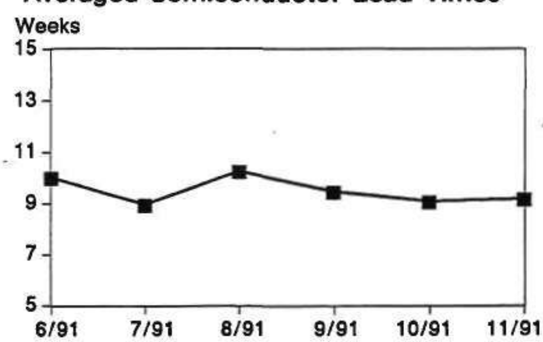


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

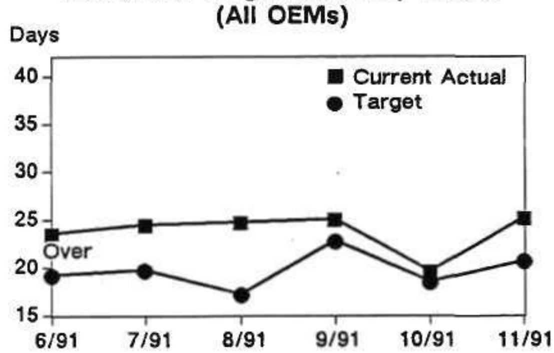
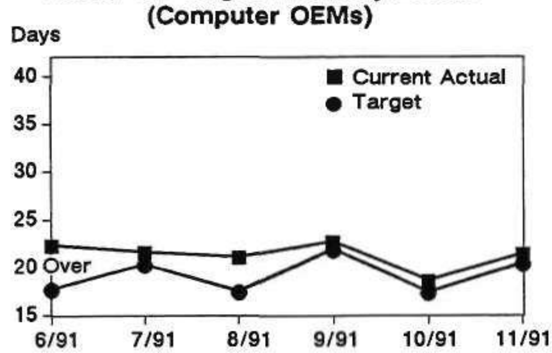


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (December 1991)

Semiconductor prices, on average, are again expected to decline 2.6 percent this month because of abundant capacity relative to flat demand levels. Besides an isolated response regarding some mature standard logic device availability, there were no problems in obtaining semiconductors in November. Dataquest continues to foresee existing semiconductor capacity levels being easily capable of meeting current and near-term future demand.

Average Lead Times Remain Steady at 9.2 Weeks

Figure 2 illustrates that despite spot lead times as low as off-the-shelf to two weeks, the average scheduled delivery remains at or near 9 weeks (currently 9.2 weeks). The lengthened lead times last month for some discrete devices and low-density SRAMs have been replaced by concern/confusion over ×9 signle in-line memory module (SIMM) availability. Currently, Hitachi Ltd. and Toshiba Corporation are not shipping any ×9 SIMM product pending the outcome of patent litigation brought on by Wang Corporation. Micron Technology and NEC Corporation have made agreements with Wang and are currently delivering ×9 SIMM products. The status of other suppliers of these modules is not known at this time. We have heard of *users* of ×9 SIMMs also being approached by Wang attorneys. The steady system demand level being fueled by price reductions is also keeping semiconductor demand steady. In the absence of an incremental demand increase, continued price and profit erosion at the system level should eventually result in reductions in semiconductor orders.

Semiconductor Inventories Bounce Up to "Average" Levels

Figures 3 and 4 show that although targeted inventory levels remained relatively constant for this month's respondents, the actual inventory level for semiconductors rose in November. The average overall inventory target and actual levels went from a respective 18.6 and 19.7 days seen last month, to a current 20.8-day target and 25.3-day actual level. The computer segment was not as volatile, going from a respective target and actual level of 17.5 and 18.8 days last month to a current 20.5-day target and a 21.5-day actual level. This slight rise in inventories is within recent historical levels and does not imply that inventory control has slipped. Targeted levels of inventories remain steady and on track, highlighting the fact that long-term goals continue to guide procurement independent of short-term perturbations.

Dataquest Perspective

The question posed in last month's *Procurement Pulse* on how long sub-20-day actual inventory levels could be maintained has been answered. The ultratight inventory control seen last month, although achievable, may be too low to allow for the flexibility needed in the current market to take advantage of incremental sales opportunities. Although an overall increase in inventories of 5 days in one month could be seen as a loss of inventory control, Dataquest sees it as a near-term adjustment to market conditions still well below the 30-day average seen over the past two years. We still see current capacity and that planned to come on-line in 1992 keeping the availability of semiconductors a nonissue for the upcoming year. In the unlikely event that there is a quick increase in demand, a brief period of stretched lead times would be quickly corrected by increases in capacity loading. As mentioned in the past, good communication with suppliers is the best way to reduce potential dislocations of semiconductor supply. ■

By Mark Giudici

Outsourcing: Trend or Fad?

Outsourcing, or contracting out manufacturing and service operations, is an old concept that is now garnering much attention in the current "downsizing" environment. Outsourcing is defined here as contracting out *for anything* when a company has no or little value to add to a process or product. Reviewing the highlights of a recent WESCON purchasing seminar, this article briefly examines the pros and cons of outsourcing, notes some of the requisites for outsourcing to be successful, and analyzes where the outsource option makes sense from a procurement perspective.

Contracting Out. . . At What Cost?

The practice of contracting out procedures or functions of a company's operations that can be done more efficiently outside is rapidly becoming a very popular method to cut costs while maintaining productivity improvements. The following benefits and challenges of outsourcing are a condensation of a WESCON panel presentation given in November by Dataquest Incorporated, Moulthrop Sales, Solectron Corporation, Sun Microsystems, Watkins Johnson Company, and Xerox Corporation (see Table 1).

Table 1
Outsourcing Benefits and Challenges

Benefits	Challenges
Flexibility	Good communication mandatory
Cost-effective	Perceived proprietary loss
Long-term approach	Requires similar company culture

Source: Dataquest (December 1991)

The general consensus of the panel was that before the outsource option was to be considered, an *honest assessment* of a company's strengths or "core competencies" must be made to determine what, if anything, would be a candidate for outsourcing.

The attractiveness of contracting out standard or commoditized procedures often combines the features of flexibility and cost reduction at the same or higher level of quality. Flexibility is gained by accessing state-of-the-art processing technology from an expert contractor at a price made competitive by market forces, not internal company demands. Using a long-term total cost approach with a contractor provides the stability necessary for quality and cost improvements to be realized by suggestions made by contractor representatives as they become familiar with a company's particular market requirements.

In order for the outsourcing of services to succeed, good communication between the company and the contractor is mandatory. The panel stated that good internal communication needs to exist within a company before external communication can be improved. In line with vendor reduction programs or strategic alliance practices, timely communication with a contractor is key in the successful implementation of an outsource strategy. The perception of loss of control ties in with the realistic assessment of a company's core competencies. Once proprietary technology, process, and directly supporting procedures have been identified, any ancillary work is a prime target for contract work. As with any key supplier, qualification is a gradual process that involves careful contract review of specifications, quality, and delivery performance. Any perceived loss of control should be erased with regular status/requirement reporting or notification. Communication is enhanced when the contractor and client company have similar ways of conducting business. The selection of a contractor often is determined by intangibles such as executive compatibility or the communication method used (written or verbal), so the ease of working and communicating with the contractor needs to be looked at closely.

Dataquest Perspective

Outsourcing can be seen as a logical extension of the strategic alliance philosophy. Critical review of what is proprietary or key to the company's future growth is mandatory before a successful outsource strategy can be implemented. In using the total cost approach to contracting out services, a company can improve its performance to its customers while focusing on areas that will ensure its future health. If a manufacturing step is outsourced, often the associated procurement function also is outsourced. The remaining procurement function is enhanced in this area because the focus expands from product specification and cost control to include contractor service performance and total cost control. The implication for purchasing managers and buyers is that some retraining or downsizing may be involved to better handle these emerging opportunities. A well thought out outsource strategy has allowed many companies to expand while their vertically integrated competitors have struggled with underused overhead costs. If done in a reasonable manner, outsourcing can improve a company's manufacturing flexibility, lower overhead costs, and allow scarce capital be used to improve the product or service to the customer. ■

By Mark Giudici

Company Analysis

Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest

In 1986, Dataquest predicted that strategic alliances would be an electronics industry megatrend for the rest of this century. During 1991, two DRAM alliances captured global attention: the IBM/Siemens joint-manufacturing venture on 16Mb DRAMs and the Hitachi Ltd./Texas Instruments second-source pact for 64Mb DRAMs. This article presents the evolving worldwide network of DRAM alliances as of December 1991 and assesses the impact and strategic competitive significance of the top arrangements.

Table 1 shows the worldwide network of DRAM technology alliances by product density as of December 1991. The table shows more than 20 alliances. The footnotes to Table 1 provide the definitions for each type of alliance and highlight special arrangements. Alliances other than those listed at the top of Table 1 are noted in parentheses and defined in the table. This information includes internal and external consumption.

Dataquest conducted an informal poll of DRAM analysts in Tokyo, London, Seoul, Taipei, and San Jose, California, regarding the critical significance of each alliance in terms of strategic competitiveness and actual or prospective market impact. Table 2 shows Dataquest's perspective on the most significant worldwide DRAM alliances.

Tables 1 and 2 build on a mass of information and insight. Using that informational mass, this

Table 1
Worldwide DRAM Technology Alliances

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances	
Supplier	Second-Source Agreements	Fab Agreements	Joint-Venture Agreements	Fab Agreements	Joint-Venture Agreements	Joint Development
Goldstar		Vitelic-MOSel				
Hitachi	Goldstar (LA)		Goldstar		Goldstar (LA)	
Hitachi						TI (and 64Mb DRAM)
IBM			Siemens (JD)			Siemens (and 64Mb DRAM)
IBM			Micron (LA)			
Matsushita		Intel (also Sales Agency Agreement)				
Micron	Sanyo (64Kx16 device)					
Motorola	Goldstar (based on Toshiba DRAM design)					
NMB			Hitachi (OEM arrangement based on Hitachi production technology)			
NMB			Ramtron International (JD)			
NMB					Ramtron	
Oki	SGS-Thomson (LA)		SGS-Thomson		SGS-Thomson	
Oki				Vitelic-MOSel	Vitelic-MOSel	
Samsung	Intel (OEM)					
Sanyo			Mosaid			
TI			HP-Canon-Singapore		HP-Canon-Singapore	
TI			Acer			
TI	Mitsubishi					
Thorn-EMI	NMB (LA per Thorn's Inmos-based patent)					
Toshiba	Motorola		Motorola			Motorola
Toshiba	Siemens (LA)					
Wang	Micron (LA re SIMMs organized ×9)					

Definitions/Notes:
FA = Fab agreement: supplier offers fab capacity for partner's product technology. In most cases, the supplier provides fab capacity and produces the partner's DRAM design.
JD = Joint development: the companies jointly agree to develop new products, which may or may not be marketed separately.
JV = Joint venture: the companies form a new joint-venture company to develop, manufacture, and market new products.
LA = Licensing agreement: supplier receives or issues a license to partner for an an up-front fee and/or royalties.
OEM = OEM arrangement: supplier sells product to alliance partner, which is sold under partner's name.
SA = Sales agency agreement: supplier sells its partner's products as either a sales representative or a value-added reseller.
SS = Second-source agreement: the companies agree to develop consistent specifications to ensure a second source.
Source: Dataquest (December 1991)

Table 2
Top Worldwide DRAM Alliances

Strategic/Competitive Significance	Market Impact (Current/Potential)
1. IBM/Siemens; Texas Instruments/Hewlett-Packard/ Canon/Government of Singapore	1. IBM/Siemens
	2. Texas Instruments/Hewlett-Packard/Canon/ Government of Singapore
3. Toshiba/Motorola	3. Hitachi/Goldstar
	IBM/Micron
4. Hitachi/Goldstar	Texas Instruments/Acer
Hitachi/Texas Instruments	Toshiba/Motorola
Texas Instruments/Acer	

Source: Dataquest (December 1991)

article analyzes the top half-dozen worldwide DRAM pacts regarding what each alliance partner gives and receives from the alliance—or does not give nor receive—with a focus on the long-term market implications for both DRAM users and IC suppliers.

IBM/Siemens

In terms of both strategic competitiveness and potential market impact, Dataquest analysts view the IBM/Siemens joint-development alliance on 16Mb and 64Mb DRAMs as the *most* significant alliance shown in Table 1. On July 4, 1991, these two global giants extended their prior 64Mb DRAM joint-development program to joint manufacturing of the 16Mb device, and the market continues to reverberate.

What the Partners Give and Get

This section examines the "give and gets" of the IBM/Siemens alliance. Readers should note in general that the items exchanged in many of the DRAM alliances shown in Table 1 sound similar (for example, process technology, risk reduction). The common strategic threads will be noted in the alliance assessments; however, this article spotlights unique or special alliance factors whenever possible.

IBM: Reducing Technology Dependence

IBM Corporation provides three tangibles for the 16Mb DRAM alliance: the basic device design; the 0.5-micron process technology (which runs on 8-inch wafers); and the fab in France. Siemens AG's practical contributions include capital and engineering talent—the latter for translating IBM's proprietary design into a product suitable for European and worldwide merchant market consumption (for example, an eventual shrink version).

What does IBM receive? Some practical elements have been indicated: an estimated 50 percent contribution by Siemens on fab costs and risk-sharing by Siemens on merchant market technology development. IBM is also likely to receive a supply of 16Mb devices starting next year for systems such as the PS/2 line.

IBM aims for key long-term strategic benefits. First and foremost is a counterbalance in Europe—and, perhaps, eventually North America—to Japan's worldwide strength in DRAMs. Second is an evolution by IBM, which is an internal DRAM supplier as well as user, toward a global shared fab strategy, perhaps allowing for entry into the merchant market.

Siemens: A Stake in the DRAM Merchant Market

What does Siemens get in exchange for its capital and clout in European and other merchant markets? Siemens' DRAM efforts have been lagging. Now, it should be able to make a timely ramp up during the second half of 1992 in the 16Mb DRAM arena. An unresolved issue is whether Siemens will become an independent DRAM supplier or a supplier of IBM DRAM products.

Eventually, Siemens might be permitted to use IBM's 0.5-micron process to expand its ASIC product offerings. Siemens has received no license, however, to the IBM process to date.

64Mb DRAM Joint Development

The 16Mb manufacturing alliance accentuates the significance of the partner's prior joint-development effort on 64Mb DRAMs. The 64Mb alliance presumably was proceeding favorably, as shown by the dramatic extension to the 16Mb part. The exchange items are similar; Siemens can promise 64Mb DRAM product technology to merchant market customers later this decade. IBM will be assured of supply for internal demand while balancing the strength of Japan-based suppliers.

TI/HP/Canon/Government of Singapore

In terms of strategic competitiveness, Dataquest analysts view the 4Mb/16Mb DRAM joint venture between Texas Instruments (TI), Hewlett-Packard Company (HP), Canon, and the government of Singapore as equal in significance to the IBM/Siemens arrangement. Dataquest analysts consider this arrangement to be second-most significant in terms of current or potential market impact. We believe that this alliance is a unique and perhaps trend-setting global consortium of DRAM users with their supplier.

TI: The Give and Get

Texas Instruments (no mystery) supplies the DRAM technology and runs the Singapore joint-venture fab. The technology for 4Mb DRAMs is a 0.6-micron process using 6-inch wafers; for 16Mb devices, a 0.5-micron process and 8-inch wafers are used. For TI, this alliance conforms with the company's long-term strategy for spreading the risk associated with the volatile international DRAM business. In exchange for DRAM technology and know-how, TI reduces the risk associated with opening its fifth submicron CMOS manufacturing plant in Asia—a costly $300-million-plus venture. Texas Instruments has an option to become the majority partner.

Everyone affected by the DRAM market—users, suppliers, investors, and governments—must prepare for the impact of the strategic alliance megatrends during the rest of this decade.

Besides capital contributions by the partners, the company has some likely—although not assured—major customers for the fab's output.

The alliance also provides TI with an expanded presence for serving users in Asia, including migrating Japan-based customers.

HP: A Network of Strategic Alliances

In addition to customer-name credibility, HP's major contribution to date is advanced customer payments. For HP, the alliance provides a guaranteed supply of DRAMs in line with the company's partnership share (nearly 25 percent) if quality/price conditions are acceptable to HP.

For Hewlett-Packard, the real benefit is linked to the company's worldwide network of strategic alliances. The alliance should strengthen its alliance partners over the long term. For example, TI is one of the leading suppliers of DRAMs to Hewlett-Packard. In turn, HP supplies computer and other systems to TI. Hewlett-Packard and Canon have an alliance in the printer business. The strategic upshot for Hewlett-Packard: The alliance enhances the global position of Texas Instruments—a key North America-based DRAM supplier—vis à vis other world competitors.

Canon: The Other DRAM-User Partner

Like Hewlett-Packard, Canon, the second DRAM-user alliance partner, provides advanced customer payments in exchange for a guaranteed supply of DRAMs given acceptable quality/price terms. In addition to strengthening HP and TI, two long-term alliance partners, Canon's IC manufacturing equipment group is likely to win increased account penetration at TI (and perhaps, over time, HP).

Government of Singapore: A Host of Benefits

The government of Singapore's main contribution is financial and other support. For Singapore, the alliance ensures a share of the joint venture's output of DRAMs to Singapore-based computer companies—a critical need there during periods of spot shortage. The alliance also advances Singapore's CMOS processing technology base for production of memory and ASICs (for example, gate arrays). The alliance puts the tiny city-nation on the global DRAM map.

Toshiba/Motorola

In terms of both strategic competitiveness and current and potential market impact, Dataquest analysts rank the DRAM alliance between Toshiba Corporation and Motorola Inc. as the third-most-significant arrangement. The first version of the alliance was formed during 1986 and expanded toward the end of 1990. Uncertainty associated with an alliance element—Toshiba's rights to Motorola's 68030 microprocessor—has diminished the market impact somewhat. Nevertheless, this alliance of two giants of the IC business, one Japan-based and the other North America-based, has had a direct impact on both DRAM market trends and the global competitive balance.

Toshiba

In this alliance, Toshiba provides the DRAM design and process technology. Toshiba leads the DRAM development efforts including development of the 16Mb DRAM. In exchange, Toshiba receives the right to sell Motorola's 68030 MPU in Japan. Toshiba never received the rights to sell the 68030 (or the 68040) in world regions other than Japan.

For Toshiba, the alliance arrangement enables Toshiba to supply 1Mb DRAMs from Motorola's Scotland fab while avoiding import duty and European reference pricing constraints.

Motorola

In exchange for Toshiba's limited license on the 68030, Motorola has received 1Mb and 4Mb DRAMs from the Tohoku, Japan, joint-venture fab. Motorola resells the product in regions such as North America and Europe. Motorola can produce 1Mb DRAMs in its worldwide network of fabs. The 4Mb DRAM can only be produced in the Tohoku fab. In order to gain worldwide rights to 4Mb DRAMs, Motorola presumably must give Toshiba worldwide rights on the 68030 or 68040.

For Motorola, a key long-term strategic goal of the alliance is acquisition of DRAM technology (for example, 16Mb DRAMs) and manufacturing know-how. An unresolved issue is whether Motorola will develop 16Mb DRAM alone or with Toshiba. For example, during 1991 Motorola and Toshiba terminated plans for a Europe-based DRAM/memory fab on the basis of competitive cost analysis, although other factors such as the 68030 negotiations played a role in the final decision. Nevertheless, Dataquest believes that eventually the Tohoku fab will produce 16Mb DRAMs for Motorola.

Hitachi/Goldstar

Dataquest views the DRAM alliance between Hitachi Ltd. and Goldstar Electronics Company Ltd., which comprises a series of licensing and fab agreements between a first-tier Japan-based supplier of DRAMs and an emerging IC power from Korea, as the third-most-significant DRAM pact in terms of current and potential market impact. The arrangement ranks fourth regarding strategic competitive significance. This agreement represents one of the key alliances between Japan- and Korea-based IC suppliers.

DRAM alliances are not a sign of weakness, but rather a necessary step for survival.

In this alliance, Hitachi provides the DRAM technology, including product design. During 1989, Hitachi designated Goldstar as a second source for Hitachi's 1Mb part, meaning a market boost for Goldstar's advance in global IC markets. In addition to establishing an alternate source for 1Mb DRAMs, Hitachi also receives some supply for resale.

Recently, Hitachi extended Goldstar's alliance to the 4Mb device. The Hitachi/Goldstar alliance is still evolving. For example, the 4Mb arrangement currently carries some of the hallmarks of a fab agreement and of an OEM arrangement. Nevertheless, this alliance is advancing and includes the 16Mb device.

IBM/Micron

Table 2 shows that several alliances tied for third place in terms of current and potential market impact. Dataquest analysts rank the alliance on 4Mb DRAMs between IBM and Micron Technology Inc., two North America-based companies, among those deemed third most significant regarding market impact.

IBM provides the DRAM process technology, which runs on 8-inch wafers. Micron uses its own 4Mb DRAM design, having elected not to develop IBM's proprietary design for merchant market consumption. (Note the challenge for Siemens in the 16Mb arena.) For IBM, the alliance provides another balance to Japan's worldwide DRAM strength: a stronger, competitive, low-cost North America-based supplier of DRAMs.

For Micron, the alliance provides access to IBM's process technology. The alliance also provides the relatively small company, which competes against the global DRAM giants, with a key long-term strategic partner. The agreement is likely to extend to the 16Mb device.

Texas Instruments/Acer

Dataquest analysts rank the joint venture in 4Mb DRAMs between Texas Instruments and Acer Incorporated (Taiwan) as one of the third-most-significant DRAM arrangements in terms of current and potential market impact. The agreement also is tied for fourth-place ranking regarding strategic competitive significance. This agreement exemplifies another key user/supplier alliance—here, between a North America-based supplier of DRAMs and a Taiwan-based user.

Texas Instruments' Role

The "give and gets" for Texas Instruments through this alliance are consistent with those of TI's alliance with HP, Canon, and the government of Singapore. In exchange for its technology, Texas Instruments reduces the risk associated with construction of this $250-million-plus investment. The technology for 4Mb DRAMs is 6-inch wafers based on an advanced CMOS trench-capacitor design. This alliance purposely bypassed the 1Mb part but is likely to be extended to the 16Mb density.

Acer's Role

Acer's contribution will be capital—about 75 percent of the quarter-billion-dollar-plus cost. The joint venture marks Acer's entry into vertically-integrated DRAM production. The real key for Acer: a guaranteed supply (50 percent) of the total output of the joint-venture fab, which should meet a full third of the 4Mb DRAM requirements for this system manufacturer. Past DRAM shortages have played havoc with this company's manufacturing plans.

Hitachi/Texas Instruments

Dataquest analysts view the joint-development agreement for 16Mb DRAMs between Hitachi and TI among the fourth-most-significant DRAM alliances in terms of strategic competitive significance. When Dataquest analysts ranked the alliances, the recent dramatic extension of the alliance to 64MB DRAM—a second source pact—had just been announced. The strategic significance of this alliance between two giants of the DRAM business—one Japan-based and the other North America-based—has presumably increased since the announcement of the 64Mb deal at the end of November 1991.

The exchange items and goals behind this alliance in general are similar to those noted in the other alliance discussions. The bottom line is that both companies want to reduce the capital risk associated with developing new generations of DRAM. Texas Instruments also views DRAM process expertise as a key stepping-stone for technology migration to digital signal processors (DSPs) and other advanced devices. Even so, the current results and evolution of this alliance have in some instances been unique.

16Mb DRAM Joint Development

The Hitachi/Texas Instruments joint-development effort on 16Mb DRAMs led to design of an innovative DRAM package known as the lead on chip with center bond package, which both suppliers will use. By contrast, the 16Mb joint-development agreements resulted in *two* different 16Mb designs: Hitachi's stacked-cell structure and Texas Instruments' trench-based storage cell approach.

64Mb DRAM: A Second-Source Arrangement

The goal of the 64Mb DRAM joint-development effort will be a second-source arrangement. Hitachi and Texas Instruments will develop a common 64Mb DRAM design. They will also use common design automation and the same 0.35-micron manufacturing processing technology. The suppliers will separately engage in mass production and marketing.

DRAM alliances can also be a technology path to other products such as ASICs or DSPs.

As noted, the alliance strategically aims to reduce each partner's financial exposure to the risk of ultimately low-priced DRAM parts that can be exorbitantly expensive to develop. The alliance should also lead the partners to other technology paths for ASICs and DSP chips.

The alliance could affect the course of Japan-U.S. trade. Significantly, Hitachi took a license on Texas Instruments' Kilby patent as part of the agreement. For Texas Instruments, the Hitachi license strengthens the Kilby patent in Japan in face of Fujitsu's ongoing legal challenge.

Dataquest Perspective

Everyone affected by the DRAM market—users, suppliers, investors, and governments—must prepare for the impact of the strategic alliance megatrends during the rest of this decade. Table 1 shows a nearly exhaustive list of DRAM technology alliances between suppliers or suppliers and users, including governments. The alliance table literally grew during the course of this article's preparation as new alliances were announced, extended, or modified.

Dataquest realizes that some alliances will terminate with little impact. As shown in Table 2, however, Dataquest's DRAM analysts in Tokyo, London, Seoul, Taipei, and San Jose now see or foresee sharp market impact and strategic competitive significance from alliances such as the IBM/Siemens pact, the joint venture between Texas Instruments/Hewlett-Packard/Canon/Government of Singapore, the Toshiba/Motorola deal, and the Hitachi/Texas Instruments joint effort.

The economic realities of the 1990s indicate some long-term consolidation of the DRAM supplier base. DRAM alliances are not a sign of weakness, but rather a necessary step for survival. From the supplier side, DRAM alliance participants like Hitachi, Motorola, Texas Instruments, and Toshiba are not the weak of the IC world. Although Dataquest at present anticipates no universal trend toward DRAM user/supplier alliances, Texas Instruments' strategy for Asia—for example, the Acer venture and the Singapore arrangement—emerges as one model for suppliers during the 1990s. DRAM alliances can also be a technology path to other products such as ASICs or DSPs. Readers should note that some of the DRAM players notably absent from Table 1 include AT&T, Fujitsu, Mitsubishi, Matsushita, and NEC.

What is the wild card in this whole set of global DRAM alliances? IBM. As the year 1992 commences, IBM will be changing and assessing or reassessing its many business options. The IBM/Micron deal shows a limit to the impact of IBM's proprietary DRAM technology on the market, but IBM's impact remains significant. Dataquest analysts already foresee significant market impact and strategic competitive effect from the IBM/Siemens alliance, especially in world regions such as Europe and North America. As IBM reshapes its business during 1992 and thereafter, the DRAM market might also be reshaped. ■

By Ronald Bohn

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- Quarterly price survey highlights
- IC packaging trends update
- January *Procurement Pulse*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 16 **November 25, 1991**

Regional Pricing Update

DQ Monday Report Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.19	0.19	0.16	0.18	0.18	0.13
74AC138	0.32	0.34	0.26	0.31	0.34	0.21
74AC244	0.47	0.45	0.36	0.42	0.48	0.34
74AC74	0.25	0.26	0.22	0.23	0.24	0.17
Lead Time (Weeks)	2	3	8	4	5	5
4F00	0.11	0.12	0.09	0.11	0.10	0.09
4F138	0.15	0.20	0.16	0.18	0.20	0.14
4F244	0.22	0.27	0.23	0.27	0.29	0.23
4F74	0.12	0.13	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.19	0.11	0.15	0.14	0.11
CODEC-FLTR 1	2.00	2.50	2.50	2.05	2.15	1.35
CODEC-FLTR 2	4.55	NA	5.00	4.85	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	NA
DRAM 1Mbx1-8	3.95	4.23	3.90	4.40	4.40	3.80
DRAM 1Mbx9-8	39.50	51.88	37.00	39.75	44.00	36.00
DRAM 256Kx1-8	1.73	1.77	1.70	1.43	1.50	1.10
DRAM 256Kx4-8	3.95	4.30	3.90	4.60	4.40	3.80
DRAM 4Mbx1-8	14.75	16.44	16.10	17.78	18.40	14.50
EPROM 1Mb 170ns	3.90	5.00	3.65	4.75	4.00	3.80
EPROM 2Mb 170ns	7.83	11.73	7.10	8.65	8.00	7.00
SRAM 1MB 128Kx8	14.63	16.48	13.40	17.10	18.70	NA
SRAM 256K 32Kx8	4.08	4.19	3.75	4.25	4.80	3.30
SRAM 64K 8Kx8	2.13	1.58	1.90	1.60	1.50	1.20
Lead Time (Weeks)	2	4	8	4	7	3
68020-16	34.50	50.20	29.00	47.25	47.50	NA
80286-16	12.13	13.84	12.00	11.50	12.80	13.00
80386DX-25	147.50	172.94	160.00	189.00	193.00	NA
80386SX-16	50.00	66.87	55.00	58.50	63.20	55.00
R3000-25	127.00	161.82	132.00	NA	NA	NA
Lead Time (Weeks)	6	6	4	NA	NA	NA

Source: Dataquest (November 1991)

Market Analysis

November Procurement Pulse: Business Levels Remain Flat; Inventories See-Saw Below 20 Days

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to both semiconductor users and manufacturers.

Semiconductor Orders Edge Up, but Overall Trend Is Unchanged

Figure 1 illustrates the continued flatness of the current market, as semiconductor orders for November are estimated to be 4.6 percent above October's levels. Correlated with the static semiconductor booking forecast is a relatively flat six-month overall systems sales outlook of positive 6.0 percent, which is down from last month's positive 7.3 percent respective figure. The computer subset of our sample is forecasting positive 5.5 percent growth, slightly down from last month's positive 5.8 percent outlook. If one takes a conservative halving of the current 6.0 percent forecast, a 3.0 percent overall system growth trend from now through April 1992 does not indicate boom times in the short term; yet it still reflects positive growth in an uncertain market.

Overall demand for semiconductors remains relatively flat, and current production levels are more than adequate to match the market slows.

Semiconductor prices continue to slip at a negative 2.6 percent rate, again matching the slow electronic market conditions. There has been some concern in the SRAM market as

Figure 1
Averaged Monthly Semiconductor Orders

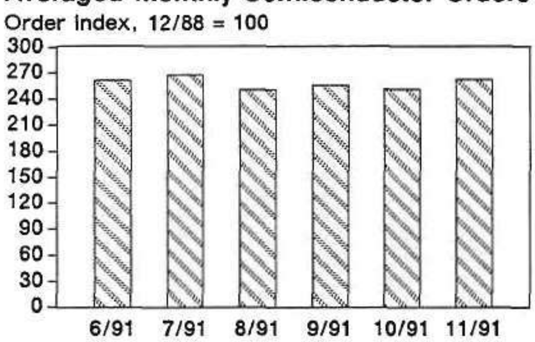


Figure 2
Averaged Semiconductor Lead Times

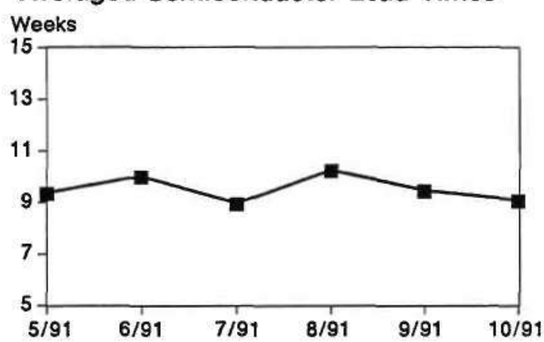


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

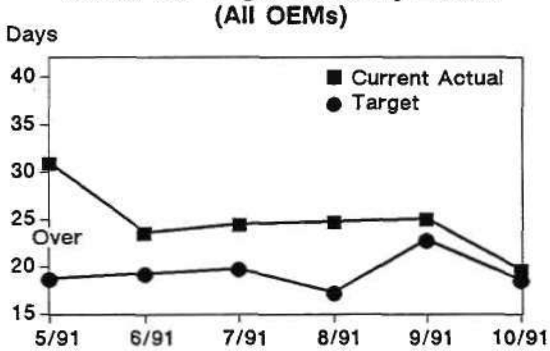
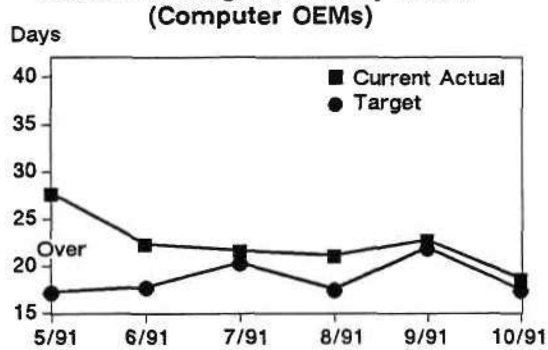


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (November 1991)

slow, low-density (64K, 256K) products have seen some price firming and increased lead times as a result of manufacturers shifting capacity to higher densities. This may be a testing of the market, but it is acknowledged that growth opportunities (and increased margins) are not being realized currently in the low-density slow SRAM market.

Lead Times Currently Down and Stabilizing

Average lead times dipped lower for the second consecutive month, down from 9.5 weeks noted last month to a current 9.1-week interval (see Figure 2). Respondents to this month's survey did note some lengthened lead times for some discrete semiconductor devices and, as mentioned, some low-density slow SRAMs. Aside from these exceptions, availability remains very good for most commodity products. The current soft market continues to be reflected in easy access to ICs at manageable price levels. At the macro level, the overall current and forecast semiconductor capacity situation will allow for shifting of like process capacity to higher-demand products with the end result being overall improved availability.

All Semiconductor Inventories Dip Below 20 Days!!

For the first time in the four years that we have been conducting this survey, *inventory levels (both target and actual) for both overall and the computer subset were under 20 days!* As seen in Figure 3, average overall target and actual inventory levels are 18.6 and 19.7 days, respectively, compared with last month's 22.8- and 25.1-day levels. Figure 4 highlights the fact that the computer group's average target and actual inventory levels went from last month's respective 22.0 and 22.8 days to the current 17.5-day target and 18.8-day actual levels.

The encouraging news is that average low inventory levels are attainable. The question is: For how long?

The combination of cost-cutting demands of the sluggish market with improvements in the majority of semiconductor delivery levels is now being reflected in the current numbers. These historically low inventory levels may rise as business activity picks up; however, for the time being, the current situation points out that, if conditions dictate, inventory control can and will be achieved.

Dataquest Perspective

Inventory levels aside, the basic market dynamics remain relatively unchanged. Overall demand for semiconductors remains relatively flat, and current production levels are more than adequate to match the market slows. As demand picks up, the worldwide capacity now in place and planned for production next year will ensure that availability of product will not be a problem. The encouraging news is that average low inventory levels are attainable. The question is: For how long? Historically, increased business activity and inventory levels have had a positive correlation. The tight level of inventory control now seen is laudable and appears to be made consistently by a portion of our sample. Whether these low levels can be maintained on an overall basis will be tested during the next business uptick. ■

By Mark Giudici

Product Analysis

Users Beware of a Truncated 1.5-Micron Gate Array Life Cycle

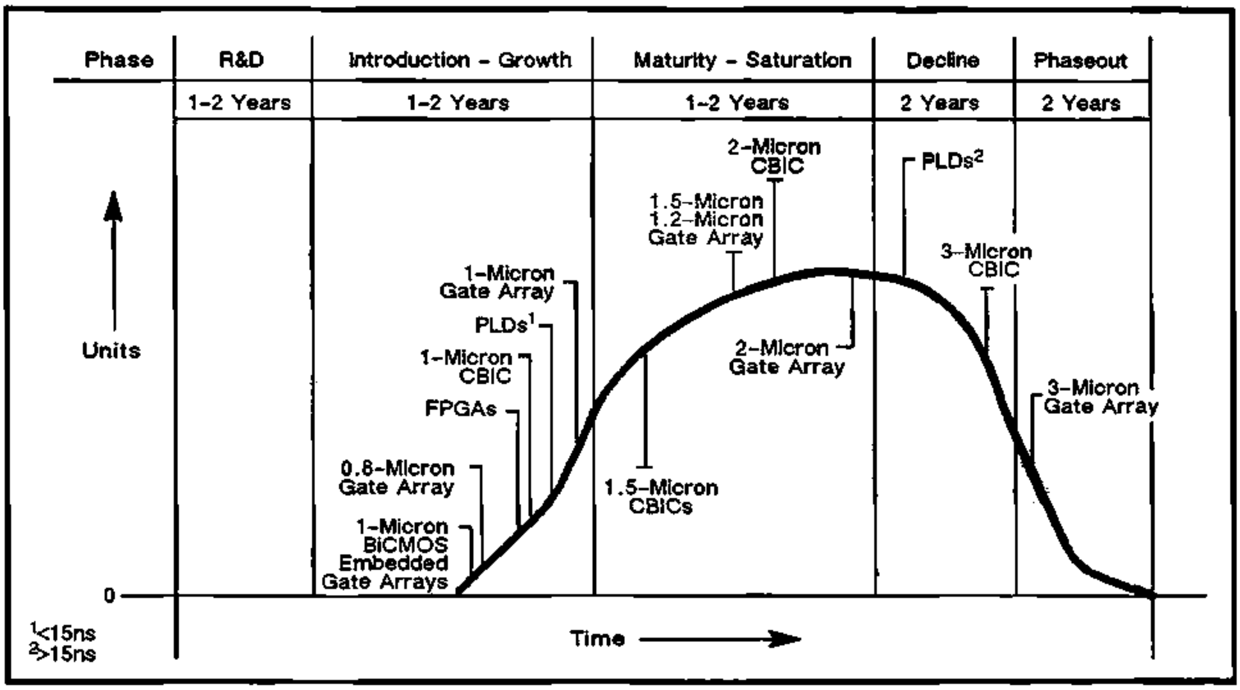
System manufacturers that use 1.5-micron CMOS gate arrays in their products should prepare for the prospect of an accelerated move of this ASIC through the life cycle. Recent research by Dataquest indicates that the array's life cycle may have a sharper slope on the downward side of the curve—meaning shorter maturity and decline stages—vis à vis other ICs like standard logic or PLDs. This article examines the implications for users of a truncated 1.5-micron gate array life cycle.

A New CMOS Gate Array Life Cycle Curve?

Figure 1 shows the ASIC product technology life cycle curve. This figure pertains to production unit volumes.

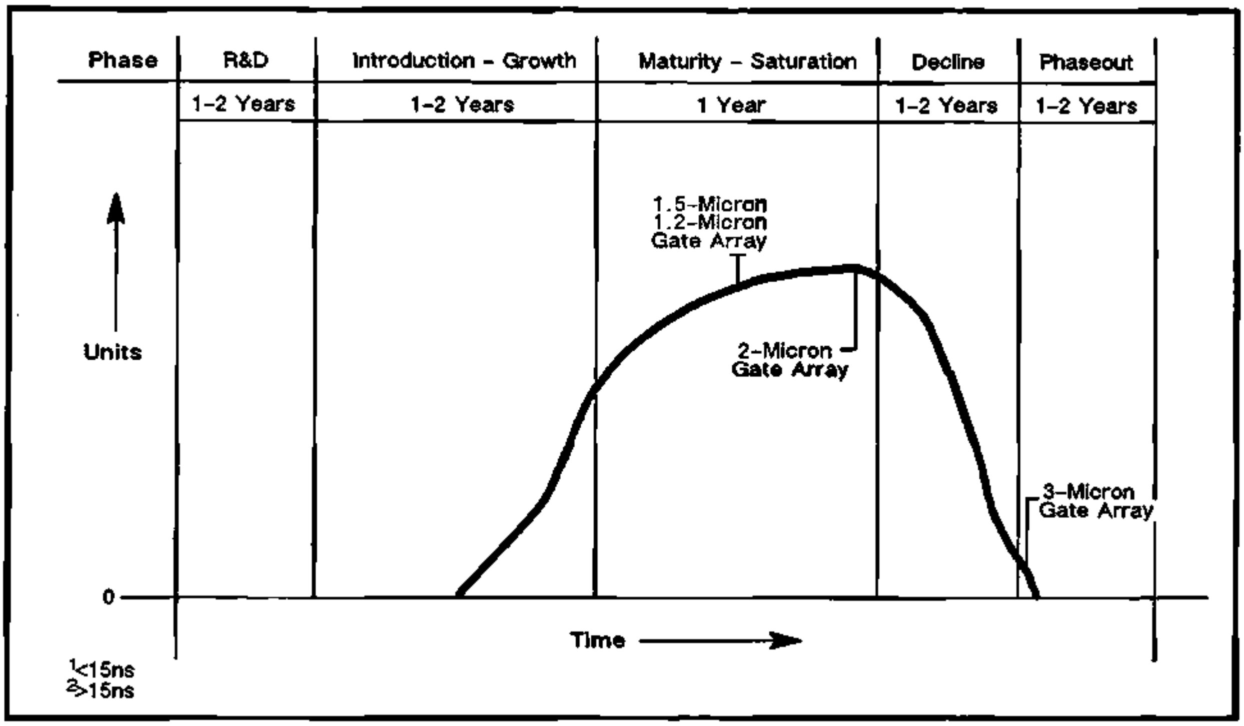
Based on recent research, Figure 2 shows a preliminary projection of how the CMOS gate

Figure 1
ASIC Product Technology Life Cycles as of November 1991
(Production Unit Volumes)



Source: Dataquest (November 1991)

Figure 2
Alternative View: Product Technology Life Cycles as of November 1991
(Production Unit Volumes)



Source: Dataquest (November 1991)

array life cycle (production unit volumes) appears to have compressed in response to intensely competitive market pressures during the past year. The broken line on Figure 2 depicts the curve, *should* the later stages of the cycle prove shorter than originally expected.

Note that attention focuses most pointedly on 1.5-micron and 1.2-micron CMOS gate arrays but also includes the 2.0-micron and 3.0-micron parts. The earlier stages of the gate array life cycle—the introduction and growth stages—do not seem to be an issue.

A key factor driving the 1.5- and 1.2-micron arrays to early oblivion—if in fact this trend persists—is the competitive battle by leading-edge suppliers of 1.0- and 0.8-micron arrays—specifically, sea of gates—to win design-ins for these state-of-the-art product technologies.

What About Other Life Cycles?

The life cycle for cell-based ICs (CBICs) as shown in Figure 1 remains mostly consistent with original expectations. The reason is that CBICs are better suited for more complex functionality including analog, mixed-signal, and/or microperipheral applications. This level of product complexity translates into longer system/CBIC life cycles. A possible exception would be garden-variety 1.5-micron CBICs that lack complex levels of functionality.

Dataquest at this time sees no major change in the outlook for other ASIC life cycles as shown in Figure 1. Nor do we see a sharp change in the outlook for standard logic life cycles. (For the standard logic life cycle curve, see the Semiconductor Procurement *Dataquest Perspective*, Volume 1, Number 2, article entitled "Standard Logic Product Life Cycles.")

Implications for Users

If the life cycle for CMOS gate arrays in line geometries of greater than 1.0 micron does compress—or already has compressed—supply base managers must be prepared to manage the product obsolescence/redesign process during the next year. The supply base management and pricing implications are spelled out in the following analysis.

A Challenge for Buyers

Many users and suppliers of 2.0-micron CMOS gate arrays and CBICs have recommended to Dataquest during the second half of 1991 that the Semiconductor Procurement (SP) service no longer track pricing for these ASICs because they are basically "dead" product technologies. In terms of new designs, this assertion is not so surprising; however, 2.0-micron parts still represent an important market segment in terms of production units for device densities of 20,000 gates or less. For users of 2.0-micron devices, this trend of decreased market interest signals that less consistent or noncompetitive pricing patterns lie immediately ahead.

Users that plan carefully should be able to make an adjustment with minimal supply line adjustment.

More surprisingly, some users and suppliers of 1.5-micron CMOS gate arrays maintain that this product technology is already passé. As indicated, users will soon—perhaps abruptly—be required to make a critical decision whether to migrate to 1.0-micron or submicron devices or to run the risk of encountering the unfavorable pricing/supply base trends typically associated with products in the decline stage of the life cycle.

Even so, not all users or suppliers share the perspective that 1.5-micron gate arrays are approaching the market phaseout stage. For example, Dataquest continues to receive inquiries from buyers regarding pricing estimates for 1.5-micron arrays that are now being designed. In addition, suppliers and users continue to provide Dataquest with competitive pricing estimates for 1.5-micron gate arrays (production unit volume).

Users Beware: Year-End 1991 Decisions May Affect You

Nevertheless, one clear implication of current market trends is that users of 1.5-micron gate arrays should be prepared for a possible abrupt shift in the supplier base. The fourth quarter of each year marks a period for IC suppliers to establish or revise their product strategies and to make changes in the product portfolio. The ASIC business—especially the gate array segment—has been brutally competitive during 1991. Some suppliers are likely to reduce their gate array product offerings as the year 1991 draws to an end and 1992 commences.

The 1.5-micron gate array technology would appear to be a prime candidate for a supplier base cut for two reasons. First, gate array suppliers continue to struggle to earn profits in this highly competitive business—and cutbacks must be made in some product areas. Second, many suppliers want to keep pace with the current shift by some first-tier buyers to 1.0-micron, 0.8-micron, and 0.7-micron devices rather than staying with the older CMOS gate array technologies.

Life Cycle Pricing

Another implication for users of 1.5-micron gate arrays would be less favorable—i.e., less competitive—pricing trends during 1992. In terms of product life cycle analysis, the decline/phaseout stage typically marks an opportunity—although not always in the IC market—for suppliers to stabilize if not increase the pricing profile.

If suppliers migrate en masse from the 1.5-micron gate array arena, the remaining suppliers likely will have less ability—and incentive—to compete aggressively on pricing vis à vis suppliers of 1.0-micron, 0.8-micron, and other submicron designs.

At this time Dataquest is conducting its fourth quarter 1991 price survey which covers the period through 1993. We will keep a close eye on the survey results regarding the choice between 1.5-micron and 1.0/0.8-micron arrays as measured in terms of price per gate and nonrecurring engineering (NRE) charges.

A Long-Term Component Engineering Challenge?

At this time, Dataquest believes that any truncation of the life cycle for CMOS gate arrays would be limited to the 1.5- and 1.2-micron geometries along with the already matured 2.0- and 3.0-micron parts. By contrast, component engineers should anticipate that the life cycle for 1.0- and 0.8-micron gate arrays will remain consistent with the original projections as shown in Figure 1. Why? The average density for these arrays should run in excess of 12,000 gates—with many in excess of 30,000 gates. These complex arrays will entail high NRE charges that now run in excess of $100,000. Once these complex arrays are designed, users will aim at amortizing the NREs over a period of several years.

The upshot for component engineers is that next year supply base managers might encounter an abbreviation of the maturity/decline stages of the life cycle for 1.5- and 1.2-micron arrays; however, the cycle for 1.0-micron and submicron arrays should conform with original expectations as shown in Figure 1.

Dataquest Perspective

Users of semiconductors are accustomed to IC life cycles that can span as long as 20 or 30 years for devices like analog circuits (for example, 741 op amp) or standard logic families (74S). The advent of ASICs during the 1980s brought to the market the other side of the coin—IC life cycles that could end after just five or six years. Users of 1.5-micron gate arrays confront the prospect that the decline/phaseout stage of the life cycle might terminate within one or two years—and not during 1995 or 1996 as originally expected.

The outlook for 1992 remains uncertain, but the size of the supplier base of 1.5-micron CMOS gate arrays is likely to become much narrower soon.

Users that plan carefully should be able to make an adjustment with minimal supply line adjustment. Dataquest recommends that companies that must continue using these devices take the following actions:

- Forge a long-term contract with your supplier—providing the supplier has a viable long-term market position—that assures your company of both unit supply *and* protection for your gate array design
- Target companies (such as National Semiconductor) that supply 1.5-micron gate arrays—as well as larger-size geometries like the 2.0-micron device—for gate counts of 20,000 or less. De-emphasize companies that are targeting very high gate count arrays (for example, sea of gates) and line geometries of 1.0 micron and smaller.

The implications regarding pricing, if any, are unclear at this time; however, the results of Dataquest's current (November-December 1991) quarterly price survey should shed light by year-end 1991. The implications for the supplier base are clearer—but negative. The CMOS gate array supplier has been brutally competitive during the 1990 and 1991 period. The outlook for 1992 remains uncertain, but the size of the supplier base of 1.5-micron CMOS gate arrays is likely to become much narrower soon. ■

By Ronald A. Bohn

Conferences and Exhibitions

Semiconductor Industry Conference '91: A Dataquest Perspective

Semiconductors and Applications

Semiconductor producers will have to compete in a market where their customers' products—computers and electronic equipment—are becoming commodities. They will have to remain technically competitive under an exponentially growing cost curve and at the same time reliably provide the highest-quality products, at the lowest price, on time, with unparalleled service. Similarly, the semiconductor equipment and materials manufacturers will need to work closely with their customers—the semiconductor producers.

> *"So be close to your customer, your customer's customer, and the end user."*
>
> Gene Norrett, Dataquest

Nevertheless, although the market is becoming more demanding, there are opportunities. Portable electronics products, personal communications products, network communications products, and multimedia products offer the best market opportunities. At the semiconductor level, this means that higher integration of functions is how system makers hope to differentiate their products. These topics were discussed at Dataquest's 17th annual Semiconductor Industry Conference held at the Monterey, California, Convention Center on October 14 and 15.

Dataquest's John Jackson, vice president and director of the Semiconductor Group, opened the conference with the observation that it has been a tumultuous year since the last Dataquest Semiconductor Industry Conference in October 1990. The market has been subjected to the whims of war and economic slump as the world experienced the Gulf war and recessions in the United States and the United Kingdom. The collapse of communism in the USSR and the opening of Eastern European borders have placed new demands on the free world economies. Germany, the strongest of the European economies, is fighting an economic slide caused by reunification costs. All of these unforeseen influences have had a dramatic impact on the electronics industry and, subsequently, on the semiconductor and equipment industries.

Electronics Industry Issues

Gene Norrett, Dataquest's corporate vice president and director of Marketing, set the theme for the conference by noting that the electronics industry is in transition, undergoing significant changes. It is maturing and thus requires companies to change how they are doing business, to focus resources on core capabilities, to build functional relationships, and to target the growth markets.

> *"Quality is what your customer says it is."*
>
> Geno Ori, Motorola

Mr. Norrett observed that some of the trends are unsettling. For example, the growth rate for the desktop PC market—one of the largest consumers of semiconductors—is flattening. Mainframes are being impinged upon by workstations, which are also eating into parts of the high end of the PC market, all of which causes a blurring in the distinction between categories.

But there are directions and signposts to point the way through the 1990s. Notebook and hand-held PCs are growing rapidly, and high-performance PCs can compete with workstations. Performance, portability, individual use, communication, integration, and multimedia are all characteristic of the products of the 1990s. Graphically oriented, software-driven, easy-to-use products are what the end users will expect. "So be close to your customer, your customer's customer, and the end user," concluded Mr. Norrett.

The Road to Quality

"Quality is what your customer says it is," commented Geno Ori, Motorola Incorporated Semiconductor Products Sector senior vice president and director of Customer Relations. Mr. Ori recounted that Motorola started the process that ultimately led the company to the Malcolm Baldrige award in 1979. Managers at an annual management meeting were trying to determine how to gain better Motorola acceptance, when one manager noted that the "product quality stinks." Bob Galvin, who was chairman and CEO at the time, made it clear he had a personal and emotional commitment to quality.

Mr. Ori said it was hard to reorient the established company culture, but the company had embarked on an extensive training program. Design for quality, design for manufacturability, cycle time management, and statistical process control became standard courses for employees. Motorola then developed a program to achieve quality. The key elements of the program are as follows:

- Develop a plan of five or six easily understood pivotal strategies
- Develop a formal or informal organizational structure to implement the plan
- Set goals to improve quality tenfold and when achieved, do it again
- Focus on the market and the customer
- Place services and support closer to the customer
- Develop a common system of vendor evaluation for the company's worldwide procurement organization
- Develop a worldwide communications capability

Out of the program came the goal of Six Sigma, which amount to 3.4 defects per 1 million opportunities. This objective is applied to all company operations including administrative processes, as well as design and manufacturing processes. Mr. Ori also said that it is essential to develop communication between the company and customer at all levels. "If we can have a two-day monthly (accounting) closing, why can't we share how we do that with our customers? It's getting together to solve a common problem," Mr. Ori said.

Evaluating Suppliers

One ingredient in achieving quality is through the suppliers. Gene Richter, executive director of Corporate Procurement for Hewlett-Packard (HP) Company, described how HP developed an extensive supplier-measurement system. He noted that some suppliers appear to have a short-term view of supplying customers. " 'Tell me how I'm measured, and I'll tell you how I behave' is how many suppliers seem to react," said Mr. Richter. This apparent attitude indicates a lack of consistency in service and product quality, he observed.

HP holds regular periodic, aggressive proactive evaluations that involve the management of both companies. The company evaluates semiconductor suppliers on technology, quality, responsiveness, delivery, and cost. Suppliers are scored in each category and compared with other suppliers of the same product types. Without disclosing competitors' names, HP shows each supplier where it ranks among all the suppliers. Mr. Richter outlined the following expectations for each category:

- Technology expectations
  - New technology
  - Mutual engineering
  - Commitment to R&D
- Quality expectations
  - Process control
  - Demonstrate product reliability by test as requested
  - Documentation—Advance notice of process/product changes
  - Responsiveness to alerts and corrective action requests
- Responsiveness expectations
  - High-level management commitment to HP
  - Effective worldwide factory and field support for all HP entities
  - Long-term product support
  - Flexibility to changes
- Delivery expectations
  - On-time delivery
  - Lead time
  - Packaging
  - Backup shipment strategy
- Cost of ownership expectations
  - Worldwide price leadership
  - Continuous cost reductions through process improvements

Semiconductor Manufacturing

SEMATECH is alive, well, and making significant contributions, reported Dr. William Spencer, SEMATECH president and CEO. However, the United States is facing a serious uphill struggle.

Manufacturing is a major technical issue facing U.S. industry today. About 30 percent of the automobiles across the United States are of foreign manufacture; in California, the percentage rises to 50 percent. All consumer electronics come from outside the United States.

From being the largest manufacturer in the world, U.S. manufacturing has declined to where the country is manufacturing only 25 percent of the goods consumed here, reported Dr. Spencer. Even if the foreign goods are produced in the United States, the money goes to Japan. Only 1 U.S. bank is in the top 40 banks worldwide.

SEMATECH was formed to address the premanufacturing issues of manufacturing infrastructure and quality management. It will meet all its objectives by the end of 1992, said Dr. Spencer. But the SEMATECH demise, reported by one newspaper, is premature because of the rapid rate of technology change. Of all the accomplishments, the building of cooperation is the most important. This is a forum for the exchange of ideas.

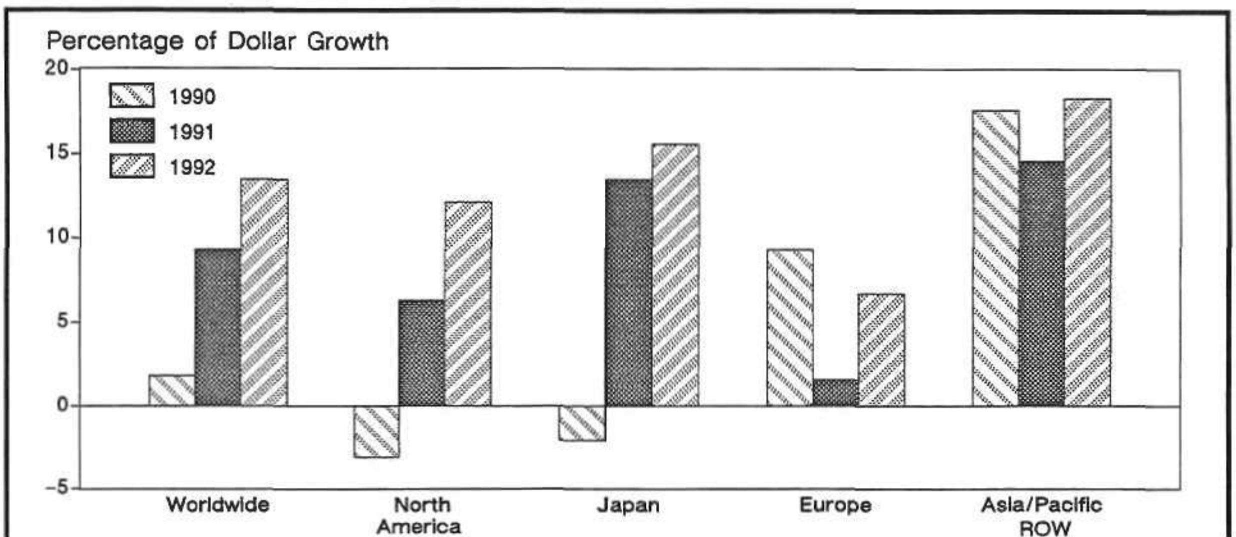
Dr. Spencer forecast that in the next century, a fab will cost over $2 billion; and with the manufacturing efficiencies of these megafabs, only about two dozen will be needed. He believes that niche markets will no longer be safe because more capable tools will be able to produce full-custom products in zero time. What SEMATECH is striving for is to accelerate technology, to reduce the current three-year development cycle to two years in order for U.S. companies to be competitive in the semiconductor market.

The Semiconductor Outlook

Jerry Banks, Dataquest principal analyst and director, reported that semiconductor consumption would grow 9.3 percent in 1991 and 13.5 percent in 1992. The near-term growth is driven by forecast economic recoveries in both the United States and the United Kingdom, together with strong economies in the major electronic equipment-consuming countries. Dataquest expects the semiconductor market growth rate to peak in 1993 at 15.7 percent. The overall forecast compound annual growth rate (CAGR) for the period of 1990 to 1995 is 11.8 percent—a far cry from the 19.1 percent achieved during the five-year period of 1985 to 1990.

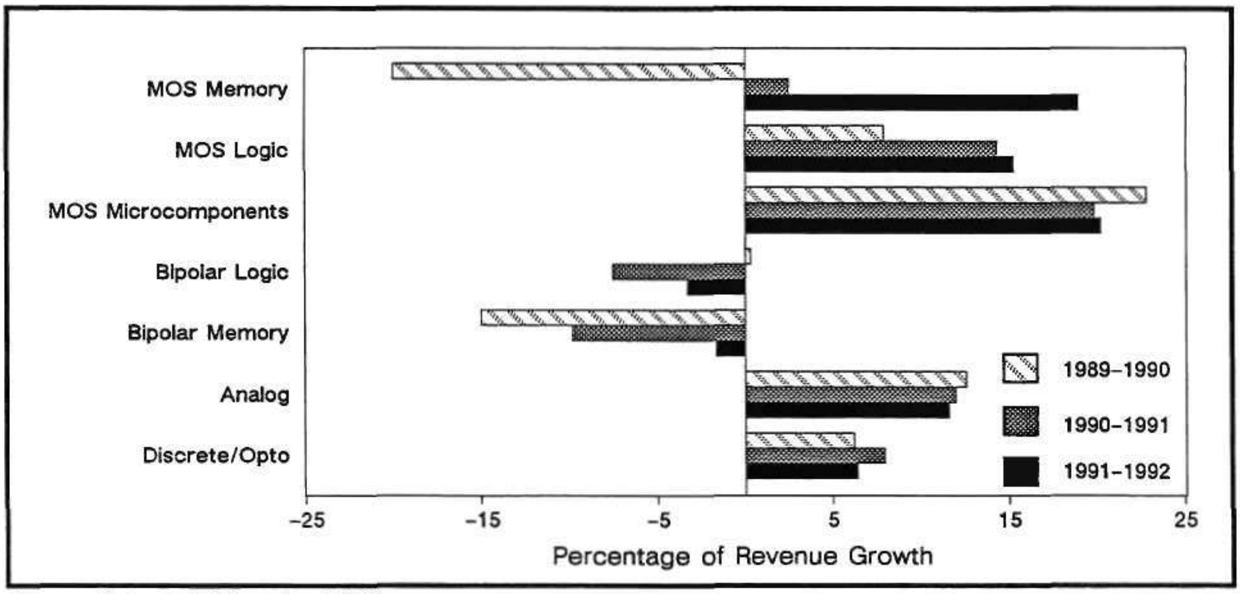
Although the semiconductor market is showing signs of maturing as shown in Figure 1 (evidenced by a slower CAGR through 1995), strong absolute dollar growth will still occur on an annual basis. As seen in Figure 2, Dataquest is forecasting that semiconductor consumption will surpass the $100 billion mark in 1995. The real challenge in the 1990s is not just how to grow revenue but rather how to achieve profitability.

Figure 1
Worldwide Semiconductor Revenue Growth Forecast by Region



Source: Dataquest (November 1991)

Figure 2
Semiconductor Product Growth Forecast



Source: Dataquest (November 1991)

Networking for Competitive Advantage

In the past, companies were vertically structured organizations, reported Stan Bruederle, Dataquest vice president and director, in his talk entitled "A New Way of Looking at the Electronics Industry—Networking for Competitive Advantage." "My objective is to suggest that we are moving from what I would call a vertically structured industry, with large companies supported by a network of suppliers of raw materials competing against each other, to what I would call a networked structure. This is where groups of specialized companies form alliances with other specialized companies to address an array of market opportunities."

> *"Multimedia is the third wave of computing."*
>
> Marc Canter, MacroMind

Mr. Bruederle observed that companies with flexible alliances, as opposed to vertical structures, are rapidly gaining market share against the vertical organizations. He cited Apple Computer Inc., Compaq Computer Corporation, and Sun Microsystems Inc. as examples of companies that had rapidly increased market share by using a network strategy. They depend on outside companies for some of the capabilities they sell or use within their systems.

Mr. Bruederle said that as the result of the commoditization of computers, companies are beginning to change the way they view their businesses. What is happening is that the decreasing price of the commodity products opens the opportunity for new applications. Computer companies are being challenged to behave more like consumer electronics companies. Because few companies can compete in all applications, develop all the needed technologies, or operate effectively in all the distribution channels, it is necessary to build network alliances. Such networked companies, Mr. Bruederle believes, will continue to grow and prosper.

Multimedia

"Multimedia is the third wave of computing," declared Marc Canter, founder and president of MacroMind, a seven-year-old multimedia software company. "The first era was the text-based era. The second era of computing was the graphical user interface—what we call the GUI era. Finally, we are heading into the third era of multimedia computing, in which the computer will have video, animation, and sound. It will be pen-based, it will be portable, it will be on a network, it will have a very fast SCSI on it, and it will have more mips and storage than you know what to do with."

Mr. Canter said that the technology needed for multimedia is here today. The problem with computers is that they are hard to use. The way the human adapts to the software is the key point where man and technology come together. The kinds of hardware Mr. Canter considers necessary, besides higher-speed processors and more memory, are stronger graphics and networking capabilities. Also, he believes that standards need to be refined—software standards, interface standards, digital/video standards, and digital/audio standards.

Mr. Canter observed that in the computer industry, 80 percent of all money is spent on hardware, 15 percent is spent on software, and 5 percent is spent on repair and maintenance. He contrasted this to the entertainment industry where the TVs, VCRs, CD players, and stereo systems command a far smaller percentage of the total industry income compared with the entertainment media—the content of a CD or VCR tape. In the computer industry, the content, or data, has had little value. With multimedia, he suggests that the value will be in the content; that there is already a merger in progress between publishing and entertainment; and that the real money will come from the content of the interactive CDs or other media.

Communications Trends

Stagg Newman, assistant vice president of technology of Pacific Telesis Group told conference attendees that personal communication, image communication, and distributed processing are the drivers for communications equipment into the future. The four enabling technologies that will allow the move to the future are already here. They are digitization, speech and image processing, fiber optics, and intelligent control. He demonstrated the difference in audio transmission a decade ago, the present, and the future with Integrated Services Digital Network.

> *"The tetherless communications systems will be good for the semiconductor industry."*
>
> Stagg Newman, Pacific Telesis

Having different phone numbers for office, fax, secretary, home, telex, e-mail, and cellular telephone can become confusing and cumbersome. Mr. Newman thinks that we are rapidly approaching the time when people will be issued one identifier number. Through that number, the system would be able to track us from place to place, city to city, or around the world. The future system will provide call directing, provide call screening, and allocate the billing. Also, he foresees scratch pads that send messages, wireless telephone exchanges in businesses, cellular notebook PCs, and video pagers.

The tetherless communications systems will be good for the semiconductor industry, said Mr. Newman. Telephones will need more processing power and sophisticated ASICs. He noted that the growth rate for communications chips is strong and will continue to be strong.

Matching User Needs

Dataquest's John Jackson moderated a panel that discussed the topic entitled "Direction of Strategic Semiconductors: Will they Match User Needs?" The panelists were Wilf Corrigan, chairman and CEO of LSI Logic; H. Egawa, senior vice president and director of Toshiba Corporation; Craig Barrett, executive vice president of Intel Corporation; and Morris Jones, senior vice president of Chips & Technologies Inc.

> *"Product flexibility is going to be critically important."*
>
> Morris Jones, Chips & Technologies

Mr. Corrigan saw the current market condition as an illustration that there is not only an excess capacity of semiconductors but also an excess of technological capacity. "The issue over the next five years is that the semiconductor technology is actually running ahead of the applications, and, to some extent, the user base is awash with semiconductor technology," he said. "I think the problem really is creating the needs for the technology rather than the silicon technology responding to the needs of the customers. Because, if the customer can define it, one way or the other, the semiconductor industry can produce the silicon in relatively short order. It only needs the definition of the need."

"Product flexibility is going to be critically important," said Mr. Jones. He thinks that many customers find themselves in the quandary of whether to use existing standards, although they may not precisely meet their needs, or go for their own specific ASIC solution with its higher risk. He believes that part of the answer is that the strategy of the future will have software as an integral part of the solution to add flexibility. "Most future products that we look at implementing and designing are far too complex to be done in hardware alone," he said. "At Chips, we view that the future products will be highly integrated single-chip products, and they are going to offer ranges of flexibility through both hardware and software microcode."

> *"We will have 100-million-transistor logic chips by the year 2000; we will probably have billion-transistor memory chips or gigabit memory chips by the year 2000."*
>
> Craig Barrett, Intel

Mr. Barrett said, "I see our challenge as twofold: we can either sell commodity products . . . those products that other people can manufacture that are either identical to or the equivalent of. The option that you have is to add some value to the transistors you make, and then get value-added pricing rather than manufacturing pricing." He identified four ways to add value: applications expertise gained from customers and end users, an efficient product design, a leading-edge fabrication process, and the upgrade and add-on distribution channel. He also commented that the semiconductor industry was on a technology treadmill—that the pattern of doubling transistor density every year to year and a half on a chip of silicon was true. "We will have 100-million-transistor logic chips by the year 2000; we will probably have billion-transistor memory chips or gigabit memory chips by the year 2000. But the object for us, as manufacturers, is to figure out how to add value and get a differentiated price for it."

Mr. Egawa noted that memory is a typical commodity product with a large market, but a difficult product area in which to maintain a stable business. He noted that the DRAM product line had strong growth through 1988, but it has slowed somewhat in the period of 1988 to 1991, and he thinks it will be even slower through 1995. The forecast is ". . . for stable growth of the DRAM business for the years 1991 to 1995. But the stable business of the DRAM is never realized." The only solutions he sees are for partnerships to be formed between vendors and customers that would allow closer monitoring of production, or to differentiate products for specialty applications.

Investor's Perspective

Tom Thornhill, vice president and semiconductor analyst for Montgomery Securities and luncheon speaker for the conference, noted that his perspective on the industry focused on where value is created, where it is added, how it can be defended, and the investment implications. "The electronics industry, because of the rate of change of technology, is particularly susceptible to shifts in value added," he said.

The ability to add value has shifted away from the PC companies, and their ability to differentiate product has declined. In this market, there has been a significant shift in the balance of value-added from systems companies to semiconductor suppliers. Mr. Thornhill commented that perhaps there had been even a larger shift to the software suppliers.

As more systems features are integrated on the silicon with the processor, it is the silicon supplier that increasingly defines the largest element of value-added in the hardware. He questioned whether the component suppliers as a group would be able to capture and hold this value-added element, or whether it will be competed away. "If it can be captured, the semiconductor industry will have the opportunity to earn a return on innovation over the next cycle and significantly increase the average return on capital," said Mr. Thornhill.

Application Markets

Worldwide equipment production is expected to grow from $612 billion in 1990 to $870 billion in 1995—a CAGR of 7.3 percent—reported Greg Sheppard, a Dataquest director and principal analyst. However, the growth will be fairly evenly divided among industry segments, and there will be little shift in the semiconductor distribution, he said.

Nevertheless, Mr. Sheppard does foresee some shift in where companies find their business. Traditional OEMs are beginning to provide the same value addition previously found in the distribution channels and among the value-added resellers. Also, these OEMs appear to be abandoning the bottom part of their vertical integration—making their own electronics—in favor of establishing tight relationships with electronics specialists. For semiconductor companies, this shift means learning where the customers are and where they are going to be in the future as they reposition themselves (see Figure 3).

Data processing—including computers, peripherals, and office automation equipment—should continue to be the largest user of semiconductors (see Figure 4). The second-largest user of semiconductors is the consumer electronics segment. "Even though this is a maturing segment, there is a high enough level of volatility and activity to pay close attention," commented Mr. Sheppard.

The enabling factors and technologies that will allow the electronics industry to advance are as follows:

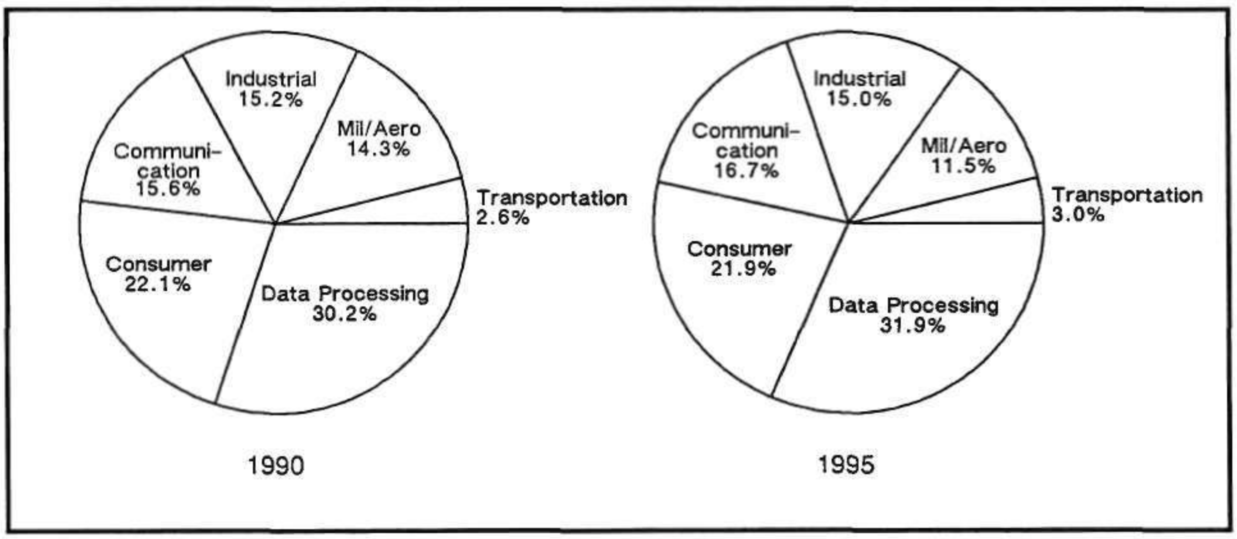
- The refinement of standards, which can trigger new markets and product displacement
- Power management, just now being seen in portable electronics
- Data and image compression for graphics and data storage
- PC cards for mass storage, memory addition, fax, modem, or applications
- Economical flat panel displays
- Handwriting and voice recognition

Mr. Sheppard noted that the market drivers for semiconductors are currently communication and networking, as well as portable and personal computing. He also noted that multimedia is beginning to become a factor. Digital television is beginning to become a reality, illustrated by the fact that digital signal processing (DSP)-like processing is going into current-model TVs. Moving further into the 1990s, personal communications (i.e., the cellular telephones, video pagers, and Dick Tracy-type video wrist communicator), HDTV, and digital photography will grow in significance. Over the horizon are parallel computing, neural computing, artificial vision, and complex speech-recognition applications.

Breakout Sessions

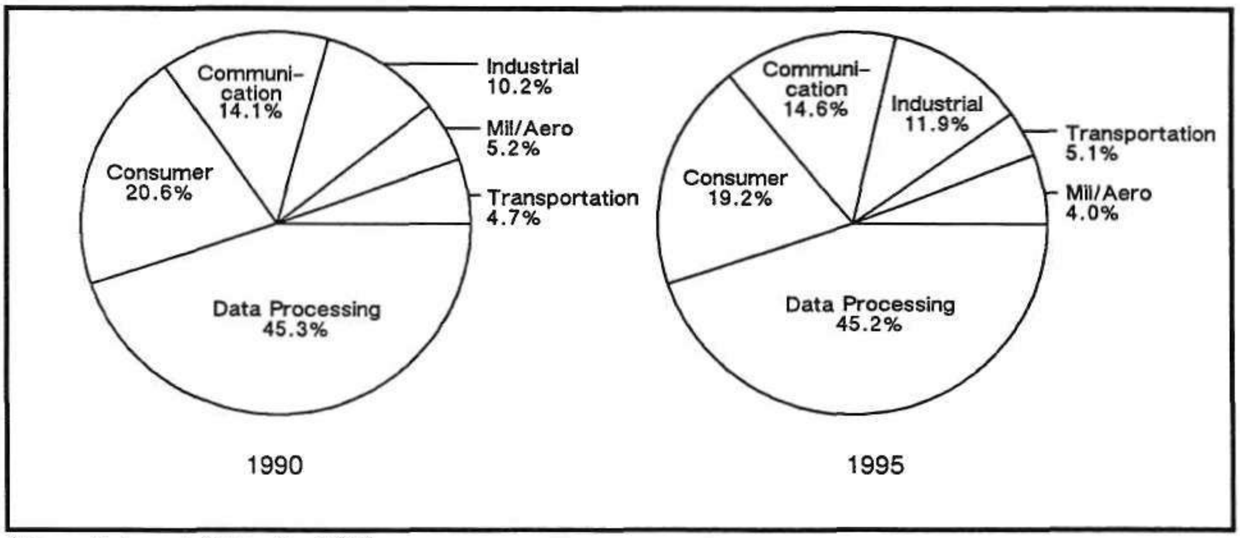
On both days of the conference, the general talks and lectures were followed in the afternoon by breakout sessions to cover subjects in more detail. The breakout sessions of the

Figure 3
Electronic Equipment Production by Application



Source: Dataquest (November 1991)

Figure 4
Semiconductor End Use



Source: Dataquest (November 1991)

first day focused on semiconductor products, manufacturing, and pricing. The individual seminars covered DRAM Device and Manufacturing Trends; ASICs, Tools and Foundry; Semiconductor Pricing and Procurement Trends; and Semiconductor Manufacturing Trends.

The second day's breakout sessions targeted semiconductor application markets, trends, and issues. The individual sessions addressed Personal and Wireless Communication; PCs and Personal Workstations; Mass Storage; and Flat Panel Displays. ■

By Marc Elltot

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective*:

- DRAM alliance update
- Purchasing issues 1992
- December Procurement Pulse

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 15 October 28, 1991

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.19	0.19	0.16	0.18	0.18	0.13
74AC138	0.32	0.34	0.28	0.31	0.34	0.21
74AC244	0.47	0.45	0.36	0.42	0.48	0.34
74AC74	0.25	0.26	0.22	0.23	0.24	0.17
Lead Time (Weeks)	2	3	7	4	5	5
4F00	0.11	0.12	0.09	0.11	0.10	0.09
4F138	0.15	0.20	0.16	0.18	0.20	0.14
4F244	0.22	0.27	0.23	0.27	0.29	0.23
4F74	0.12	0.13	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.19	0.11	0.15	0.14	0.11
CODEC-FLTR 1	2.00	2.50	2.50	2.05	2.15	1.35
CODEC-FLTR 2	4.55	NA	5.00	4.85	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	NA
DRAM 1Mbx1-8	3.93	4.23	3.92	4.40	4.40	3.80
DRAM 1Mbx9-8	39.25	51.88	35.00	39.50	44.00	36.00
DRAM 256Kx1-8	1.70	1.77	1.65	1.43	1.50	1.10
DRAM 256Kx4-8	3.93	4.30	3.92	4.60	4.40	3.80
DRAM 4Mbx1-8	15.00	16.44	16.20	17.95	18.40	14.50
EPROM 1Mb 170ns	3.95	5.00	3.65	4.75	4.00	3.80
EPROM 2Mb 170ns	7.85	11.73	7.10	8.65	8.00	7.00
SRAM 1MB 128Kx8	14.88	16.48	13.40	17.10	18.70	NA
SRAM 256K 32Kx8	4.08	4.19	3.45	4.25	4.80	3.30
SRAM 64K 8Kx8	1.90	1.58	1.65	1.60	1.50	1.20
Lead Time (Weeks)	2	4	4	4	7	3
68020-16	34.75	50.20	29.00	47.25	47.50	NA
80286-16	12.50	13.84	12.00	11.50	12.80	13.00
80386DX-25	152.50	172.94	160.00	189.00	193.00	NA
80386SX-16	50.00	66.87	55.00	58.50	63.20	55.00
R3000-25	127.00	161.82	132.00	NA	NA	NA
Lead Time (Weeks)	6	6	4	NA	NA	NA

NA = Not available
Source: Dataquest (October 1991)

Market Analysis

October Market Watch: Inventories and Business Now Flat; Some Positive Signs Noted

The *Market Watch* is a monthly Dataquest report that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Steady As It Goes . . . Bookings and Billings Averages Are Static

As Figure 1 illustrates, the book-to-bill ratio for September remained at a low of 0.94 following two below-parity months of this key index. The actual average booking and billings totals for September reflect a relatively unchanged picture since last month, with the three-month average booking level up a positive 0.2 percent and the corresponding average billing level up 1.0 percent over August. The flattening of order dollars ties in with the static price situation analyzed later in this article. Unit shipment levels appear to remain flat with inventory control, ensuring that order rates mirror system booking levels. Based on discussions with key users, we expect semiconductor order rates to remain relatively flat over the next quarter as the uncertain market conditions get worked out.

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

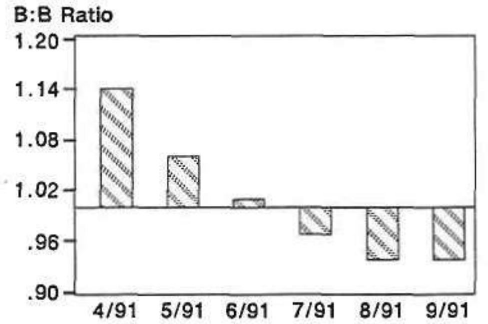


Figure 2
DOC Computer Demand

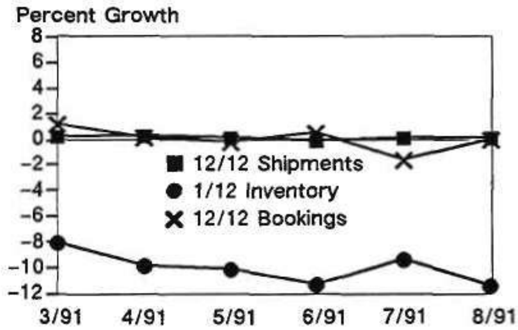


Figure 3
Semiconductor Inventory Level

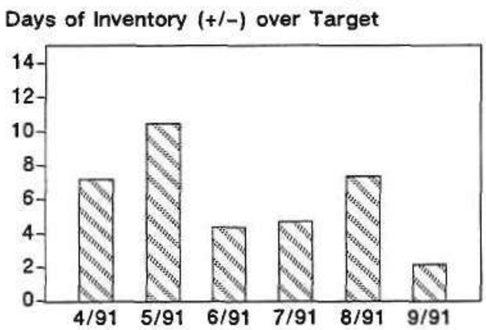
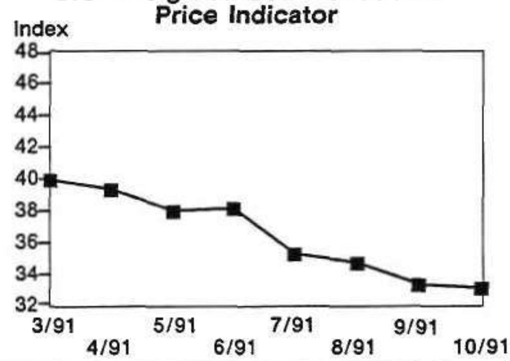


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (October 1991)

Computer Orders Pick Up Slightly; Billings Remain Flat

The annualized 12/12 rate of change for computer bookings rose above 0 percent growth to a positive 0.1 percent for the month of August. Combined with a flat 12/12 shipment rate of change of 0.2 percent and a drop in the 1/12 inventory rate to a negative 11.3 percent, the market for computers still reflects the slow/no growth equilibrium that began earlier this year (see Figure 2). As a result of the fierce price competition now going on, incremental increases in computer unit sales are not likely to affect the annualized dollar shipment rate in the near term.

The overall market remains pensive—low inventories, flat/declining prices, and flat demand have become the accepted norm.

The new product announcements made this month may spark business levels upward, but these results will not be reflected in the Department of Commerce's numbers until late in the first quarter of 1992. Until then, although the ingredients exist for a business turnaround, assuaging customers' anxieties and meeting/exceeding their needs is the first priority now for suppliers.

Semiconductor Inventories Within Two Days of Target!

Figure 3 highlights that the difference between actual and targeted inventory levels for September was the lowest noted over the past six months (only 2 days!). The targeted inventory level for September rose to 23 days from the low point of 17 days noted in August, while the actual level remained at a flat 25 days. The actual inventory level has not changed for three consecutive months now, reiterating how well inventories are being managed in this flat market. The rise in average target levels appears to be an adjustment to better reflect an achievable goal versus a difficult-to-meet ideal. Forecast accuracy continues to be getting much attention from system companies as many are now planning next year's volume requirements. Close communication now with suppliers regarding current and future capacity expectations should include contingencies for upturns in business activity that Dataquest expects to see by the second quarter of next year.

Semiconductor Prices Low and Unchanged

The flat pricing shown in Figure 4 reflects a current wait-and-see attitude on the part of suppliers now deciding what levels of semiconductor capacity will be needed in 1992. Supplies of DRAM, SRAM, and 32-bit microprocessors remain abundant, with lead times hovering around an 8-week average. As mentioned earlier, the religion of inventory control is keeping the current ease of availability from becoming an unneeded inventory buildup. The European reference pricing for the fourth quarter appears to be more in line with market dynamics (i.e., no appreciable price increases), and Japanese memory product pricing in the United States seems now to be in line with home market pricing.

The issue of x9 SIMM pricing resulting from the Wang versus Toshiba and NEC litigation will most likely result in a 4 to 5 percent price adder for patent royalties on all x9 SIMMs (including the three-piece solution). Although there currently is some disruption of deliveries for Toshiba and NEC SIMMs, once this premium is absorbed into the average price level, continued price declines are still expected.

Dataquest Perspective

The overall market remains pensive—low inventories, flat/declining prices, and flat demand have become the accepted norm. Although most of the ingredients of an economic upturn in electronics are in place, the mixture for the next cycle is more dependent on software suppliers than hardware companies. In discussions with semiconductor users and suppliers at the recent Dataquest Semiconductor Conference in Monterey, California, the overriding theme was that enabling software needs to be better integrated into product introductions or revisions. Ease of use of existing (and future) system designs appears to be an area of hardware growth that requires increased coordination with software designers. As the economy s-l-o-w-l-y crawls out of its slump, most businesses are poised to take advantage of it. Continued focus on the fundamentals now remains the primary means of surviving until business picks up.

By Mark Giudici

Product Analysis

Mixed-Signal ASICs

Mixed-signal in Europe represents one of the highest growth areas in the ASIC market. Cell-based ICs (CBICs) represented 80 percent of the mixed-signal ASIC market in Europe in 1990. Of the total cell-based IC market, 30 percent was made up of mixed-signal CBICs. Although this market segment is enjoying very high growth, certain factors are limiting it:

- The low number of designers capable of designing mixed-signal devices
- The shortage of mixed-signal design tools
- The high cost of mixed-signal tests

This article examines this high-growth market and analyzes its limiting factors. It also suggests what is needed to overcome the limitations and the possible consequences of any changes.

Definitions

Dataquest's definition of a mixed-signal ASIC is an ASIC device with both digital and analog signal input or output (excluding line driver outputs and single comparator and Schmitt trigger inputs). Mixed-signal ASICs fall into two broad categories. Simple, mixed-signal ASICs use precharacterized cells that can be tested using a digital tester, whereas more complex, high-performance mixed-signal ASICs require a mixed-signal tester. The definition is intended to cover both categories.

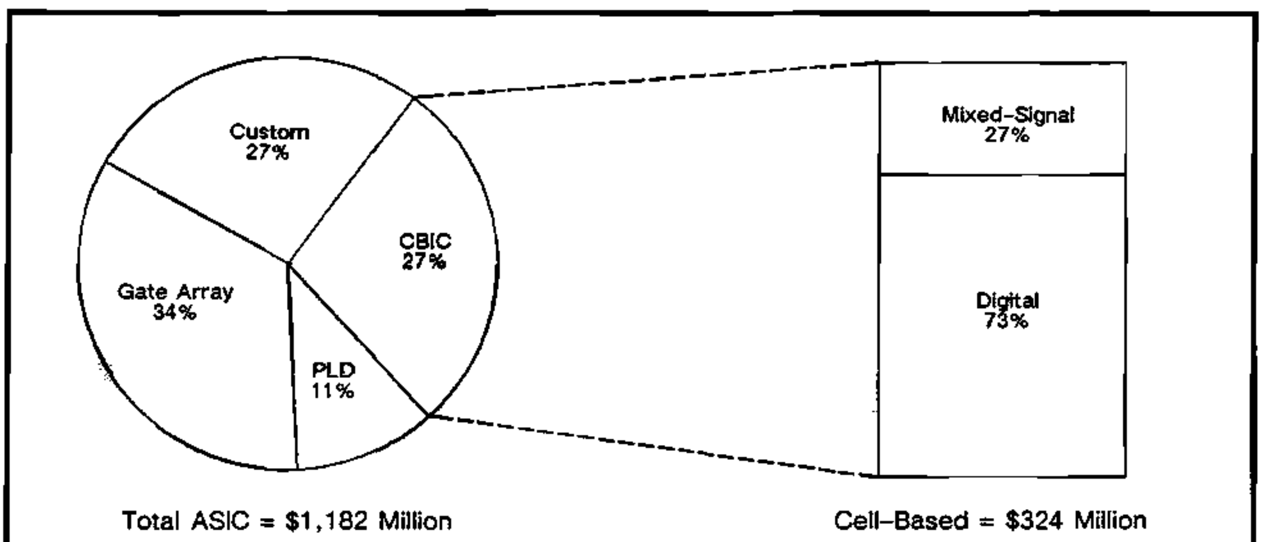
Companies and Markets

The European mixed-signal ASIC market grew to $171 million in 1990, a growth of 68 percent over 1989. This is compared with a growth of 16 percent for the total ASIC market in Europe. Over 80 percent of this mixed-signal revenue was for MOS cell-based ICs. Figures 1 and 2 show that mixed-signal CBIC revenue now represents 30 percent of the total CBIC revenue in Europe, up from 27 percent in 1989. CBIC revenue has also increased its share of the total ASIC market in Europe from 27 percent in 1989 to 33 percent in 1990.

The top 10 mixed-signal ASIC suppliers to the European market are shown in Table 1. The leading supplier, Mietec, grew its revenue because of its presence in the telecommunications market, and specifically because of its involvement with Alcatel's System 12 exchanges. This is a high-growth market where European telecom suppliers are world leaders.

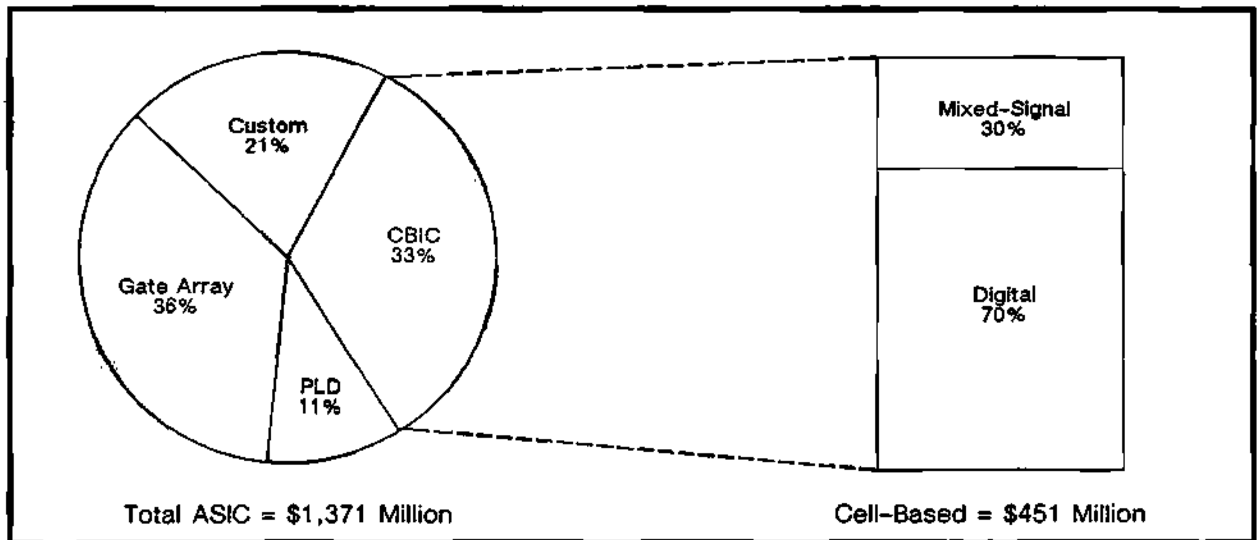
Austria Mikro Systeme (AMS), ranked second, also has strong telecom links and also supports its telecom activity with automotive and industrial applications. Both Mietec and AMS have enjoyed high growth in this market and both companies' success reflects the importance of the telecom, automotive, and industrial market

Figure 1
ASIC Product Split 1989



Source: Dataquest (October 1991)

Figure 2
ASIC Product Split 1990



Source: Dataquest (October 1991)

Table 1
Top 10 Suppliers, 1990 Estimated MOS Mixed-Signal ASIC Revenue

1990 Rank	Company	1989 Sales ($M)	1990 Sales ($M)	1990-1989 Growth (%)
1	Mietec	27	63	133
2	AMS	14	27	93
3	IMP Europe[1]	11	16	45
4	GEC Plessey	0	15	NM
5	Sierra Semiconductors	4	10	250
6	Texas Instruments	6	8	33
7	National Semiconductor	6	6	0
8	Harris Semiconductor	0	4	NM
9	LSI Logic	2	2	0
10	Allegro[2]	0	2	NM

NM = Not meaningful
[1] Now known as Dialog Semiconductor
[2] Previously known as Sprague
Source: Dataquest (October 1991)

segments in mixed-signal ASICs. Figure 3 shows the applications share for both companies' revenue in 1990.

Technical Issues

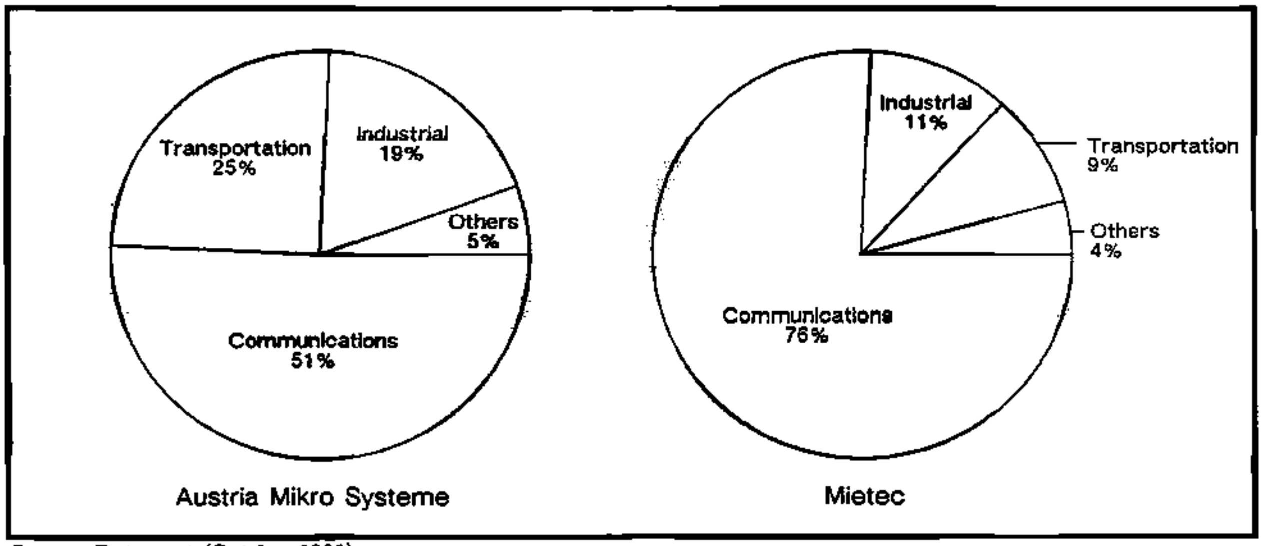
Software

The software used for ASIC design has to date concentrated on digital ASICs. Only three parameters can be varied for digital cells: power, speed, and size; whereas over 40 parameters can be varied for analog cells such as op amps. Thus, design of these cells is much more complex and the software's task much harder, partly explaining why software tools for analog and mixed-signal ASIC design lag behind those of digital design.

The greatest shortfall for software in analog and mixed-signal ASIC design is in the modeling of the circuit. Software tools provide modeling capability, but the models for the cells have not yet been written and matched to the silicon. Development of the models can be very time consuming and so far has been the responsibility of ASIC manufacturers. Simple cell models may require only a few lines of model code description; but to model accurately, an analog cell requires several pages of description. This needs to be repeated for all cells in a cell library, and descriptions also need to be matched to the silicon performance of the cells. At present, there is no method for extracting data for the models automatically from test chips, so all this work requires considerable engineering effort by ASIC manufacturers.

Traditionally, the design of mixed-signal ASICs has been separated into digital and analog components; the two parts are designed separately and then joined together. The software tools also follow this division. Problems arising from the design come from this interface, and most of the reiterations of prototypes are because of this. The digital and analog circuitry interact on the silicon; but because the software tools treat the two parts separately, this interaction is not

Figure 3
ASIC Applications Share 1990



Source: Dataquest (October 1991)

simulated. In addition, techniques used for digital and analog simulation are different, so this also presents interface problems when the two parts are joined. Software companies are working on solutions to these problems, and there are tools that can provide some analysis of the circuit as a whole, rather than as two separate parts. However, the tools are not at a stage comparable to digital design, where automatic generation of large areas of design is possible. We estimate that it will be two to five years before the software is at a level where circuit generation, rather than circuit analysis, will be possible.

The greatest benefit provided by software tools is time. Design time can be reduced significantly through faster and more accurate simulation. If only one iteration is saved by using better software, three to six months can be saved in product development. This saving comes from reduction in redesign, reprototyping, and retesting. With product lifetimes reducing, saving six months can be vital to the profitability of a product.

Test

Testing of mixed-signal ASICs is very expensive; mixed-signal testers cost between $1 million and $4 million. High cost is one reason companies have tried to compromise in their mixed-signal offering providing analog cells that can be tested with a digital tester. For high-performance analog cells, however, this is not possible.

Mixed-signal testing encompasses much more than just generation and application of test vectors. The yield of a mixed-signal ASIC can be improved considerably through careful design of analog cells in a circuit. At prototype stage, the device needs to be sufficiently tested to measure yield improvements when required, so careful test design is necessary. This also applies to digital circuits, but not to the same degree.

A test for a mixed-signal device can take 40 seconds or more because of settling times needed for some analog cells, compared with less than 1 second for most digital ASICs. This long test uses expensive resources and may result in need for additional testers. Complexity of the test program and length of some mixed-signal tests mean that the amount of engineer involvement in test program development is very high, which can limit a company's design throughput. Strategies such as scan- or self-testing give much help in testing digital circuits, but there are no test strategies available yet for mixed-signal ASICs. Therefore, no easy solution is in sight to resolve these issues. Most digital strategies test functionality rather than performance. Analog components need a performance test, so the digital strategies will not work.

Design

Design of mixed-signal ASICs is still very labor-intensive. The software tools provide some support, but not to the same degree as for pure digital ASICs. Because of this, mixed-signal ASIC design is much closer to custom design than to cell-based or gate array. The extensive influence of mixed-signal ASIC design on production and test means that much closer cooperation is needed between customer, designer, and test engineer. Close involvement of the customer in the design process can yield great dividends later. Development of a specification can identify design and test constraints. Intelligent setting of design limits can, for example, mean only a digital tester is used rather than a mixed-signal tester. Engineer involvement can also prevent a design's becoming untestable.

The greatest benefit to a company will come from intelligent use of the design resource, and most of the profit for a mixed-signal design will come from leveraging this design resource. Leverage comes in part from development of a targeted cell library. The most efficient use of a design engineer's time is to develop components that can command high margins or be used many times. A major competitive advantage can be gained in preempting requirements of a particular application segment by developing a cell library in time to make maximum use of future needs.

Dataquest Perspective

The mixed-signal ASIC market is growing at a rate well above the average for the ASIC market as a whole. One factor limiting growth is still design capacity, but it cannot be solved simply by recruitment of more design engineers. Test is also a major limit to the growth of the market. Software tools are improving, but they are still not at the same level as digital design tools. The mixed-signal ASIC market is closer to custom design than cell-based design, so the need is for design expertise from designers. However, improvements in design techniques, manufacturing processes, and software mean that the advantage gained by having an in-house design team will gradually be diminished.

As software tools improve, so will the ASICs they design. Fewer compromises will be made in performance, so additional expertise provided by designers will be needed only for smaller niches such as very high performance ASICs. Then the healthy margins enjoyed by the few mixed-signal ASIC manufacturers will be quickly eroded by companies taking a commodity approach to mixed-signal ASICs. Very high performance mixed-signal ASICs will always be in demand, but few companies will be prepared to pay the high price for them.

Digital cell-based designs required considerable design expertise when the digital CBIC market was emerging. This was also closer to custom ASIC than gate array. Constraints were placed on the design process in layout of the cells and tests that were performed; then cell-based design became easier. Software tools also improved and overcame some constraints previously imposed on design. Mixed-signal ASIC works within few constraints at the moment, which is why the software tools have such a difficult job. Intelligent setting of limits will allow tools to develop and ease the design task for ASIC users, thus opening up the mixed-signal ASIC market. A large number of ASIC suppliers will jump into what was previously a high-margin market. This will force prices and margins down, and mixed-signal ASIC will join digital ASIC in the battle for profits and market share.

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By Mike Glennon

In Future Issues

Articles on the following topics will be featured in future issues of the Semiconductor Procurement *Dataquest Perspective:*

- November *Procurement Pulse*
- Standard logic versus ASICs
- 1991 Semiconductor Conference highlights

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 14 October 14, 1991

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.19	0.18	0.17	0.18	0.18	0.13
74AC138	0.32	0.33	0.28	0.31	0.34	0.21
74AC244	0.47	0.44	0.38	0.42	0.48	0.34
74AC74	0.25	0.25	0.23	0.23	0.24	0.17
Lead Time (Weeks)	2	3	7	4	5	5
4F00	0.11	0.12	0.09	0.11	0.10	0.10
4F138	0.15	0.19	0.16	0.18	0.20	0.14
4F244	0.22	0.27	0.23	0.27	0.29	0.23
4F74	0.12	0.13	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.18	0.11	0.15	0.14	0.11
CODEC-FLTR 1	2.00	2.43	2.50	2.05	2.15	1.45
CODEC-FLTR 2	4.55	NA	5.00	4.38	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	NA
DRAM 1Mbx1-8	3.93	4.11	3.92	4.40	4.40	3.80
DRAM 1Mbx9-8	38.75	50.40	35.00	39.75	44.00	37.00
DRAM 256Kx1-8	1.70	1.72	1.65	1.43	1.50	1.10
DRAM 256Kx4-8	3.93	4.18	3.92	4.60	4.40	3.80
DRAM 4Mbx1-8	15.13	15.87	16.20	18.25	18.40	15.00
EPROM 1Mb 170ns	3.95	4.86	3.65	4.75	4.00	3.80
EPROM 2Mb 170ns	7.85	11.38	7.10	8.75	8.00	7.30
SRAM 1Mb 128Kx8	14.88	16.05	13.40	17.10	18.70	NA
SRAM 256K 32Kx8	4.08	4.07	3.45	4.25	4.20	3.30
SRAM 64K 8Kx8	1.90	1.53	1.65	1.60	1.50	1.20
Lead Time (Weeks)	2	4	4	4	7	3
68020-16	34.75	47.78	29.00	47.25	47.50	NA
80286-16	12.50	13.44	13.00	11.50	12.80	13.50
80386DX-25	152.50	167.97	160.00	189.00	193.00	NA
80386SX-16	50.00	64.95	55.00	58.50	63.20	55.00
R3000-25	127.00	147.45	132.00	NA	NA	NA
Lead Time (Weeks)	4	6	4	NA	NA	NA

NA = Not available
Source: Dataquest (October 1991)

Market Analysis

October Procurement Pulse: Business Levels Flatten as Inventories Are Up and Lead Times Down

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to both semiconductor users and manufacturers.

Another Flat Month of Semiconductor Orders Mirrors the System Market

The overall trend of semiconductor order levels for the last six months has remained relatively flat, as seen in Figure 1. The 1.2 percent drop in our order index ties in with the overall business climate, which is basically in a holding pattern awaiting a turnaround in the economy. The six-month system sales outlook remains relatively rosy at a positive 7.3 percent, slightly lower that last month's 7.7 percent level. The computer subset of our sample has lowered its expectations to 5.8 percent from last month's 7.4 percent, primarily as a result of fierce price competition. Semiconductor prices continue to decline slowly at a negative 1.6 percent rate over last month, again tying in with the overall

Figure 1
Averaged Monthly Semiconductor Orders

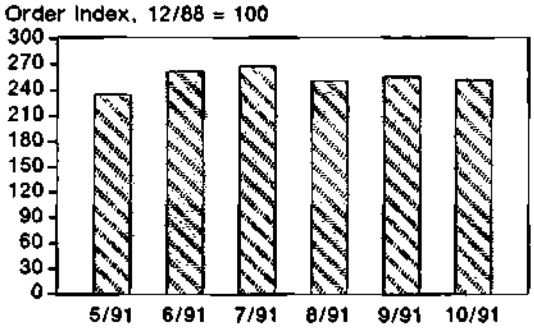


Figure 2
Averaged Semiconductor Lead Times

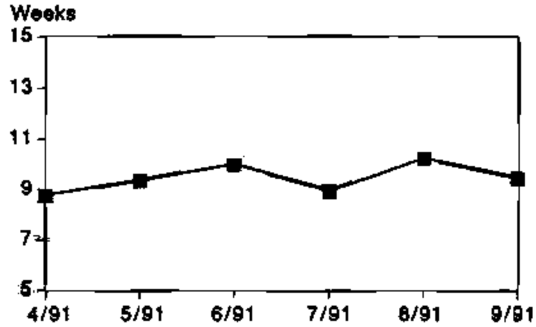


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

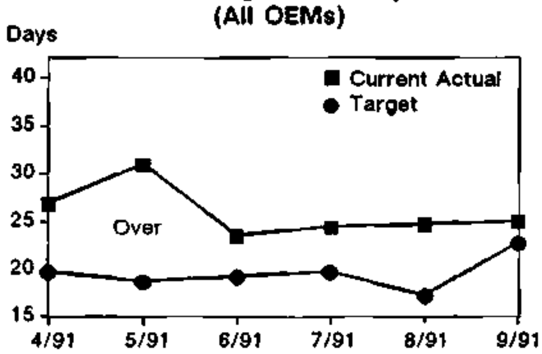
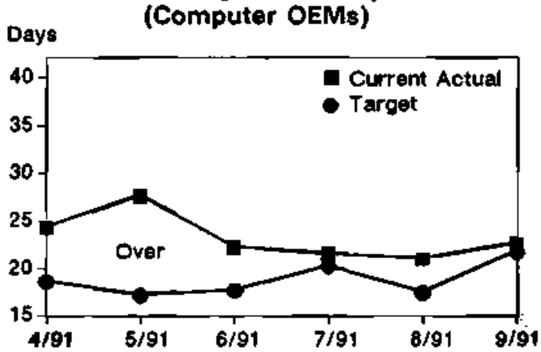


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (October 1991)

balanced market. Due to uncertainty in the direction of 4Mb DRAM demand, some Japanese suppliers are contemplating shifting capacity to consumer products where demand is stronger. If this occurs in aggregate, firming of 4Mb prices as supplies tighten up could undo the economic crossover to the 1Mb device that occurred six months ago. We do not anticipate availability or price problems in the DRAM market because of the growing base of non-Japanese capacity now coming to production.

Lead Times Dip Below 10 Weeks; Availability Remains Good

As shown by Figure 2, the average lead time fell to 9.5 weeks from last month's six-month high point of 10.3 weeks. With a background of steady order levels, the slight blip in lead times seen last month has been adjusted for, and a more historical delivery span is again emerging. Accurate user forecasting continues to prevent delivery delays/extensions with strategic suppliers. Delivery of DRAMs in compliance with the recent U.S.-Japan Semiconductor Trade Arrangement is now well understood and is not causing delivery or price aberrations. Any concerted effort to control supplies of product to firm or raise prices in the current market will result in loss of revenue due to improved competitiveness in both the memory and microprocessor markets. Dataquest still foresees this steady market continuing for the near term as capacity levels of semiconductor suppliers accurately meet demand levels.

Semiconductor Inventories Inch Up Slightly to 25 Days

The slight rise in overall actual inventories (25.1 days versus last month's 24.8 days) illustrated in Figure 3 is actually no change when rounded out. What did change is the overall targeted inventory level that rose from 17.3 days to a historically consistent 22.9 days. This increase reflects a few respondents' raising inventory targets to reachable levels while keeping actual levels under control. A good example of inventory control is shown in Figure 4, where the target and actual inventories of the computer company respondents is less than one day (22.0 targeted versus 22.8 days actual)! As mentioned in earlier *Procurement Pulses* issues, the 20-day targeted inventory level and 30-day actual level appear to be evolving into a respective sub-20-day to sub-25-day target-actual inventory paradigm. Twelve turns of semiconductor inventory remains the aggregate target level as companies maintain cost control measures in the current flat market. We expect to see further improvements in inventory levels as forecasting accuracy improves.

Dataquest Perspective

Although the basic indices have not changed appreciably since our last report (or for the last three months), a slight bit of optimism is seen in the user's outlook. Increased competition in the 32-bit microprocessor market will eventually translate into improved availability and pricing for these parts that, up until now, have enjoyed above-average demand in a flat market. Whether competitive 32-bit MPU pricing will stimulate growth in a replacement systems market (laptop PCs) or create new applications is a hot question now being discussed by many of the support chip suppliers planning capacity levels for next year. The basic fundamentals of forecast accuracy combined with improving availability should allow for sustainable business now in the near term and above-average supplier support over the next 12 to 18 months.

By Mark Giudici

The Single Europe Act Drives Restructuring of Semiconductor Distribution

Considerable acquisition and divestiture activity is taking place among semiconductor distribution companies in Europe at the moment. Both European and U.S. electronics distribution groups have been buying up distributorships in order to expand their positions in preparation for post-1992 Europe. For distributors, the Single Europe Act could mean substantial cost savings. It promises lower distribution costs through centralized warehousing, less expensive transportation, and reduced bureaucracy. The act will also affect how franchises are awarded across the European Community (EC). It will tend to standardize the contracts that distributors have with their franchises and to increase the pressure to move to standard European price lists.

Dataquest believes that some distributors may be setting their expectations too high. There is still much work to be done—in Brussels and throughout the EC—before the Single Europe Act can be fully effective. It may take several more years before the full benefits of a unified European market really will be felt. Also, the act will do little to change the fact that the EC consists of 12 separate countries with individual cultures. The distribution business, which is built on serving local customer needs, will still have to do business at this local level—a fact that non-European companies should particularly bear in mind.

This article includes extracts from a joint Dataquest/Europartners Consultants study on the component distribution market entitled "Worldwide Electronics Components Distribution." It provides an analysis of top European distributors in France, Germany, Italy, and the United Kingdom as well as the leading U.S. distribution companies that are currently engaged in trying to penetrate the European market.

Acquisition and Merger Activity

In the last two years, substantial changes have taken place in the structure of the European electronic components distribution industry; and in the last six months, the pace of change has quickened. These changes have been caused by distribution companies preparing and positioning to compete in a post-1992, unified European market.

In late 1989, the Swiss Elektrowatt Group acquired the Hamburg-based distributor Enatechnik from Unitech, signaling Unitech's final exit from the component area. A few months later, the Swiss Elbatex Group acquired Jermyn in Germany from Lex and, at the same time, Aquitech in France, Omni Ray in Germany, and Veridata in Switzerland. These acquisitions, together with their existing components businesses, are likely to produce a turnover of more than $200 million in 1991. The giant Germany conglomerate Veba, through its subsidiary Rein Electronic, has also embarked on an acquisition plan with its purchase of the Memec Group in 1990. Rein already has substantial electronic sales, principally in the field of computer products.

On the U.S. front, the two major groups in electronic components—Hamilton-Avnet Electronics and Arrow Electronics—have been active in searching for suitable partners in Europe. Of the two, Arrow has been more successful. Two years ago Arrow acquired Axiom, RR Electronics, and Retron from Electrocomponents. It has now built up substantial holdings in Spoerle in Germany and the Silverstar/Lasi group in Italy. In June 1991, Arrow announced the acquisition of all the electronic components activities of the Lex Group in the United States and Canada. With the European component businesses of Lex available for sale, it remains to be seen whether either Hamilton-Avnet or Arrow will purchase them to strengthen its worldwide portfolio. Compared with Arrow, Hamilton-Avnet's activities have been limited. In June of this year, it acquired The Access Group from Diploma in the United Kingdom.

Table 1 shows semiconductor revenue of the top semiconductor distribution groups in Europe and the United States in 1990. From it, the comparatively large size of the two leading U.S. groups is visible. (Complete top 10 rankings are available in the *Worldwide Electronic Components Distribution* report.) Table 2 compares the relative sizes of the leading Western semiconductor distribution markets. The four big European markets total $1,934 million, less than half the size of the U.S. distribution semiconductor market.

Table 1
Estimated Top European and U.S. Electronic Components Distributors

	Sales 1990 (Millions)	Sales 1990 (US$M)	Market Share (%)
France (FF)			
Sonepar	484	89	22
FHTEC	374	69	18
Germany (DM)			
EBV	228	141	24
Spoerle	200	123	21
Italy (L)*			
Silverstar/Lasi	85	71	20
United Kingdom (£)			
Diploma	73	130	22
MEMEC	59	105	18
United States ($)			
Hamilton-Avnet	601	-	13
Arrow	416	-	9

*Billions
Source: Dataquest/Europartners Consultants (October 1991)

Table 2
Estimated Size of Total Semiconductor Distributor Resales in 1990 by Major Country Market

	Sales 1990 (Millions)	Sales 1990 (US$M)
France (FF)	2,200	404
Germany (DM)	950	586
Italy (L)*	425	355
United Kingdom (£)	330	589
United States ($)	4,625	-

*Billions
Source: Dataquest/Europartners Consultants (October 1991)

Regional Markets

Germany

The background to the German semiconductor distribution market in 1990 was one of change. That was the year of German reunification, and, although today the initial euphoria has gone, reunification did result in some positive market forces. The electronics market experienced a boom in demand for consumer and telecommunications goods, which fed through to the semiconductor market, making Germany the strongest semiconductor market in Europe last year. Despite this, the overall distribution market for semiconductors dropped by 1.5 percent in 1990 compared with 1989. This drop was caused primarily by price erosion in commodity memories. Last year, semiconductor manufacturers began implementing initiatives aimed at taking costs out of the chain between manufacturer and end customer. These were primarily focused on stock reduction and are now having a positive affect on distribution sales. Examples of this are National Semiconductor's Prima program and SGS-Thomson and Motorola's market price programs.

The leading semiconductor distributors in Germany are EBV and Spoerle. Together they held 45 percent of a distribution market that was estimated to be worth DM 950 million or $586 million in 1990.

EBV

EBV is the biggest semiconductor distributor in Germany, although in fact it is only the second largest German components distributor overall. The company is also the only major distributor in Germany still in private hands. EBV is primarily engaged in semiconductor distribution, with only a very small systems distribution of VME boards from Motorola. EBV has nearly 180 employees. Because of the private ownership structure of the company, it seldom publishes details of its sales or profitability. We estimate that in 1990 its total sales amounted to DM 250 million, of which DM 228 million was from semiconductor sales. The company has been consistently profitable over the last few years. The forecast for 1991 is for only a slight sales increase, however, because EBV's main customers are in industrial electronics where export sales are currently difficult.

Spoerle

Spoerle is the second largest semiconductor distributor in Germany. Nevertheless, it is by far the largest German electronic components distributor in both total turnover and number of franchises. Total sales of Spoerle in 1990 without its two subsidiaries—Unielectronic and Proelectron—were $225 million or more than DM 330 million. However, estimated semiconductor sales in Germany were only DM 200 million. The American distributor Arrow holds 40 percent of Spoerle's shares. Spoerle's profitability is seldom published, but the company is, according to managing Director Carlo Giersch, "the most profitable distributor in Germany." The profit for the portion of Spoerle accounted for in Arrow's annual report was $10 million (after tax).

United Kingdom

In the United Kingdom the percentage of total sales of semiconductors through component distributors has fallen from 26 percent in 1988 to a current level of 24 percent, mainly due to two major factors:

- The shift in the United Kingdom's electronic equipment manufacturing base between 1988 and 1990—During this period, larger and mainly foreign owned companies such as Digital Equipment Corporation, IBM, and Sony, tended to form partnerships with selected semiconductor manufacturers in order to reduce costs. These partnerships have worked on "ship to line" deliveries for many commodity semiconductors. The programs have been successful and have resulted in the semiconductor manufacturers handling virtually all the semiconductor sales to these companies directly.
- The "see-saw" of commodity memory prices—Manufacturers that have attempted to avoid the risk of price protection claims by encouraging their distributors not to stock

memory devices but to rely on their own inventories instead have sometimes come unstuck. As a result, the regular availability of distribution quantities of memories has suffered and sales have decreased.

The leading semiconductor distributors in the United Kingdom in 1990 were The Diploma Group and MEMEC. Together they held a 40 percent share of a market estimated to be worth £330 million or $589 million.

Diploma

The Diploma Group was the largest semiconductor distribution organization in the United Kingdom in 1990, with estimated sales of £73 million. It was established as a group with counterphased business interests (building, steel, and electronics)—that is, businesses with markets that are cyclical but move out of phase with one another. This structure would ensure stable growth at the total group level. Diploma's electronics distributors have until recently been managed with a light rein, which has been a successful strategy. The group structure has been comparatively stable for many years, apart from the merging of DTV and Nortronic in 1988. In June 1991 however, Diploma sold The Access Group to Hamilton-Avnet for £13.8 million. At the time of divestiture, The Access Group's sales were running at about £21 million per annum. Diploma now consists of Anzac, Macro Marketing, and Nortronic-DTV.

MEMEC

MEMEC is the second largest semiconductor distributor in the United Kingdom, with estimated 1990 semiconductor sales of £59 million. It is a successful entrepreneurial operation that was founded in the 1970s and was subsequently floated as a public company. The original strategy was to focus on high-technology suppliers, and MEMEC developed a strong agency business based on this principle. Over the years, the tendency has been to move into increasingly complex areas, and much of the group turnover is now more fairly described as being in systems rather than in components. In the component field, MEMEC acts as the holding company for Ambar Cascom, Ambar Components, Kudos, Logical Integration, Micro-call, Thame Components, and Versa-Dis. In 1991, the MEMEC Group was purchased by the German Raab Karchar Group.

France

Dataquest estimates that sales of semiconductors through French components distributors in 1990 fell by 10 percent compared with the 1989 level. This was symptomatic of the poor overall market conditions affecting the entire French electronics market. It was against this background that the Sonepar Group consolidated its position as France's biggest semiconductor distributor, and the FHTEC Group (consisting of Rea, RTF, and Scientech) took the number two position from Tekelec. Together the two groups hold 40 percent of a French distribution semiconductor market that was worth FF 2,200 million or $404 million in 1990.

Sonepar

Sonepar was the first French group to invest in electronic components when it acquired Almex in 1970. Now it is the largest semiconductor distributor in France, with estimated semiconductor sales of FF 484 million in 1990. The group, internationally involved in electrical parts distribution, has formed a special holding company called Sonepar Electronique to encompass the subsidiaries operating as electronic components distributors. The operating companies in France are Almex, Eprom, Franelec, ICC, PEP, Rhonalco, Scaib, and Techdis. Sonepar Electronique is the only French group that has both a Pan-European and American presence. It owns companies operating in Belgium, The Netherlands, Spain, the United Kingdom, and the United States.

FHTEC

The FHTEC Group was formed in 1988 by merging the REA and RTF groups. The group has a turnover of FF 750 million and has 400 employees. We estimate that its semiconductor sales in 1990 amounted to FF 374 million, or half the group's total turnover. The main companies in this group were reorganized in 1990, and the companies selling electronic components are now grouped in a subholding company called FHTEC Composants. The headquarters and the warehouses of the three companies are located in Chatillon (near Paris) at the same address. Other companies in the group are trading, or value-added, distributors in video, computers, and instrumentation.

Italy

Distribution sales of semiconductors in Italy rose by just over 3 percent in 1990 compared with 1989, the opposite trend to that experienced in the other major European markets. It is fair to say, however, that most major semiconductor distributors are experiencing severe profit-related problems and currently adopting a number of cost-reduction measures. Because of this, the Italian semiconductor distribution market has undergone more structural change in the past 18 months than it experienced in the last decade. The combined activities of Silverstar and Lasi, part of the Silverstar group, represent the largest semiconductor distribution network in Italy. Their estimated total semiconductor sales in 1990 were £85 billion, representing 20 percent of an Italian semiconductor distribution market worth £425 billion. In 1991, the U.S. distributor Arrow took a substantial stake in the Silverstar/Lasi group.

Silverstar

Silverstar is the oldest established components distributor in Italy, founded in 1954. The company began as a stocking rep for RCA Tubes. During the 1950s and 1960s, Silverstar added both components and instrumentation lines. Indeed, for many years the company has been an exclusive representative for Scientifics Atlanta, Spectrafisics, and Tektronix in Italy. In 1970, the component division was separated out from the equipment franchises; major efforts have been made to streamline the product range. With the acquisition of Lasi in December 1983, the group became the largest broadliner of active components in Italy. In the 1980s, the group acquired majority participation in another distributor, Claitron, which handles Japanese components and systems lines.

Lasi

As already explained, Lasi became part of the Silverstar Group in 1983. At that time, the major lines were Advanced Micro Devices (AMD), General Instrument, Harris, MHS, National, RCA, and Thomson. A major effort has been made in the past eight years to reorganize the product portfolio. The Intel franchise was acquired in 1986, and AMD was dropped. Following the merger of SGS and Thomson in 1988 the full SGS-Thomson line was acquired. At Lasi, the strategy is now to offer new lines like Actel, Amtel, AT&T, Datel, and Weltech as a stocking rep. Recently, IDT was also added. With the exception of Intel systems products and 3M, the company is devoted to active components.

United States

The U.S. semiconductor distribution market grew by just over 6 percent in 1990 compared with 1989, against an overall 11 percent growth in sales of all components handled by distribution. The top 10 distributors represented over 60 percent of the total end-market sales. The semiconductor sector within distribution still remains the largest single element, but it is diminishing in its dominance of the distribution market. In 1989, it represented 48 percent; in 1990, it dropped to 46 percent. The entire U.S. semiconductor industry—both manufacturers and distributors—was badly affected by commodity memory price erosion, especially in the 1Mb and 4Mb DRAM areas.

Hamilton-Avnet Inc. and Arrow are the two biggest semiconductor distributors in the United States. Together they controlled 21 percent of a total semiconductor distribution market estimated to be worth $4,625 million in 1990.

Hamilton-Avnet

Hamilton-Avnet was the largest semiconductor distribution group in the United States in 1990, with estimated semiconductor sales of $601 million. Incorporated in New York in 1955, Avnet is a public company traded the New York Stock Exchange and on the Pacific Stock Exchange. Its prime mission is the distribution of electronic components and computer products to industrial and military customers, with components shipped as received or with value added. The company also is in the electrical and video communication distribution and manufacturing business. The electronic marketing group is the company's largest business, with sales of $1.43 billion, representing 80 percent of its 1990 total sales revenue of nearly $1.8 billion. Semiconductor business accounts for about one-third of the company's revenue.

Arrow

Arrow Electronics was the second largest semiconductor distributor in the United States in 1990, with estimated sales of $416 million. The company was formed in 1946 and is now engaged in the distribution of electronic components, systems, and related products. Arrow also refined and sold lead through its subsidiary, Schuylhill Metals Corporation, which was sold for $33.5 million in September 1988. In January 1988, Arrow Electronics acquired Ducommun Data Systems, Kierulff Electronics, and MTI Systems Corporation from Ducommun Incorporated for a cost of $113 million. The deal consisted of $80.5 million in cash and the balance in company stock. The company also includes wholly owned subsidiaries in Canada and the United Kingdom, a 50 percent joint venture in Japan, 40 percent interest in Spoerle in Germany, and a substantial holding in Silverstar/Lasi in Italy. In 1991, it acquired Schweber from Lex. This latest acquisition will make Arrow the largest semiconductor distributor in the United States, based on 1990 sales data.

Dataquest Perspective

Acquisition and divestiture activity among European and U.S. components distributors is at fever pitch. The focus is on consolidation in Europe. The motivation behind it is preparation for the advent of the Single European Market, and the expectation is improved margins through improvements in economies of scale. This is key because, for many, profits are hard to achieve at the moment, as sales are down.

For European distributors, the Single Europe Act could mean substantial cost savings. It promises lower distribution costs through centralized warehousing, cheaper transportation, and reduced bureaucracy. The act will also affect how franchises are awarded across the EC. It will tend to standardize the contracts that distributors have with their franchises and increase the pressure to move to standard European price lists. It is highly likely that distributor contracts requiring exclusive sales territories will become illegal, and the changes in competition rules will help distributors with Europe-wide networks of offices, as they will be able to provide better service to their customers.

American distributors perceive a threat and a possible opportunity. The threat is that if they do not have a presence in the EC before the end of 1992, they may find it very difficult to enter later. So plans they may have to establish worldwide distribution businesses would be affected. The opportunity is in the Single Europe Act itself; it should lead to doing business in a way similar to that of their home market, for the reasons already mentioned.

Many U.S. distributors believe that their experience in the United States, which is a large monolithic market with wide geographic regions, will enable them to compete more effectively against more nationally based organizations. Having said that, it must be remembered that these large U.S. distributors have very low net margins compared with their European counterparts. To companies with ambitions of building pan-European distribution businesses, Dataquest offers the following observations.

In June, the European Commission warned the 12 EC states that they are holding up the final stages of the single market plan. Statistics show that of the 282 proposals contained in the Single Market Act, 89 remain to be adopted; furthermore, only 11 proposals have been adopted fully in the past 6 months. Once the proposals have been adopted, they must still be incorporated into national laws, and that often takes as long as two years. This could mean that many of the proposals will not be law in time for the completion deadline on December 31, 1992. Once the proposals have finally been incorporated in the constitutions of the 12 EC states, it will probably take years for the full impact of the changes to take effect. So nothing magic is going to happen on January 1, 1993. Change will be gradual.

The Single Europe Act may establish the legal structure for a unified market in the EC, but each of the 12 member nations has its own unique culture. In a business sense, this means that each nation will continue to have its own local market needs and its own particular way of doing business. This fact must be of paramount importance to distributors, which typically deal with small to medium-size customers that tend to be nationally focused. The U.S. distributors would do well to remember this as they move into Europe.

Finally, a positive input. At a recent buyers' roundtable discussion chaired by Dataquest at its European headquarters, procurement executives from multinational OEMs involved in computer and telecommunications equipment manufacture expressed the common view that they were increasing the amount of business they did with distributors. They said that this was a facet of a general trend their companies were following—to subcontract as much of their production and procurement requirements as possible. For them, the rationale behind using a distributor was primarily to reduce inventory holding. However, a vital qualification for the distributor is the ability to provide direct "ship-to-line." As such, they were choosing distributors that were financially stable and able to supply an extensive kit of parts, not just semiconductors.

By Jim Eastlake

(This article includes extracts from a new Dataquest/Europartners Consultants study entitled Worldwide Electronic Components Distribution. *The report provides detailed market studies on the electronic components markets and players in France, Germany, Italy, Japan, the United Kingdom, and the United States. For further details, please contact Richard Noden at Dataquest's European headquarters at Denham, England. Telephone +44 895 835 050 or Fax +44 895 835 260.)*

Product Analysis

Does Intel Face a Turning Point as IC Pricing Pressure Builds?

With 1991 nearing an end, market factors signal continued downward pressure on IC prices in North America. The results of Dataquest's third-quarter 1991 North American bookings price survey reveal strong signs of price pressure in the microprocessor (MPU) and DRAM segments. For example, Motorola offers a host of lower-priced, 32-bit MPUs—an appropriate response to current market conditions. Another example: The fourth-quarter contract-volume bookings price for 1Mb DRAMs on some orders should be as low as $3.60. Major issues to be addressed in this article are whether users can expect Intel to undergo a turning point in the 80386/80486 pricing strategy during the rest of 1991 and the impact prospective DRAM capacity changes will have on pricing—and when?

The price analysis presented in Table 1 correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement service clients on September 6, 1991. The survey information was collected by Dataquest's Research Operations interviewing team. For Semiconductor Procurement clients that use the on-line service, prices presented here correlate with quarterly and long-range price tables dated September 1991 in the Semiconductor Procurement on-line service. Price tables are available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: Fourth Quarter 1991." For additional product coverage and more detailed product specifications, please refer to these sources.

Microprocessor Trends

The fourth quarter of each year marks a key period of business decision making. Users are making critical evaluations of their system migration plans for 1992 and beyond, including the microprocessor choice. Advanced Micro Devices (AMD) and Chips and Technologies (C&T) attack Intel Corporation on the low end and midrange of the performance scale. Suppliers of reduced-instruction-set computing (RISC) processors mount a high-end attack with Motorola Incorporated everywhere. Figure 1 shows the North American bookings price forecast for key 32-bit MPUs. It shows a competitive arena pitting AMD, Intel, Motorola, and suppliers of RISC chips against one another. Intel's strategic response in the next several months to market competitive forces could well determine whether or not Intel remains long-term king of the worldwide microprocessor market. A key issue: Will users soon see a genuine turning point in Intel's 80386/80486 price strategy toward more aggressive pricing?

The Competitive Arena

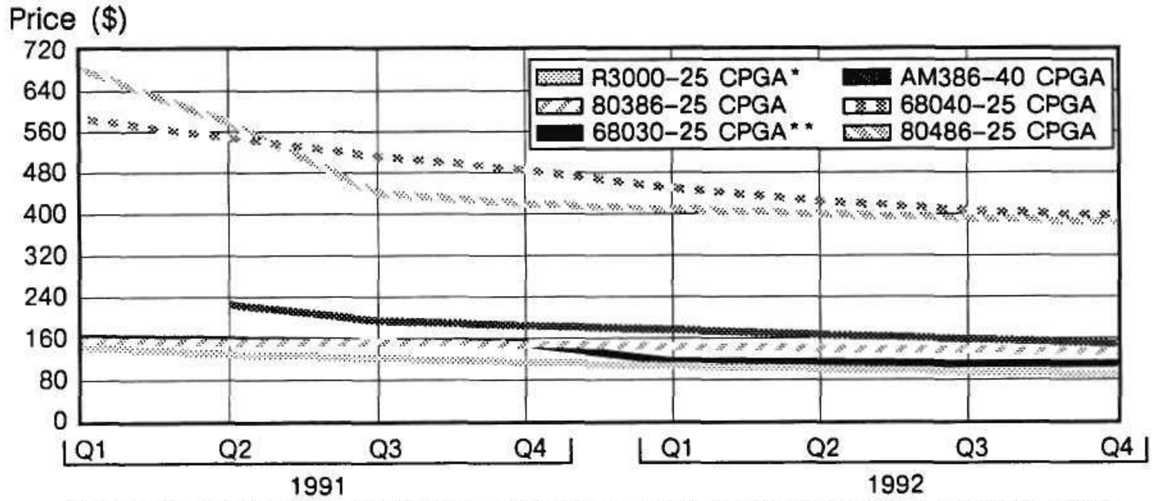
Slow system sales in North America and Europe (with the exception of workstations) in the face of an expanding supplier base mean increased competitive pressure on MPU suppliers during the second half of 1991. Despite legal and marketing uncertainty, AMD and C&T plan to take share from Intel's once-exclusive 80386 domain and also the 80486 business.

Table 1
Estimated Semiconductor Pricing and Lead-Time Trends (North American Bookings, Volume Orders)

	1991 Pricing Trend (Dollars)			
Part	Estimated Q3 Price Range	Forecast for Q4	Estimated Q4 Price Range	Lead Times
80286-16 MHz PLCC	11.80 to 14.55	11.50	10.04 to 13.25	1 to 10 weeks
80486-33 MHz CPGA	410.00 to 445.00	425.00	405.00 to 427.00	6 to 8 weeks
68EC020-16 MHz PQFP	NA	25.00	25.00	4 to 8 weeks
1Mb × 1 DRAM 80ns, DIP/SOJ	4.00 to 4.49	4.18	3.60 to 4.40	1 to 8 weeks
4Mb × 1 DRAM 80ns, SOJ 300 mil	15.50 to 16.50	14.75	14.00 to 15.45	1 to 12 weeks

NA = Not available
Source: Dataquest (October 1991)

Figure 1
Microprocessor Price Trends



Note: This information coordinates with Dataquest's quarterly forecast for 1991–1992 dated September 1991.
* Price for this device excludes FPU, memory management, and related accessory ICs.
** 68030-25: CQFP for 1992.

Source: Dataquest (October 1991)

AMD's first line of attack, as shown in Figure 1, offers a faster 386 device (i.e., 40 MHz) at competitive pricing. So far, the market has not budged much from the Intel 80386 brand name, partly because AMD is still building its supply of parts. AMD is likely to continue to ramp supply of the 40-MHz AM386 and then wage an all-out price war as 1991 ends, lowering the AM386 price profile shown on Figure 1. The market impact of C&T, if any, should start to manifest itself at that time.

Sluggish demand combined with increased supplier competition would *appear* to augur a turning point in Intel's aversion to low-ball price competition. An analysis of the assumptions behind Dataquest's forecast on Intel MPUs, however, shows that such a turning point is not likely to occur *except* for large-order buyers of lower-performance devices. In other words, Intel will focus on the sale of 32-bit MPUs that sell at $200 or more and place less emphasize on 32-bit devices that sell for well under $200.

Another Look at the Assumptions behind the 80486 Price Forecast

For the multiple set of assumptions that guide Dataquest's 1991 to 1995 price forecast for Intel MPUs, see the SUIS Newsletter 1991: January-March 1991-07, entitled "Users' Long-Range Price Outlook—80X86s versus AMX86s versus 680X0s versus RISC Processors" and the Semiconductor Procurement *Dataquest Perspective*, Volume 1, Number 9, July 22, 1991, article entitled "System Price Cuts Augur a Midyear 1991 Downward Shift in IC Prices."

A Two-Tier Pricing Strategy?

At this time, Dataquest's Semiconductor Procurement analysts are monitoring client reports and other sources to determine if an additional assumption should be made—that Intel is moving to a *two-tier* price structure as a response to competitive forces. One tier would be the familiar Intel price-resistant strategy but limited to high-performance MPUs (80486 family and above). The new second tier would be a more aggressive price strategy for the lower half of the Intel MPU product portfolio, the 80386 family. A quick preview of our perspective: Despite mounting competitive pressure on the the lower half of the Intel MPU product portfolio, only a few major buyers can expect a sharp price break for maturing products.

A Consistent First Assumption—Be Synchronized with Intel's MPU Plans

A fundamental assumption lies behind the Intel MPU price forecasts. Intel will most favorably support users that coordinate system life cycles in line with Intel's migration schedule. As will be discussed, despite current competitive factors, Intel is likely to adhere to this prong of its product/pricing strategy. For example, the mid-year 1991 easing of the price for 80486 ICs, along with the recent introduction of low-power 80486 parts, signal Intel's objective to migrate users to the higher-priced 80486 family and away from the lower-priced 80386 family.

Intel's Shifting Rules of the Game—Or an FTC Wild Card?

Dataquest continues to assume that Intel—still the holder of monopoly power through its MPU patent portfolio—will time the "shift" of users to high-end MPUs like the 80486 in line with Intel's profit objectives and not necessarily in conformity with users' strategic plans. The current investigation by the U.S. Federal Trade Commission makes Intel alert to North American users' concerns over fairness (e.g., periods of allocation). The FTC investigation could become a "wild card" that upsets Intel's long-term pricing strategy. Otherwise, we expect Intel's pricing strategy to be based on a series of carefully timed, if not abrupt, shifts of Intel users to ultimately higher-priced devices.

For example, looking to the fourth quarter of 1991, Intel just announced a series of 32-bit MPUs aimed at manufacturers of portable PCs. One objective: to move some users from the 20-MHz 80386SL device, which sells for $135 (1,000 units) to a 25-MHz version that sells for $189 (same volume). Users of the 20-MHz device should prepare to migrate to the higher-speed part or else eventually risk decreased supplier support. The concomitant introduction of low-power 80486/80486SX devices is a sign of Intel's goal to migrate users *now* to the higher-priced 80486 arena and away from the lower-priced 80386/80386SX market. According to the SP quarterly price survey, Intel's 16-MHz 80386SX and 20-MHz 80386SX devices (1,000-5,000 unit volume) should sell during the fourth quarter of 1991 for $56.35 and $84.90, respectively. The 25-MHz 80386 device should sell for $153.50 during the fourth quarter (same volume). By contrast, the new Intel devices are priced higher. Prices for the low-power versions of the following ICs (1,000 units) are as follows: 16-MHz 80486SX—$235; 20-MHz 80486SX—$266; 25-MHz 80486—$471. Users should note the $200 price point.

Competitor's Options?

AMD, C&T, and other competitors must soon make a key strategic decision: to focus on the 80386 marketplace or to leapfrog aggressively to the 80486 segment. Recent trends indicate that the PC life cycles are lengthening vis-à-vis original expectations, which means a longer-term opportunity in the 80386/80386SX business. Intel's competitors face two risks: first, they lag Intel, and by focusing on the 80386 segment now and next year these companies will continue to lag Intel—especially as the company makes proper use of its marketing and legal clout to preserve its monopoly position. However, if they make a strategic jump to the 80486 arena and system life cycles become extended, they face the risk of a deadly, premature battle against Intel.

Assumption: Intel's Imperviousness to Price Competition

As noted last quarter, a third assumption behind Dataquest's 80486 price forecast, that Intel intends to be relatively impervious to external price competition vis-à-vis prior MPUs such as the 80286/80386SX, seems subject to change given second half 1991 competitive realities (AMD, C&T). Nevertheless, a main point of the discussion above on Intel's fourth-quarter shift to new parts is that unlike competitors such as Motorola, Intel continues to emphasize higher-priced/higher-performance 32-bit MPUs.

Dataquest firmly believes that over the long term, Intel will ignore to the best of its ability competitors' prices for similar type products. Intel can remain immune to monopoly charges of "predatory pricing," a no-no under antitrust laws. To paraphrase Lord Keynes, however, we are all dead in the long run—so how will Intel respond to competitors' prices in the short run?

As indicated last quarter, users are seeing a somewhat sharp drop in prices for 25-MHz 80486 and 33-MHz 80486 MPUs. As noted, Intel's objective of migrating users with the lower-priced 80386 family to the much higher-priced 80486 family, in part, accounts for this price scenario. The rate of price declines since the parts introduction during the fourth quarter of 1989 is still in line with historic cost learning curve expectations.

Market forces such as flat demand and increased competition could mean continued sharp drops in 80486DX prices during 1992. Nevertheless, for 1992 Intel prefers to shift users to even higher-priced devices as opposed to slashing prices for 25-MHz and 33-MHz 80486 ICs. Although no firm price estimate is available yet, Intel plans to achieve volume-level production of the 50-MHz 80486 device during fourth quarter 1991. An objective is to draw users away from 25-MHz 80486 or 33-MHz 80486 MPUs, which could fall below the $400 price level by year-end 1991 (1,000-5,000 units) and toward the much higher priced 50-MHz part. A related objective is to set the stage for a late 1992/early 1993 user migration to the 80586 device. For users, the likely reality is that Intel will not fundamentally alter its price strategy for high-performance MPUs such as the 50-MHz 80486 or the 80586 successor. Intel assumes timely market acceptance for these parts and will not shift the price curve downward barring a genuine competitive threat.

RISC ICs could prove such a threat. Dataquest's 80486 price forecast does not currently assume that Intel will aggressively compete on price against multisourced RISC ICs. Sun's SPARC architecture means market success for Sun. If the ACE Consortium can jumpstart the number of design wins for the just-announced R4000 64-bit device, Intel would eventually—willingly or not—adopt a more aggressive pricing strategy for the 50-MHz 80486/80586 products. Intel's high-end CISC MPU strategy will not change otherwise.

Assumption: No Intel Price Wars

Dataquest continues to assume that Intel will avoid a pricing war with AMD, C&T, or any other 80386/80486 market competitor. For example, the 40-MHz AM386 part had some effect over the first half of 1991 on Intel's pricing for the 80386/80486 families, although the AMD part more dramatically influenced the evolution of Intel's product portfolio (e.g., 80486SX, 80487) and especially the timing of new product introductions. The crying question in many users' minds is: What must happen for Intel to shift to a more aggressive pricing strategy—if only at the low end of the performance scale—and when?

At this time, Intel still refuses to be drawn into outright pricing battles. For example, in Asia the Intel 80386/80486 brand name continues to carry great clout with users. The 40-MHz AM386 is being evaluated by prospective major users in Asia, Europe, and North America, but the device has not yet had an impact on Intel's general pricing strategy. Dataquest has received reports, however, that for some large orders in different world regions Intel recently granted unusually sharp volume discounts on pricing. To date, this price scenario remains the *exception* and not the rule—especially for users who buy in volumes of 1,000 to 5,000 units.

AMD is gearing—in terms of volume supply—for an AM386/80386 price war. AMD has the potential to effect a change in Intel's strategy. The timing: the first half of next year, which gives Intel time to pull wild cards from the Intel deck of product/marketing/legal strategies so as to avoid such a price war.

Despite intense competition, users should not expect Intel to drastically slash fourth quarter 1991 pricing of the 16-MHz 80386SX device from the $50 to $55 level—or of the 20-MHz version from the $80 to $85 level. Nor should users expect pricing for the 25-MHz 80386 IC to crash from the $150 to $160 range to anything approaching $100.

Intel will make a fierce competitive response to the AMDs and C&Ts of the world. The marketing and legal fronts will be the first lines of attack. A shift of fab capacity to other devices such as the 80386SL-25 or the 80486 family, which offer higher selling prices, would be another response. But a price war in which Intel bleeds red—as in financial loss—would be the last resort.

Memory Trends

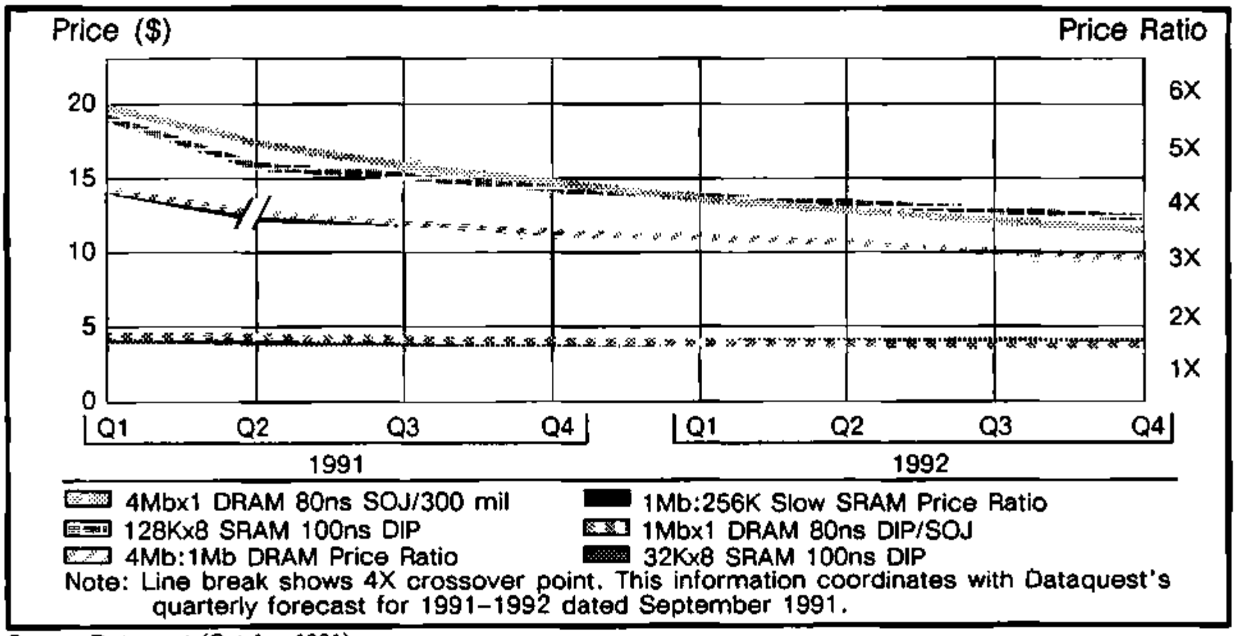
As noted last quarter, Japan-based suppliers of slow SRAM in densities of 256K and below and fast SRAM in densities of 64K and below have become resistant to future declines in pricing. The big memory market rumble, however, concerns prospective DRAM capacity changes—a supplier response to disappointing 4Mb DRAM demand. The low end of 1Mb DRAM contract-volume bookings price range in North America should hit near $3.60 in fourth quarter 1991.

Megabit-Density DRAM

Figure 2 depicts the North American pricing outlook for megabit density DRAM and 256K/1Mb slow SRAM. Some suppliers of 4Mb DRAM are so disgruntled with slow market demand for this device that they are evaluating a slow rate of increase in 4Mb DRAM capacity. A connection exists between 1Mb DRAM and 256K slow SRAM pricing trends and between 4Mb DRAM and 1Mb slow SRAMs, indicating that some suppliers will shift capacity between these two memory types in response to demand trends (see Figure 2). The market effect of DRAM capacity shifts occurs with a typical time lag of one to two quarters. At present, DRAM lead times are manageable: 1 to 8 weeks for 1Mb DRAMs and 1 to 12 weeks for 4Mb devices.

Contract-volume users in North America can expect a decline in pricing—perhaps a sharp decline—for 1Mbx1 DRAM 80ns (DIP/SOJ) during the fourth quarter of 1991. The seller's market of early 1991 has receded. The large-volume

Figure 2
4Mb DRAM and Slow DRAM Crossovers Estimated North American Bookings; Contract Volume*



Source: Dataquest (October 1991)

bookings price for 1Mb DRAMs in North America should average $4.18 *or lower* for fourth quarter 1991 versus pricing of $4.50 to $4.60 during the first half of the year. The large-volume price for 4Mb DRAM 80ns SOJ (300 mil) should drop—in line with original expectations—to $14.75 for fourth quarter 1991. Suppliers resist more aggressive cuts in 4Mb DRAM pricing—one way to stimulate demand—and ponder instead production changes.

DRAM Price Ranges

Although survey confidentiality limits disclosure of exact pricing points, the price range from the recent survey reveals the dynamics of this competitive market. The fourth quarter 1991 price estimate of $4.18 for 1Mbx1 DRAM is based on survey estimates ranging from $3.60 to $4.40. The fourth quarter 1991 estimate of $14.75 for 4Mbx1 DRAM is based on survey responses ranging from $14.00 to $15.45. Price pressure is building in the 1Mb DRAM segment.

Can Suppliers Manage the Market and Avoid a DRAM Price Break?

Slow 4Mb DRAM demand and sub-$4 pricing for 1Mb DRAM in North America signal trouble for the worldwide network of DRAM suppliers. Last quarter, Dataquest looked at the market forces that could cause a major break in 1Mb DRAM pricing during the second half of this year. With DRAM suppliers now assessing 1992 capacity/product plans, suppliers are uncertain whether to try to throttle capacity—and hold pricing up—or go for market share by competing on price. A look at the assumptions behind Dataquest's megabit-density DRAM forecast indicates that suppliers are likely to price 4Mb DRAMs conservatively but lower 1Mb DRAM pricing more aggressively.

DRAM Pricing Assumptions

For the assumptions behind Dataquest's 1991 to 1995 price forecast for 1Mb DRAMs and 4Mb DRAMS, see SUIS Newsletter 1991-09 entitled "The American Megabit-Density DRAM Price Outlook: Today (1991), Tomorrow (1993), and The Distant Future (1995)" and the Semiconductor Procurement *Dataquest Perspective* Volume 1, Number 9, July 22, 1991, article entitled "System Price Cuts Augur a Midyear 1991 Downward Shift in IC Prices."

In summary, the four assumptions are as follows:

- More than adequate DRAM capacity to meet demand
- The demise of FMVs

- Continued DRAM cost-based price reductions
- Non-Japanese suppliers seeking 1Mb DRAM market share

At this time, we believe that the first assumption—about capacity—has become most critical to the pricing outlook for both the first and second halves of 1991. We will examine nuances and implications of possible changes in this assumption.

Let's look at the other three assumptions. Regarding the second, the new Japan-U.S. trade agreement terminated the fair market value pricing system. We see no way for the new agreement—including the fast-track antidumping provision—to make DRAM prices increase or permanently stabilize in North America. Client reports to Dataquest reveal that Japan's Ministry of International Trade and Industry (MITI) shares this view. The third is that Dataquest's DRAM cost-model assumptions as stated in prior newsletters and *Dataquest Perspective* reports remain consistent.

Regarding the fourth assumption, the shift of the DRAM marketplace to a buyer's market over the second half of 1991 reinforces our view that non-Japanese suppliers will seek 1Mb DRAM market share through competitive pricing in fourth quarter 1991. Whether they pursue this strategy after December 31, 1991, however, depends in part on capacity decisions now being made by first-tier Japan-based suppliers of 1Mb and 4Mb DRAMs.

The Swing Assumption: More than Adequate DRAM Capacity

Dataquest continues to assume that global DRAM capacity will exceed market demand during the first half of this decade. Dataquest also emphasizes that the large DRAM capacity has to be utilized for oversupply to occur. A critical caveat: In the short term, DRAM producers could very well choose not to use their full-production capacity.

This scenario seems to be unfolding to *some* extent in the 4Mb DRAM arena now, as occurred in the 1Mb arena last year at this time. If 4Mb capacity/spending plans are scaled down—especially by first-tier Japan-based suppliers—4Mb DRAM pricing in North America would still decline during 1992 but at a slower rate than orginally projected.

Dataquest stands by the assumption of more than adequate 1Mb DRAM capacity now and in the future. In addition to the key role played by non-Japanese suppliers, however, the prospective return of just one or two first-tier Japan-based suppliers to a more aggressive role in the 1Mb arena would exert stronger downward pressure on pricing during 1992.

Key Points

Two main points should be noted. First, DRAM suppliers likely do *not* have enough time to avert an aggressive round of 1Mb DRAM pricing during the fourth quarter of this year. Second, suppliers are more likely to reduce 1992 4Mb DRAM capacity plans—and not slash 4Mb prices—in face of slow demand as 1992 approaches.

Fast SRAMs

The 64K segment serves as a microcosm of the fast SRAM marketplace. For example, Japan's MITI has informally set a $3 barrier below which suppliers' average selling prices should not drop—and, on the whole, Japan-based suppliers keep pricing at or above this level. An unwritten $2 threshold exists in the 16K fast SRAM segment.

Applications Driver

Another trend is that, with cache-tag applications in part driving market demand, the supplier base for 64K fast SRAMs in the ×4 configuration should be more vibrant than other configurations (i.e., ×1, ×8). Dataquest expects unit growth of 64×1 fast SRAMs to lag growth for 16K×4 devices. The result is that the price for 16×4 SRAMs 25ns should soon be lower—$3.45 during fourth quarter 1991—than the price of 64K×1 SRAMs 25ns ($3.60) and remain lower during 1992.

Fast SRAM Micromarkets

The fast SRAM business maintains the hallmarks of a series of micromarkets. New suppliers from North America (e.g., AT&T) and other world regions are using the 8K×8 SRAM 25ns segment as an entry point for penetrating the business. We expect competitive prices for 1992 to average $3.29 for the year; however, the supplier base is likely to shift as current players migrate to other segments of the 64K marketplace or to higher-density devices (e.g., 256K fast SRAMs). Pricing for 256K fast SRAMs has become quite competitive—with some reports of prices as low as $5.50 or less for 32K×8 SRAMs 35ns.

Nonvolatile Memory

Our outlook for pricing of nonvolatile memory remains consistent with prior expectations, with several exceptions. For example, pricing EPROMs in densities of 1Mb and greater has been more competitive recently—in part because the 4Mb device nears the ramp stage of its life cycle. Dataquest's *On-Line DQ Monday* service reports third quarter bookings as low as $3.85 in North America; however, contract-volume prices as reported in the quarterly survey remain above $4. Prices below $4 can be expected in early 1992.

Prices for some 4Mb ROM have been higher than originally expected, but not dramatically so. The North American bookings price of 512Kx8 ROM 200ns (50,000 units) continues to hover near $4, with suppliers showing resistance to a rapid rate of pricing erosion. By contrast, pricing for 256Kx16 ROM (same speed/volume) fell below $5 in the third quarter and should approach $4.25 in the fourth quarter of next year.

Dataquest Perspective

The fourth quarter of each year marks a period of change—if not turbulence. The fourth quarter of 1991, a recessionary year for several world regions, will be no exception. Systems manufacturers look for a business upturn that has not yet materialized for many companies. Under these conditions, most IC suppliers confront bruising competition.

To answer the first of the two key questions asked at the outset: Users should not yet expect Intel to undergo a sharp turning point in the 80386/80486 pricing strategy. To do so would go diametrically against the Intel corporate grain—and wreck a pricing structure that returns to Intel one of the highest profit margins in the industry. Intel's profit record over the past several years should allow the company several quarters of less than impressive results—from the Intel perspective—before management would consider such a fundamental change of strategy.

Moving to the next critical issue facing the IC business as 1991 moves to a close—impact of any DRAM capacity cutbacks on pricing: If first-tier suppliers of 4Mb DRAMs do increase capacity at a slower rate, users will see a slower rate of 1992 pricing attrition and perhaps a new round of DRAM market turbulence. Suppliers of 1Mb DRAMs, nervously eyeing the mention—let alone, prospect—of mid-$3 pricing quotes, stand between a rock and a hard place. The rock is the ample 1Mb DRAM capacity to meet supply, which signals an aggressive fourth-quarter round of pricing. The hard place is the option of increasing the 4Mb DRAM effort—a move into an already soft market.

A likely fourth quarter 1991 DRAM scenario is that suppliers of 1Mb DRAM that historically have demonstrated a willingness to compete on price will engage in an aggressive round of competitive pricing—which may end abruptly during early 1992. Most suppliers of 4Mb DRAM will price conservatively, watching the moves by the first-tier Japan-based companies.

By Ronald Bohn

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- Dataquest's 1992 Semiconductor Forecast
- Mixed-Signal/Analog Semiconductor Update
- October *Market Watch*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 13 September 23, 1991

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.20	0.18	0.18	0.18	0.18	0.13
74AC138	0.33	0.33	0.32	0.31	0.34	0.21
74AC244	0.49	0.43	0.43	0.42	0.48	0.34
74AC74	0.26	0.25	0.23	NA	0.24	0.17
Lead Time (Weeks)	2	3	7	4	5	5
4F00	0.11	0.11	0.10	0.11	0.10	0.10
4F138	0.15	0.18	0.17	0.18	0.20	0.14
4F244	0.24	0.26	0.24	0.27	0.29	0.23
4F74	0.12	0.13	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.18	0.11	0.15	0.14	0.11
CODEC-FLTR 1	1.88	2.38	2.50	2.03	2.15	1.35
CODEC-FLTR 2	4.00	NA	5.00	4.25	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	
DRAM 1Mbx1-8	4.08	4.24	3.95	4.75	4.80	3.90
DRAM 1Mbx9-8	38.75	50.09	36.00	41.50	48.00	38.00
DRAM 256Kx1-8	1.70	1.69	1.65	1.50	1.55	1.10
DRAM 256Kx4-8	4.08	4.28	3.95	4.98	4.80	3.90
DRAM 4Mbx1-8	15.13	17.19	15.50	18.45	21.00	15.50
EPROM 1Mb 170ns	4.00	5.08	4.00	5.50	4.00	3.80
EPROM 2Mb 170ns	7.93	12.43	8.00	9.30	8.00	7.30
SRAM 1Mb 128Kx8	15.13	15.91	13.60	17.50	19.00	NA
SRAM 256K 32Kx8	4.10	4.06	3.70	4.33	4.80	3.30
SRAM 64K 8Kx8	2.00	1.54	1.65	1.65	1.50	1.20
Lead Time (Weeks)	4	4	4	4	7	3
68020-16	35.00	50.46	31.00	47.25	49.50	NA
80286-16	12.00	14.26	13.00	12.90	12.80	13.50
80386DX-25	152.50	179.16	170.00	210.00	193.00	NA
80386SX-16	50.00	65.81	55.00	62.00	63.20	55.00
R3000-25	127.50	149.91	132.00	NA	NA	NA
Lead Time (Weeks)	6	6	4	NA	NA	NA

NA = Not available
Source: Dataquest (September 1991)

Market Analysis

September Market Watch: Seasonal Slows Still Cast Haze on Demand Upturn

The *Market Watch* is a monthly Dataquest report that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

The Book-to-Bill Slips for the Fourth Month Running . . . It Must Be September!

Following the historical trend of the past three years (1988 to 1990), the August book-to-bill ratio declined to 0.94 after three months of the falling bellwether (see Figure 1). The three-month average bookings level for August fell 2.5 percent from July's level and was 1.2 percent lower than August 1990's comparable figure. The billing picture is somewhat brighter, with monthly billings for August up 5.3 percent over July levels and 0.9 percent higher (i.e., flat) than year-ago August levels. The "normal" seasonality of slow summer semiconductor activity is being compounded by a low demand for systems that does not appear to show signs

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

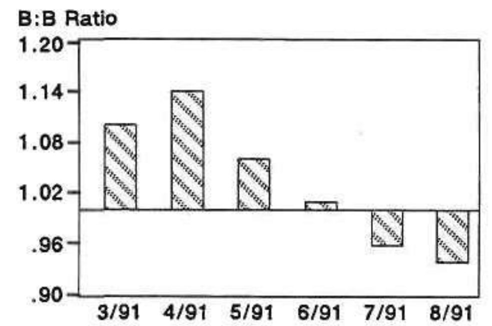

Figure 2
DOC Computer Demand

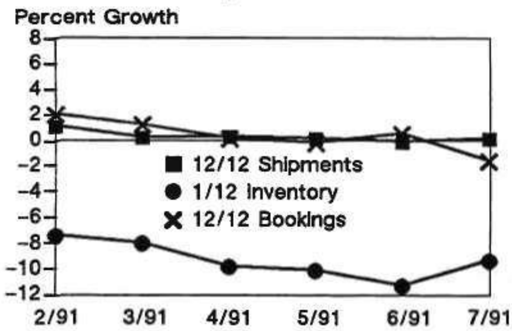

Figure 3
Semiconductor Inventory Level

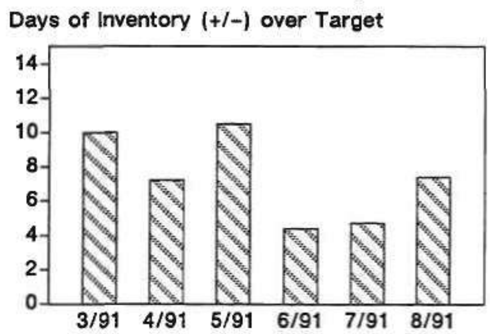

Figure 4
U.S. Weighted Semiconductor Price Indicator

Source: WSTS, U.S. Department of Commerce, Dataquest (September 1991) of improving over the short term. Using history as a guide, the book-to-bill ratio continued to decline through November during the 1988-to-1990 three-year period. What this ratio highlights is ample availability and capacity amid a slow market.

Computer Order Rates Go Negative, Billings Remain Flat

For the first time in 53 months, the 12/12 rate of change for computer bookings dipped below negative 1.0 percent (7/91 = negative 1.5 percent, 2/87 = negative 2.2 percent)! The 12/12 billings rate remained relatively unchanged at 0.2 percent, and the 1/12 inventory rate increased slightly to negative 9.2 percent from the May low point of negative 11.2 percent (see Figure 2).

Because everyone currently is more or less in the same economic boat, satisfying the customer is the overriding goal that is the prime differentiator in determining whether business is made or lost.

Although the annualized system booking rate is negative, inventories remain very low and under control. The continued market malaise affecting the electronics industry does not appear to be abating; however, recent new product announcements may spur incremental growth. With the rapid commoditization of systems, productivity improvements will be coming from software that makes generic hardware proprietary. As standards develop for next-generation operating systems and application software, the growth of computer systems and supporting peripherals should follow.

Semiconductor Inventory Targets Tighten Up

Although Figure 3 appears to show an increase in inventory levels, overall actual inventories remained static at July's level of 25 days. What changed appreciably was the overall inventory target, which went from an average 20 days to 17 days! The net result is an increase of less than three days difference (2.7 days) added to last month's 4.7-day delta, which was primarily caused by tougher goals being set for inventory levels. The old 20-day target/30-day actual inventory range is being rapidly replaced by a sub-20/30-day inventory paradigm. As mentioned in the last *Market Watch*, improvements in inventory control now being seen were expected. The next area that many systems companies are addressing is forecast accuracy, which will result indirectly in further inventory level improvements.

Semiconductor Prices Continue to Slip, Matching System Demand

Figure 4 illustrates that semiconductor pricing continued to slowly decline (negative 1.1 percent) compared with last month's index, again mirroring the relatively balanced (yet sluggish) market. Some below-market spot pricing of DRAMs and EPROMs continues to spice up a relatively mundane supply/demand balancing act. These low-price plays for market share have been short lived and of limited quantity to date. The confusion over home market versus export market pricing of DRAM by Japanese suppliers has subsided with some firming of prices by some suppliers. The quick coordination of the home market and export market pricing for Japanese DRAM suppliers is being addressed. Non-Japanese suppliers are cautiously taking advantage of the situation with products priced slightly lower.

Dataquest Perspective

Despite a sluggish summer, the fundamentals of tight inventory control and cost containment are still allowing the industry to quickly react to any change in demand. The combination of well-managed inventories with forecasting improvements will allow for a gradual acceleration out of the current slump. The balancing act of the market seen for the past six months continues to force companies and their suppliers to improve on the variables of the total cost equation (delivery + quality + price + technical support + customer service). Now that the annual contract negotiation season is upon us, many companies are meeting with their regional procurement divisions to better understand the overall market and plan how each region can improve total costs. Because everyone currently is more or less in the same economic boat, satisfying the customer is the overriding goal that is the prime differentiator in determining whether business is made or lost. ■

By Mark Giudici

0011363

Japanese Semiconductor Alliance Update: The Second Quarter of 1991

During the second quarter of 1991, which ended on June 30, Dataquest recorded 19 new alliances involving Japanese semiconductor companies (see Table 1). Although this number is short of the 25 alliances recorded in the first quarter, it is close to the average number of new alliances registered per quarter during the previous year. This decline in new alliances recorded between the first and second quarters of 1991 qualitatively matches a similar trend in 1990. For most Japanese companies, the first quarter of their fiscal year coincides with the second quarter of the calendar year. This one-quarter offset raises the possibility that financial planning schedules formulated during the first quarter of the fiscal year may cause a lull in new alliances during the second quarter of the calendar year, because many companies might be tentative about making new agreements prior to the conclusion of a finalized financial plan for the new year.

Dataquest finds no evidence that Japanese companies have changed their emphasis on strategic partnerships within the framework of their overall corporate strategies. We therefore forecast a continuation of past strategic alliance formation trends.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 1:

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement

Table 1
Japanese Semiconductor Alliances—Second Quarter 1991

Company 1	Company 2	Product	Agreement Type	Agreement Date
NEC	AT&T	0.35-micron process technology	TE, JD	4/91
Tokyo Electronic Design	Intel Japan	In-circuit emulators	JD	4/91
NEC	Sharp	16-bit microprocessors	SS	4/91
Sony	AMD	IC process technology	LA	4/91
Canon	TI, HP, Singapore government	16Mb DRAMs	JV	4/91
NKK	Macronix International	Mask ROMs	FA, JD	4/91
Matsushita	Weitek	Math coprocessors	LA, FA	5/91
Nippo Sangyo	Togai Inflalogic	Fuzzy logic chips	JV	4/91
Hakuto	Lattice Semiconductor	CMOS PLDs	SA	4/91
Hitachi	Compass Design Automation	0.8-micron ASIC cell libraries	JD	5/91
NEC	Robert Bosch	Automotive microcontrollers	JD	5/91
TDK/Silicon Systems	Level One Communications	LAN chips	IV	5/91
TDK/Silicon Systems	Philips	BiCMOS process technology	LA	5/91
Sumitomo Metal Mining	N Chip	Multichip modules	SA, JD	5/91
Mitsui & Co.	FSI International	Surface cleaning equipment	JV	6/91
Hitachi	NMB Semiconductor	4Mb DRAMs	FA	6/91
Asahi Microsystems	AHA	Data compression LSIs	SA, JD	6/91
Nippon Synthetic Rubber	Insystems	LCD AM test equipment	SA	6/91
Tomen Electronics	VLSI Technology	ASICs, SRAMs	SA	6/91

Source: Dataquest (September 1991)

- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

During the second quarter, two major semiconductor companies, Hitachi and NEC, entered into new alliances that involved next-generation technologies. NEC formulated an alliance with its longtime partner, AT&T, to jointly pursue a 0.35-micron CMOS process technology, and Hitachi teamed up with NMB Semiconductor (NMBS) to download some of its 4Mb DRAM production. The latter agreement is noteworthy because it is relatively rare for major competitors in Japan to team up. However, partnerships that align major competitors appear to be increasingly common worldwide, as epitomized by the recently publicized technology-sharing agreement between IBM and Apple Computer. NMBS entered into the agreement with Hitachi hoping to gain some relief from its financial difficulties by increasing demand for its products, while NMBS' production capacity will allow Hitachi to concentrate on 16Mb DRAM development. AT&T and NEC will share research and production facilities to develop and bring to market products based on advanced process technologies. Furthermore, NEC and AT&T will conduct joint marketing efforts.

Foreign government incentives led many U.S. and Japanese semiconductor manufacturers to invest in Southeast Asia-based ventures in the past decade. However, a drawback to these arrangements was, to the dismay of the host governments seeking to gain access to advanced technology, that participating companies generally only transferred assembly-type technology and rarely transferred state-of-the-art technologies. Now Texas Instruments (TI), Hewlett-Packard (HP), Canon, and the Singapore government have formed a joint alliance to produce 16Mb DRAMs in Singapore. Sponsored by the Singapore government, this new joint venture involves the vendor, TI (a supplier of leading-edge technology), and HP and Canon (16Mb DRAM users) from the earliest investment stages to share the risk by guaranteeing both a market for the vendor and a memory source for the users. Dataquest expects this variety of multinational alliances to proliferate throughout the 1990s.

Strategic Alliances

NEC/AT&T

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

Canon/Hewlett-Packard/Singapore Government/Texas Instruments

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

Hitachi/NMB Semiconductor

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

Dataquest Perspective

The alliances of Japanese semiconductor suppliers have ramifications for their customers when they involve actual or potential competitors. Close scrutiny of supplier alliances needs to be made from a competitive and a supply-base management perspective regularly. Dataquest will continue to monitor these and future alliances.

(Portions of this article were originally published by Dataquest's Japanese Semiconductor Industry Service and are reprinted with its permission.) ■

By Junko Matsubara
Mark Giudici

Product Analysis

New Memory Product Offerings: Differentiation and Density

This article contains a synopsis of memory product news events gathered from the trade press and company releases brought to Dataquest's attention during the second quarter of 1991. Significant developments include the availability of 4Mb SRAMs, 10ns 256K SRAMs, 8ns 64K SRAMs, 90ns flash devices, an 8Kx9 monolithic FIFO, and important speed upgrades in both FIFOs and dual-port RAMs. Table 1 shows the new products announced during the second quarter of 1991.

DRAM Developments

Micron Technology

Micron has announced that it is currently taking orders for a recently qualified MIL-STD-883 version of its 80ns 1Mx4 device.

In another announcement, the company disclosed a manufacturing agreement allowing

Table 1
New Memory Products—Second Quarter 1991

Company	Density/Description	Speed
DRAM Developments		
Micron	4Mb military	70ns
	4MB memory card	
	8MB memory card	
Sanyo	1Mb (Micron licensee)	
Toshiba	1Mb video RAM	80ns
SRAM Developments		
Cypress	64K, BiCMOS	8ns
	16K, ECL	6ns
	64K, ECL synchronous	
EDI	1Mb	25ns
	256K	15ns
	256K, synchronous	12ns
Hitachi	4Mb, pseudo static, 3V	120ns
IDT	16KB RISC cache module	33 MHz
	2Mb modules	15ns
	1Mb modules	15ns
	128KB, i486 cache module	50 MHz
	64K	8ns
	2Mb module	15ns
	512K module	10ns
Logic Devices	256K	16ns
Micron	1Mb	20ns
	256K	15ns
	64K	10ns
	256K, latched	15ns
	256K, synchronous	15ns

(Continued)

Table 1 (Continued)
New Memory Products—Second Quarter 1991

Company	Density/Description	Speed
SRAM Developments (Continued)		
Motorola	256K	10ns
NEC	4Mb	55ns
Paradigm	4Mb module	20ns
Sharp	1Mb low power	100ns
Toshiba	4Mb pseudo static	70ns
	1Mb	85ns
Nonvolatile Memory Developments		
AMD	512K flash	90ns
	256K flash	90ns
Cypress	512K EPROM	20ns
Intel	1Mb block-erase flash	120ns
Xicor	1K serial EEPROM	
	8K serial EEPROM	
	2Mb EEPROM	
	64K microcontroller EEPROM	
Specialty Memory Developments		
IDT	FIFO	25ns
	FIFO modules	30ns
	Dual-port SRAM	25ns
	FIFO	15ns

Source: Various Publications, Dataquest (September 1991)

Sanyo to manufacture Micron's 64Kx16 design in Japan. The agreement exchanges the design and process technology for undisclosed royalties. Finally, Micron introduced JEDEC standard DRAM cards in both 4 and 8MB configurations, organized as either 1-2Mx36 or 2-4Mx18 bits. These devices are expected to sample in the third quarter of this year and will be followed by smaller 2MB configurations (256Kx36, and 512Kx18).

NEC

More than 50 varieties of 16Mb DRAM are planned for introduction by NEC beginning this summer. Engineering samples of 16Mx1 and 4Mx4 devices were delivered in March.

Toshiba Corporation

Toshiba has introduced a third-generation, 80ns 1Mb video RAM in both 128Kx8 and 256Kx4 configurations. Standard devices are available in addition to versions that boast several added features such as persistent write per bit in support of the TI TMS34020 graphics processor, block write, flash write, and split transfers. All versions of the devices are in full production.

SRAM Developments

Cypress Semiconductor

Cypress has announced a technology transfer with National Semiconductor wherein Cypress' Aspen subsidiary will produce National's ECL I/O 6ns 2Kx9 SRAM in both ECL 100K and ECL 101K versions. Under this agreement, Cypress will also receive the right to manufacture National's 8Kx9 synchronous ECL I/O SRAMs.

Cypress Semiconductor and IDT

Cypress and IDT both have independently announced the availability of 8ns 64K TTL-I/O BiCMOS SRAMs. Both are targeted at the

40-MHz R3000 RISC microprocessor. Several versions of both companies' devices are slated for production, with common I/O versions with and without output-enable pins in current production.

Cypress and IDT also announced new 8Kx8 BiCMOS SRAMs having access times of 9ns, and 10ns, respectively.

EDI

EDI has announced two new commercial 1Mb SRAMs and four synchronous 256K SRAMs, both targeted at the commercial market. The 1Mb devices are offered in 256Kx4 and 128Kx8 organizations, in both SOJ and 400-mil ceramic DIP packages. Both organizations run at 25ns and are in production.

The synchronous devices are offered in either a 64Kx4 or a 16Kx16 configuration. The 64Kx4 device can be procured either with (12ns) or without (15ns) registers, and the 16Kx16 device operates at 17ns and can be ordered with or without latches. These four 256K devices are now being shipped under a second-source agreement with Motorola and a development agreement with Sharp.

Hitachi

Hitachi is shipping samples of a 3V 4Mb pseudo-static RAM. The device is organized as 512Kx8 bits and is packaged in a 525-mil 32-pin SOIC. Access times are as fast as 120ns, and power consumption is reportedly 12 to 30 percent lower than competing devices.

Integrated Device Technology

IDT has announced several SRAM modules including processor-specific caches and general-purpose high-density SRAMs. One processor-specific device is a resettable dual 16KB cache module for R3000 RISC processors with clock speeds of up to 33 MHz. The reset feature is expected to be used as a consistency mechanism between cache and main memory, especially in multiprocessing systems. Another module is aimed at the Intel i486 and supports zero-wait caches at speeds up to 50 MHz. A 128KB cache increment can be added by plugging in a 72-pin SIMM. Both cache modules are now in production.

Standard 256Kx8 and 256Kx9 15ns modules in smaller packages than the JEDEC standard were also announced and are currently available.

Speed upgrades were announced for three wide modules, a 16Kx32 ZIP (10ns), a 64Kx16 DIP, and a 64Kx32 SIMM (both now at 15ns). Samples of all three are now available, with production slated for the third calendar quarter.

The new product offerings highlight the fact that higher-speed, multiple-organization memories continue to proliferate.

A module that incorporates an R3000 RISC CPU, 32KB of instruction cache, and either 16 or 32KB of data cache, and can be obtained either with or without a floating point coprocessor, became available this April. This module is a means of simplifying high-speed cache design in RISC-based embedded systems where space is at a premium. Clock speeds of up to 33 MHz are supported.

Logic Devices Inc.

Boasting the capability of supporting future 50-MHz speeds of the SPARC RISC microprocessor, Logic Devices announced its alternate-source design of the Cypress 16Kx16 SPARC cache RAM. The plug-compatible part is offered in 33, 24, 20, and 16ns speed grades to support SPARC clock speeds of 25, 33, 40, and 50 MHz, respectively. Production volume is now available.

Micron Technology

Two 16Kx16 and two 16Kx18 fast static RAMs were announced this quarter. Both organizations are offered either with latched inputs or with input registers. The x16 parts are equivalent to existing Motorola products, and the x18 versions are similar with the addition of parity bits. The press release did not mention if the x18 versions conformed to the JEDEC standard x18 pinout. All four parts come in 52-lead PLCCs or small-footprint PQFPs and are available as engineering samples at speeds as fast as 15ns.

Micron also has introduced a monolithic 128Kx8 in a 400-mil DIP package with only a single chip select. Although most monolithic devices have two chip selects, the industry-standard module has only one. The single-chip select pin of Micron's 128Kx8 allows its new monolithic device to be pin-compatible with the industry-standard 128Kx8 module. Speeds of up to 20ns are in production.

Speed upgrades have been performed on all densities of Micron's standard SRAM family. The 64K density is now offered at 10ns, 256Ks are as fast as 15ns, and the megabit is now offered at 20ns. The megabit and 256K densities are in production, with the 64Ks sampling to go into production in the third quarter.

Micron is now making its megabit and 256K products available in die form, all tested to speed via hot chuck testing. Fastest guaranteed speeds are 25ns for the megabit, and 20ns for the 256K devices. The dice, as well as all of the previously mentioned products, are offered in four temperature ranges: commercial, industrial, automotive, and military.

Motorola

Motorola has introduced 10ns versions of its 32Kx8 and 64Kx4 SRAMs. These SRAMs have been manufactured using Motorola's 1.0-micron triple-metal BiCMOS process. Samples are now available, with production scheduled for late in the second quarter.

NEC

Samples of a 55ns low-power 4Mb SRAM have been shipped by NEC. The device is aimed at notebook and laptop PCs and consumes only 0.4μA when in standby mode.

Paradigm Technology

Paradigm announced a 4Mb 20ns SRAM module, reportedly the first of a forthcoming family. The 512Kx8 device is constructed using Paradigm's own 128Kx8 SRAM chips. Availability information should be requested from Paradigm.

Sharp

Sharp will be increasing its monthly 1Mb SRAM production from a current rate of 100K to 500K units by the end of the year. The 20ns version, which has been shipping in the United States, has just begun shipment in Japan.

In May, the company sampled a 100ns, 1Mb SRAM with power consumption reported to be only 20 percent of that required by existing devices. This product ships in a 32-pin DIP, SOJ, and TSOP.

Sharp plans to sample 4Mb SRAMs this fall and should enter production in the spring of 1992.

Toshiba

Toshiba America has introduced a 70ns, 4Mb pseudo-static RAM in a 512Kx8 organization. The JEDEC-standard pinout used by this device is an upgrade to the pinout of a standard 400-mil 128Kx8. These devices are in full production and are targeted at such applications as laptop PCs and hand-held instrumentation.

Supply decisions made now will impact availability of the system that these parts go into.

Toshiba also has announced a low-power 128Kx8 standard SRAM with a typical power dissipation of 27.5mW per MHz and a maximum standby current of 30 microamperes. Designed for battery backup applications such as bar code readers and volt meters, the SRAM runs at speeds as fast as 85ns and is in full production in JEDEC standard 600-mil DIP and 525-mil SOP packages.

Nonvolatile Developments

Advanced Micro Devices Inc.

AMD has announced what it claims to be the industry's fastest 64Kx8 and 32Kx8 flash devices, featuring 90ns access times. They are packaged in 32-pin DIP and PLCC packages to facilitate upgrades to higher densities. These devices follow the Intel/AMD convention for 12V programming, the same as followed in both companies' 1Mb devices. The 64Kx8 is in volume production, and the 32Kx8 was to go into volume production by the end of the quarter.

Cypress Semiconductor

Cypress Japan is now sampling a 512Kb EPROM whose access time is 20ns for any address within a 64-byte range but is 65ns whenever a 64-byte boundary is crossed. This device is being marketed as a support component for the SPARC processor in embedded applications.

Fujitsu

Fujitsu plans to enter the flash market with a 16Mb device that is expected to sample at the end of 1992.

Intel Corporation

A novel architecture of flash memory has come out of Intel. Although the part is in a 128Kx8 organization, it is split into an 8Kx8 segment, two 4Kx8 segments, and a 112Kx8 segment. The 8Kx8 segment has a hardware lockout feature to allow a BIOS bootstrapping routine to be locked into the memory. Intel hopes that designers will use this single component to replace several devices (EPROM, EEPROM, and battery-backup SRAM) within their systems. Packaged in DIP, PLCC, and TSOP packages, 120ns and slower versions are now in production in two varieties: one whose lockout segment is in the top part of memory and one with this segment at the bottom.

Xicor Inc.

Xicor introduced two serial I/O EEPROMs in 1Kb and 8Kb densities. The devices are pin-compatible with each other, and their simple two-wire interface allows devices of 1, 2, 4, 8, or 16Kb to be inserted into the same 8-pin socket. Both parts are in production now and operate over either the commercial or industrial temperature ranges using a 3.3V +/- 10 percent power supply.

Another product is Xicor's new 8Kx8 EEPROM, with address and data multiplexed to the same pins in order to support the needs of Motorola microcontrollers. Control pins have been optimized to simplify connecting this product to Motorola's line of microcontrollers. According to Xicor, the part is now in production.

Xicor's third announcement was for a 256Kx8 EEPROM module in a JEDEC standard DIP pinout. Composed of four Xicor 64Kx8 monolithic EEPROMs, the module is in production. Xicor claims that this device is the densest EEPROM on the market today.

Specialty Developments

Integrated Device Technology Inc.

On the FIFO front, IDT has introduced one new FIFO, speed upgrades of three existing FIFOs, and a FIFO module family. IDT's 9-bit wide FIFOs in 256, 512, and 1K depths were all upgraded from 25ns to 15ns and 20ns speed grades, with production now available. An 8Kx9 25ns asynchronous FIFO, which IDT claims is the deepest in the industry, was announced for immediate availability. This deep device is intended to simplify design and reduce board space in high-resolution graphics boards and data acquisition systems. Finally, FIFO modules in 8/16/32Kx9 and 16/32Kx18 organizations were announced. All devices are now available in 30ns speed grades.

A new 25ns speed grade of 10 current IDT dual-port RAMs was announced. Production quantities are now available for 25ns version upgrades of IDT's master and slave 1Kx8s, 2Kx8s, and 2Kx8s with interrupt. The master and slave 1Kx8 and 2Kx8 devices are now also being offered in a center power/ground DIP pinout to reduce internal noise and ground bounce.

Dataquest Perspective

The new product offerings highlight the fact that higher-speed, multiple-organization memories continue to proliferate. The choice of supplier for these new devices should be balanced between system architecture requirements, market availability, and the number strength of suppliers. Supply decisions made now will impact availability of the system that these parts go into.

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By Jim Handy
Mark Giudici

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- Quarterly Price Survey highlights
- Microcomponent product trends
- October *Procurement Pulse*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 12 — **September 9, 1991**

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.20	0.18	0.18	0.18	0.18	0.13
74AC138	0.34	0.32	0.32	0.31	0.34	0.21
74AC244	0.49	0.42	0.43	0.42	0.48	0.34
74AC74	0.26	0.24	0.23	0.24	0.17	
Lead Time (Weeks)	2	3	6	4	5	5
4F00	0.11	0.11	0.10	0.11	0.10	0.10
4F138	0.17	0.18	0.17	0.18	0.20	0.14
4F244	0.24	0.25	0.24	0.27	0.29	0.23
4F74	0.12	0.12	0.12	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.18	0.11	0.15	0.14	0.11
CODEC-FLTR 1	1.83	2.34	2.50	2.03	2.15	1.35
CODEC-FLTR 2	4.00	NA	5.00	4.25	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	NA
DRAM 1Mbx1-8	4.08	4.17	3.95	4.75	4.80	3.90
DRAM 1Mbx9-8	38.75	49.39	36.00	41.50	48.00	38.00
DRAM 256Kx1-8	1.70	1.69	1.65	1.50	1.55	1.10
DRAM 256Kx4-8	4.08	4.28	3.95	4.98	4.80	3.90
DRAM 4Mbx1-8	15.25	17.24	15.50	18.45	21.00	15.50
EPROM 1Mb 170ns	4.00	5.00	4.00	5.50	4.00	3.80
EPROM 2Mb 170ns	8.13	12.21	8.95	9.30	8.00	NA
SRAM 1Mb 128Kx8	15.55	15.63	14.00	17.50	19.00	NA
SRAM 256K 32Kx8	4.10	3.99	3.70	4.33	4.80	3.30
SRAM 64K 8Kx8	1.95	1.51	1.65	1.65	1.50	1.20
Lead Time (Weeks)	4	4	2	4	7	3
68020-16	35.00	49.57	31.00	47.25	46.50	NA
80286-16	12.00	14.01	13.50	12.90	12.80	13.50
80386DX-25	150.00	176.39	170.00	210.00	193.00	NA
80386SX-16	47.50	64.66	55.00	62.00	63.20	55.00
R3000-25	128.00	147.27	132.00	NA	NA	NA
Lead Time (Weeks)	4	6	4			

Note: This information appears in the on-line *DQ Monday Report* dated August 26, 1991.
NA = Not available
Source: Dataquest (September 1991)

Market Analysis

September Procurement Pulse: Orders and Inventories Steady, While Lead Times Rebound

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to both semiconductor users and manufacturers.

Semiconductor Order Levels Flatten, in Line with System Sales

Figure 1 illustrates the relative static nature of semiconductor order levels over the past six months. The current level of semiconductor orders is only 1.6 percent higher than that seen in last month's survey and mirrors the overall electronics industry (i.e., unchanged). The survey respondents' six-month system sales outlook remains positive at 7.7 percent but is down from last month's 11.3 percent. As mentioned in last month's *Procurement Pulse,* the high system sales then forecast did not correlate with expected price declines in semiconductors and the overall flat macro-economic/electronic market situation. The lower but positive six-month system sales outlook appears more realistic relative to the current and near-term market situation. Semiconductor prices are expected to

Figure 1
Averaged Monthly Semiconductor Orders

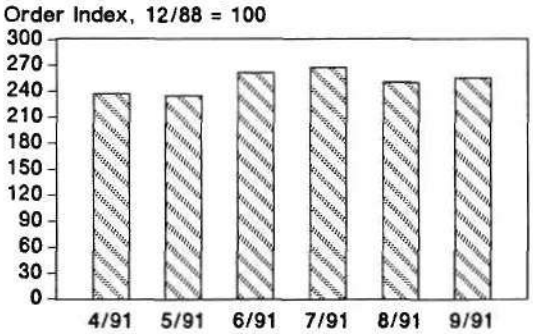


Figure 2
Averaged Semiconductor Lead Times

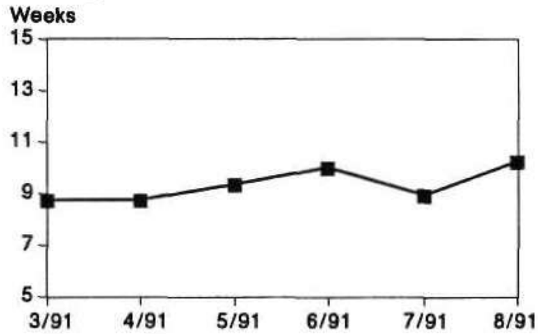


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

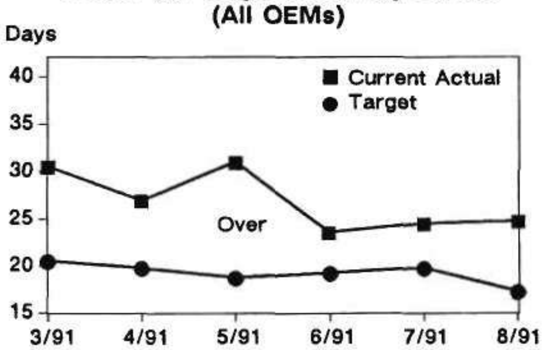
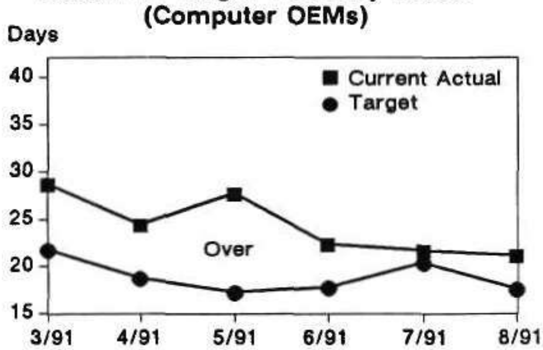


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (September 1991)

decline, but at a slower pace than last month (negative 1.7 percent currently versus negative 2.4 percent). The reduction in the rate of price decline is due in part to the firming of DRAM prices by some large Japanese suppliers as they sort out the ramifications of the recent U.S.-Japan semiconductor accord. Some companies are discussing reducing production levels to better meet lower demand.

Lead Times Extend Slightly, Now Averaging 10.3 Weeks

The average semiconductor lead time rebounded back to slightly above 10 weeks versus last month's 9-week average. Although orders activity has remained steady, some suppliers have had unexpected orders placed because of the lack of competitors' delivery. In aggregate, these unforecast orders have extended the overall lead-time average. The balancing act of meeting static demand levels with an occasional uptick continues. Ongoing forecast accuracy on the users' part must be maintained and improved upon in order to achieve low inventory levels and predictable lead times. The confusion surrounding the U.S.-Japan Semiconductor Trade Arrangement (which was effective August 1) appears to be subsiding with a more coordinated effort being made to correlate regional DRAM pricing differences. In light of the steady-state supply demand situation, Dataquest continues to expect the average lead time to be within the 8- to 12-week range for the remainder of this year.

Semiconductor Inventories Low and Planned to Go Lower

On-hand semiconductor inventories remained unchanged since last month, but the targeted goal declined by more than 10 percent! The overall average targeted and actual inventories for August were a respective 17.3 and 24.8 days compared with our last report's like figures of 19.8 and 24.5 days. The computer segment average target level for August declined to 17.6 days from last month's 20.4-day aberration, while actual levels inched down from 21.7 to 21.2 days. Figures 3 and 4 point out that the slope of each target line is near zero, while each actual inventory line has a definite negative inclination. The difference between target and actual is shrinking, attesting to the resolve of electronics companies to pare back inventories as much as possible to keep costs under control. It also appears that as actual inventories decline, target levels are more slowly reduced. The 20-day target, 30-day actual inventory standard seen for the past two to three years now looks more like an average 18-day target, 25-day actual inventory paradigm. The level of inventory controls now in place caused by flat business conditions will be maintained as business picks up as a result of price pressure in the systems markets that shows no sign of easing.

Dataquest Perspective

The status of availability, delivery, and pricing have not changed appreciably since our last report . . . all are very good and under control. Respondents continue to note that quality and support for obsolete products with end-of-life buys are areas that suppliers need to focus on in the near term. Although some memory devices are having longer lead times, semiconductor users need to ensure that there are no surprises with their suppliers now that the annual contract season is here. The intangible portion of the total cost function of product (for instance, customer service, technical support, good communication) is becoming more a factor in maintaining and growing business in the current market. With the tangible costs controlled, those companies that excel in the intangible areas will have the most to gain. ■

By Mark Giudici

Product Analysis

On the Surface: Package Demands Continue to Mount

Once upon a time, packaging engineers sat back and waited for the integrated circuit (silicon) to be developed. When ready, it was packaged in the only package available—the dual-in-line package (DIP). Oh, if only life were still that simple. The fact is today, packaging engineers have never faced more of a challenge—the variety of package types and possible solutions is staggering.

Bye, Bye DIP—Surface Mount is Here

Until a few years ago, the DIP—both plastic and ceramic—was *the* mainstream package for all ICs. The speed of the circuit was not limited, to any great extent, by package design and materials. The small piece of silicon could easily fit into the package body, and the need for many leads over 40 was rare. Thus, package size and density were not key issues. Package cost was a consideration, but silicon functionality dominated any issue in IC selection and use. Reliability continued to improve as better materials were developed.

All of this changed with the arrival of ASICs. The drive for miniaturization challenged designers to develop smaller, higher-lead-count, finer-pitch packages with improved thermal and electrical performance, all at a lower cost. Additionally, tape-automated bonding (TAB), flip-chip, multichip modules (MCMs), and other fine-pitch bonding technologies have been developed to meet the high-lead-count requirements. In short, component packaging is now more than just packages. It is part of total system design and manufacture, interacting with the silicon die and other materials to form the final solution.

Table 1 highlights that 80 percent of ICs were packaged in the DIP in 1989. That number declined to 76 percent in 1990. Thus, use of surface-mount packages reached 24 percent of all IC packages used in system manufacturing for the first time in 1990.

Smaller and Thinner Packages

As ICs with larger die sizes (600 mils square and upward) are being developed, applications are focusing on thinner packages and tighter pitches to achieve the high density required. Very fine pitch packages, down to 0.25mm (10 mils) and below, will require solutions to handling, coplanarity problems, and board assembly techniques. As this fine-pitch progression continues, standardization is becoming more prevalent; for example, almost all new packages are based on metric units. The JEDEC JC-11 packaging standards committee of the EIA will be registering only metric-based IC package outlines by the end of next year.

The trend is toward thinner as well as smaller. Three packages represent this trend—the SSOP, TSOP, and TQFP (see Table 2). The SSOP family of packages range in lead count from 8 to 28 leads, with an average body size of 5.3mm (210 mils). These packages are used for the

Table 1
Estimated Worldwide IC Package Production
(Billions of Packaged IC Units)

Package	1989	1990	1991	1992	1993	1994	2000
Plastic DIP	22.63	20.36	18.13	16.21	14.70	11.40	1.84
Ceramic DIP	3.58	3.25	3.21	3.04	2.92	2.62	1.33
Small Outline	4.74	5.58	7.27	8.86	11.81	12.43	14.61
Plastic Chip Carrier	0.43	0.47	0.62	0.81	0.90	0.80	0.34
Ceramic Chip Carrier	0.25	0.27	0.30	0.41	0.43	0.39	0.16
Quad Flat Pack	1.86	2.72	4.31	7.05	14.1	14.99	28.30
Ceramic PGA	0.18	0.26	0.41	0.64	0.81	0.86	0.48
Plastic PGA	0.09	0.15	0.25	0.55	0.77	0.90	0.59
Others (TAB, COB, MCM*)	1.61	2.22	4.31	8.19	14.60	19.00	98.00

*Die demand into module construction
Source: Dataquest (September 1991)

Table 2
New Fine-Pitch Packages

Package	Acronym	Pitch (mm)
Thin Small Outline Package	TSOP	0.5, 0.4, 0.3
Shrink Small Outline Package	SSOP	0.5, 0.4
Very Small Outline Package	VSOP	0.5, 0.4
Very Small Quad Flat Package	VQFP	0.5, 0.4, 0.3
Thin Small Quad Flat Package	TQFP	0.5, 0.4, 0.3

Source: Dataquest (September 1991)

more common low-lead-count logic and linear circuits.

The TSOP is becoming the new dominant package for memory. With a maximum package body thickness of 1.0mm (40 mils), lead counts of 18 to 40, and lead configuration on both the ends (type I) and the sides (type II) of the package, the TSOP is ideal for applications in which package profile is critical. IC memory cards, smart cards, data cards, cameras, camcorders, and notebook, palm-top, and pocket computers are all using the TSOP design. Because it is nearly three times thinner and four times smaller in volume, the TSOP is already being proposed to replace the SOJ as the main memory package of choice for 16Mb DRAM; it is also being used for 4Mb devices.

The TQFP is an extension of the EIAJ quad flat package. The TQFP, like the TSOP, utilizes 1.0mm (40 mils) maximum package thickness and is used to house microprocessors and ASICs in applications in which low profile and high density are necessary. Mitsubishi currently has a 576-lead package (40mm × 40mm square) used to contain its CMOS M6008X gate array.

Because the pin grid array (PGA) is still believed to offer the best compromise between density and lead count, it continues to be used in many applications. Ceramic versions can handle high thermal power requirements. PGAs also are moving to narrower pitches (50 mils). Surface-mount versions are being created by shortening the pins and mounting with a butt joint or by eliminating the leads altogether and using solder reflow attachment methods with TCE-matched substrates. If used with copper/polyimide routing for signal planes, enhanced signal integrity results, allowing for a lower-cost route to MCMs.

High Density and High Lead Count—Still Not Enough

As packages continue to shrink down to the size of the silicon, other factors become apparent. The existing wire-bonding packaging technologies do not meet the speed and power requirements demanded by faster clock rates. Novel packaging techniques must be implemented. New materials, additional power and ground planes, bypass capacitors, and package simulation models such as SPICE will help enhance performance. Multimetal lead frames, mostly using TAB tape, are being evaluated. Hewlett-Packard has developed a demountable TAB (DTAB) for high-performance, high-pin-count packages. DTAB uses a proprietary "bumpless" inner lead-bonding (ILB) technique and is fully reworkable, resulting in a cost that is less than that of a comparable ceramic PGA.

Perhaps one of the largest-growing interconnect areas is that of the MCM. Still in the development stage, MCMs hold the promise of meeting the performance challenges offered by the silicon. Although much has been discussed regarding electrical MCMs, little is known of optical interconnects and their relation to MCMs. Optical MCMs promise to provide the highest performance interconnect available, optimizing system performance in the 1-GHz range and beyond. Metal-based conventional MCMs act as antennas and radiate energy into free space; they are susceptible to crosstalk and radio frequency interference (RFI). Advanced Packaging Systems (APS) is developing an MCM technology utilizing optical interconnects. Benefits are shown in Table 3.

Table 3
MCMs Move from Metal to Optical Interconnects

Characteristic	Metal	Optical
Maximum Practical Frequency	1.5 GHz	1,000 GHz
Minimum Number of Layers for High-Performance Interconnect	4	1
Interconnect Density/Layer	600 lines/in.	1,500 lines/in.
Cost per Outboard Connection	$0.01-$0.03	$20.00
Module Cost	Comparable	Comparable
Crosstalk	Yes	No
RFI Immunity	Poor	Excellent
Availability	Now	1993

Source: *E. E. Times*

Dataquest Perspective

Package lead counts continue to grow. Molded plastic packages are being defined up to 576 leads and beyond. TAB shows promise above 300 leads, where conventional wire bonding may be limited. Computing speeds continue to rise, constantly challenging even the newest packaging technologies. A total approach to interconnects at all levels of integration—silicon, package, substrate, subsystem, and final system—is mandatory for success.

Procurement and component engineering professionals should jointly review the availability of proposed standardized surface mount packages prior to final design-in. Familiarity with new product designs and their future semiconductor requirements is becoming more of a requisite for both groups. As systems continue to shrink in size and the length of electronic product life cycles declines, knowledge of package standards and their capabilities becomes more important. In an effort to clarify these issues, Dataquest will continue to monitor and analyze future developments in the critical area of semiconductor packaging. ■

By Jim Walker
Mark Giudici

The User's View of the SRAM Supplier Base and Product Life Cycles

Summary

Based on Dataquest's final estimate of suppliers' 1990 SRAM market shares, this article assesses the product life stage as of September 1991 for fast SRAMs in densities of 16K through 1Mb and slow SRAMs in densities of 64K through 1Mb. Our goal is to provide users with an evaluation of the supply/supplier base for these devices during the 1990s. This assessment provides users of SRAMs with direction and advice for choosing suppliers.

Overview

This article provides SRAM users with practical and strategic information for choosing which devices to use and from which suppliers. (This article replaces the "SRAM Product Trends" section of the *Industry Trends* binder of the former Semiconductor User Information Service.) Dataquest defines fast SRAMs as SRAMs with access times at or less than 70 nanoseconds (ns) and slows SRAMs as devices with access times of more than 70ns.

This article provides IC purchasers and component engineers with a strategy for managing demand for SRAMs on a cost-conscious basis over the long term despite shifts in the market or among suppliers. A key element to the strategy is for users to match system life cycles with SRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans with SRAM life cycles and plan for product shifts in those cases where system/SRAM life cycles do not match.

The first section of this article develops a guide to cost-effective, long-term procurement of SRAMs through the use of product life cycle analysis. The second section on top-ranked SRAM suppliers looks at the market positions and product strategies of the leading suppliers. The third section combines the analyses of SRAM life cycles and the supplier base. This format gives users a practical way of assessing their ability to obtain a supply of these devices from the various suppliers during the 1990s in line with users' long-term system migration plans. Cumulatively, the information in these sections enables users to develop a sound strategy for satisfying demand for SRAMs on a consistent, cost-conscious basis over the long term despite shifts in the market or among suppliers.

SRAM Product Life Cycles

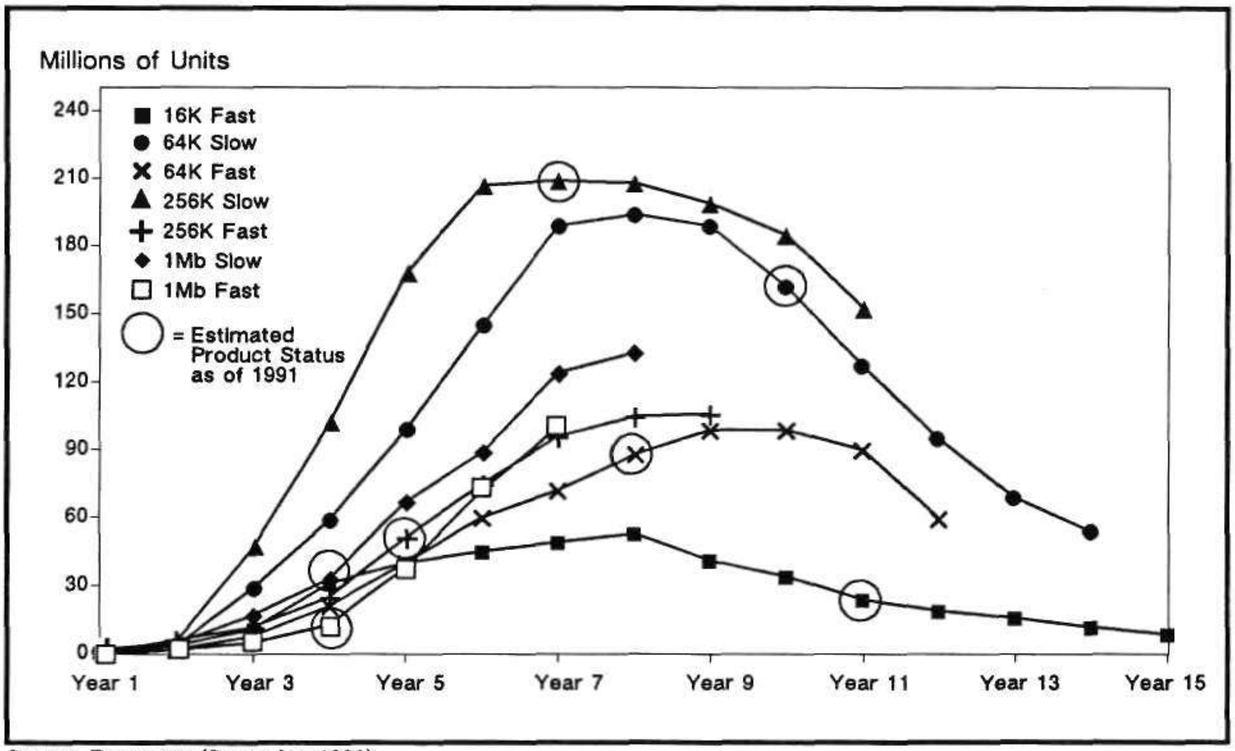
This section uses information on SRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. This section also lays the basis for other analyses based on SRAM life cycle curves.

Typical Life Cycles for SRAM Products

Figure 1 shows a series of curves that depict the life cycles of fast SRAMs with densities of 16K, 64K, 256K, and 1Mb and slow SRAMs with densities of 64K, 256K, and 1Mb.

Figure 1 reveals that SRAMs—excluding the R&D phase—typically experience a life cycle of 15 years or more. Fast SRAMs may not reach

Figure 1
SRAM Product Life Cycles by Density as of September 1991



Source: Dataquest (September 1991)

their peak stage until the eighth or ninth year of their life cycle. Why? Suppliers continue to introduce faster-speed versions that, in effect, prolong the cycle. By contrast, slow SRAMs typically achieve the peak stage of the cycle during their seventh or eighth year.

Figure 1 shows that users of fast SRAMs can expect a large supply of 64K parts (nearly 100 million units) and 256K devices (75 million units) in 1992. Supply of 1Mb fast SRAMs is expected to start to ramp up during 1993. The supply of fast 16K SRAMs continues to decline and should fall to under the 20 million unit level during 1992.

Regarding slow SRAMs, Figure 1 shows that the 256K device should serve as the mainstream part for the 1991 through 1994 period. Supply of 256K slow SRAMs should reach or exceed an annual level of 200 million units from 1991 to 1993 and then decline somewhat. The supply of 1Mb slow SRAMs should start to ramp during 1992 and 1993 but should not reach the 100 million unit level until 1994.

The information in Figure 1 forewarns that users of 64K slow SRAMs can expect supply cutbacks. Unit output should *drop* 15 percent during 1991 to a level of 162 million units. Supply is expected to decrease to 127 million units for 1993 and will continue to fall over time.

SRAM Life Cycle Stages

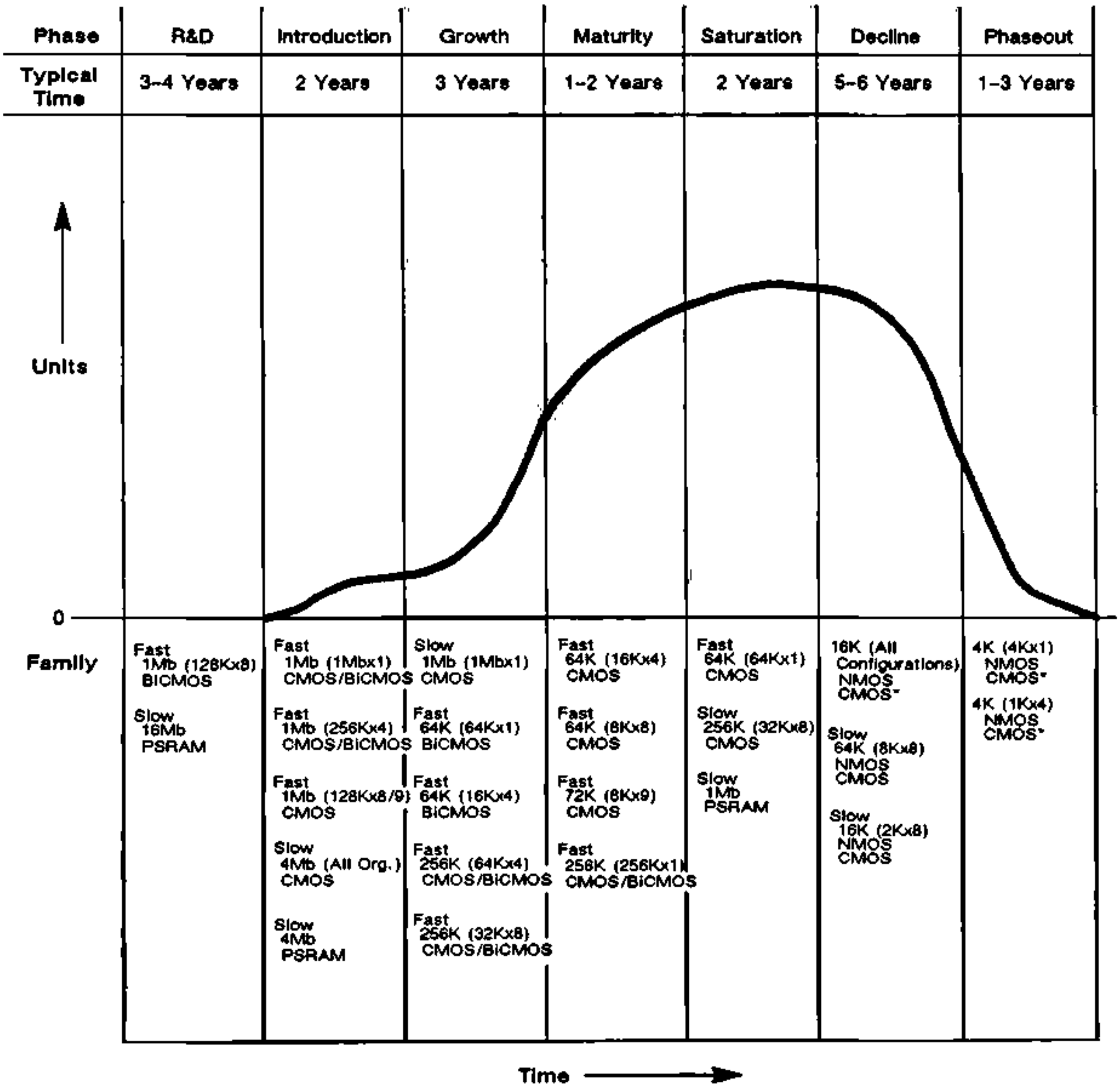
Figure 2 depicts SRAM life cycles on the basis of configuration and technology, breaking each stage of the cycle into specific time intervals.

As shown in Figure 2, the SRAM R&D stage occurs over a three- to four-year period. The introduction and growth stages extend for five years. The peak maturity-saturation stage totals three to four years, which is somewhat shorter vis-à-vis other memory ICs. A relatively long decline/phaseout period, which typically runs for six to eight years, balances the shorter peak stage. For example, fast SRAM suppliers typically stretch life cycles over time by designing faster versions of older-density parts.

SRAM Life Cycle Stages by Density

Figure 2 shows that 4K fast SRAMs are being phased out by many suppliers. The 16K fast SRAMs and 16K slow SRAMs are now moving

Figure 2
SRAM Life Cycles by Product Configuration over Time



*Fast and slow
Source: Dataquest (September 1991)

through the decline stage, with supply of these parts expected to drop below the 10 million unit level by 1995. High-speed CMOS versions of 4K and 16K SRAMs should have the longest life cycles within these segments.

As noted, the 64K slow SRAM is in the decline stage of its curve; however, the product's phaseout is not expected until after 1995. By contrast, Figure 2 reveals that the 256K slow SRAM stands at the peak stage of its life cycle. The decline stage for 256K slow SRAMs should start by 1995; however, the life cycle will continue throughout the 1990s.

As shown in Figure 2, the 64K fast SRAM is moving into the peak stages of the life cycle. The peak stage will last through 1994. This product's life cycle should extend nearly to the year 2000. The life cycle of 256K fast SRAMs—which now moves through the growth stage and is expected to peak during the 1995 to

1996 time frame—should extend beyond the year 2000.

Figure 2 shows that the life cycle of 1MB slow SRAMs is expected to extend until the end of the 1990s. The cycle for 1Mb fast SRAMs—which is at the introductory stage—should push beyond the year 2000. The life cycle for 4Mb slow SRAMs—which are under development—should extend to the year 2005.

Supplier Analysis

This section analyzes the product and market strategies of the leading SRAM suppliers. It covers product positioning, market ranking, and related issues.

Table 1 shows Dataquest's final 1990 worldwide market share ranking of the top suppliers for devices with densities of 16K to 1Mb. The ranking is based on bits for fast SRAMs and on dollarized units for slow SRAMs.

Table 1 shows a wide supplier base for fast SRAMs and a more narrow base for slow SRAMs.

The Wide Fast SRAM Supplier Base

Users should note that fast SRAMs serve as a technology driver for some IC manufacturers, although DRAMs are better known for playing that critical role. The fast SRAM business also

Table 1
1990 Ranking of Top SRAM Suppliers by Density[1]

	16K		64K		256K		1Mb	
Company	Fast	Slow	Fast	Slow	Fast	Slow	Fast	Slow[2]
AMD	11							
Cypress	1		4		4			
Fujitsu	6		3	7	1	6	1	6
Goldstar				10				
Hitachi	2	5	1	2	2	1	2	1[2]
Hyundai		8		9		13		
IDT	2		7		7			
Matra MHS	7		9		13			
Matsushita					9			
Micron	13		11		5			
Mitsubishi	16		6		9	5		5
Motorola	5	8	5		10	12		
NEC	15		12	5	14	2		4
Oki						10		7[2]
Performance	8		14		15			
Samsung				5	12	8		7
Sanyo		1		8				
Seiko			15	12		7		
SGS-Thomson[3]	2	6	2	11				
Sharp	12	2	13	1	11	11		
Sony	10	9	8	4	3	3	3	3
Toshiba	8		10	3	8	4		2[2]
Vitelic	13							
UMC	16	4						
Winbond		10						

[1]Based on dollarized units share for slow SRAM and on bits share for fast SRAM.
[2]Includes pseudo SRAMs.
[3]Includes Inmos.
Source: Dataquest (September 1991)

offers many special niche market opportunities. For these two reasons, the fast SRAM supplier base is wide, and new entrants are waiting to enter this arena.

By contrast, slow SRAMs serve as fab fillers that enable suppliers, which are typically vertically integrated manufacturers, to meet internal captive demand and keep fabs operating at higher capacity levels. The slow SRAM supplier base is limited compared with other semiconductor products because of the captive demand element.

Dataquest Recommendation on Fast SRAM Supplier Base

The supplier base for fast SRAMs has recently been marked by a series of market departures—Advanced Micro Devices Inc., Inova Semiconductor, National Semiconductor Corporation, and Philips Components—and entries—AT&T, Quality Semiconductor Inc., and Winbond Electronics Corporation. The reason is that the prospect of lucrative profit margins draws new entrants into the business, which generates intense market competition.

The supplier base could be poised for more reshuffling over the long term. Dataquest recommends that users monitor the fast SRAM supplier base not only by assessing the fast SRAM supplier base *but also* by keeping an eye on the *DRAM* supplier base, including supplier alliances on DRAMs. Why? In gauging shifts among the many worldwide players in the fast SRAM market, a supplier's DRAM technology capability—for suppliers that have this technology—may serve *in some cases* as the best gauge of a fast SRAM supplier's long-term staying power as well as an indicator of future market entrants.

Cypress Semiconductor Corporation

Table 1 shows Cypress' 1990 ranking in fast SRAM in terms of bits. Cypress ranks first among suppliers of fast 16K SRAMs and fourth in both the fast 64K and fast 256K segments.

Cypress maintains a strategic focus on fast SRAMs as a technology-process driver. The company's strength in fast SRAMs stems from an ability to push SRAM product technology in order to drive access times to ever-faster thresholds. Cypress' strategy has remained consistent over time: It dependably supplies new SRAM products that offer state-of-the-art speeds in lower-density devices (e.g., 16K or below) and gradually extends that strategy to higher-density segments. Users can expect Cypress to make timely market penetration in the fast 1Mb SRAM segment as that market grows.

The company also pursues an aggressive legal strategy in terms of patent and intellectual property laws. Another plus: Cypress has added SRAM and other IC fab capacity at submarket cost.

Fujitsu Ltd.

Fujitsu continues as a leading global force in the fast SRAM business. As shown in Table 1, Fujitsu ranks first among suppliers of fast 256K and fast 1Mb SRAMs and sixth in the 256K slow and 1Mb slow SRAM segments. The company holds third place in the fast 64K arena and sixth place in the fast 16K segment.

For this vertically integrated producer, internal captive demand requires that the company maintain the leading edge in fast SRAM technology and manufacture slow SRAMs. Fujitsu ranks among the top 10 producers of megabit-density DRAM, with fast SRAM serving as much as a technology driver as do DRAMs. Users can expect Fujitsu to stay at the forefront of SRAM product technology in terms of device speed and density. The company should continue as a long-term force in the SRAM business, including the BiCMOS fast SRAM segment.

Hitachi

Hitachi, another vertically integrated supplier, continues to exert worldwide power in the fast and slow SRAM marketplaces. Table 1 shows that Hitachi ranks first among suppliers of fast 64K SRAMs and second in the fast 16K, 256K, and 1Mb segments. Table 1 also reveals Hitachi's leadership position in high-density slow SRAMs—it ranks first in both the 256K and 1Mb slow SRAM arenas.

Users can expect Hitachi to remain at the forefront of SRAM technology regarding product speed and density. The BiCMOS process should be a key element to its long-term strategy.

Hitachi is also a leading producer of megabit-density DRAM. The key DRAM technology driver relates to another aspect of the supplier's SRAM strategy—to preserve and advance its leadership role among suppliers of high-density slow SRAMs including pseudo-SRAMs (PSRAMs).

IDT

Integrated Device Technology (IDT) lost some momentum in the fast SRAM business in 1990. The company strategy focuses on using the advantages of its BiCMOS process to regain position as a speed leader in the SRAM product arena.

Table 1 shows that the company ranks second among suppliers of fast 16K SRAMs and seventh in both the fast 64K and fast 256K segments. In terms of market direction, IDT continues to shift away from its original product—standard SRAMs for North America, including for military users—to the worldwide sale of application-specific memories (e.g., FIFOs) in commercial markets.

Micron Technology Inc.

As shown in Table 1, Micron continues its advance in the highly competitive global memory markets. The supplier uses the DRAM as a key technology-process driver. As shown in Table 1, Micron does not rank among the top 10 suppliers (in terms of bits) in the lower-density fast SRAM segments but holds fifth position in the expanding 256K fast SRAM arena.

Users can expect Micron's fast SRAM product strategy to shift with competitive market forces. The company aims to serve demand for specialty memory such as for FIFOs and to avoid head-to-head pricing wars with industry-giant competitors in the process, but it can shift capacity to more mainstream products in line with evolving market trends.

Mitsubishi Electronics Corporation

The strategy at Mitsubishi, a vertically integrated supplier, calls for a long-term commitment to the competitive SRAM marketplace. DRAMs are also a key element of this manufacturer's market strategy.

Mitsubishi battles to maintain its ranking in the worldwide SRAM business (e.g., 256K segments). As shown in Table 1, Mitsubishi ranks sixth among suppliers of fast 64K SRAMs and ninth in the 256K fast SRAM arena. The supplier ranks fifth in the slow 256K SRAM and slow 1Mb SRAM segments.

Motorola Incorporated

Motorola's advance in the worldwide semiconductor memory marketplace has not always been smooth. For example, demand for microprocessors can periodically divert organizational resources from SRAMs. Even so, this industry giant targets SRAMs and DRAMs as key elements of its long-term IC product portfolio. The company's future product direction in SRAMs links partially to its role as a supplier of application-specific memories.

Table 1 reveals that Motorola ranks fifth among suppliers of fast 16K SRAMs and fast 64K SRAMs. The vertically integrated manufacturer ranks tenth in the 256K fast SRAM segment and twelfth in the 256K slow SRAM business. SRAM users should expect Motorola to penetrate the 1Mb slow and fast SRAM segments during the 1991 to 1992 time frame.

NEC Corporation

For NEC, a vertically integrated supplier, DRAMs play the role of technology driver more so than do fast SRAMs. Satisfying captive demand for slow SRAMs also plays a key role in NEC's strategic plans. Table 1 reflects this strategic reality.

As revealed in Table 1, NEC ranks second in the 256K slow SRAM arena and fourth in the 1Mb slow SRAM segment. Users of slow SRAMs can expect NEC to play a continuing strong role in the slow SRAM business. Should a major shakeout occur among suppliers of fast SRAMs, NEC's strength in the DRAM technology could serve as a route for long-term advancement in that business.

Samsung Electronics Company Ltd.

Samsung continues to advance in the worldwide memory market. Table 1 shows that the vertically integrated South Korea-based supplier ranks fifth in the 64K slow SRAM segment, eighth in the 256K slow SRAM arena, and seventh in the growing 1Mb slow SRAM business. A twelfth-place ranking among suppliers of 256K fast SRAMs signals the company's evolving SRAM market strategy.

Users can expect Samsung to establish its long-term reputation in SRAMs by serving demand for slow SRAMs. DRAMs drive Samsung's IC process technology, which translates into market strength in slow SRAMs. From this base, Samsung can eventually advance into the higher-density fast SRAM segments and perhaps quickly in the event of a market shakeout in that arena.

SGS-Thomson Microelectronics B.V.

As shown on Table 1, SGS-Thomson ranks second among suppliers of 16K fast SRAMs and also—including Inmos Corporation's share—in the 64K fast segment. The supplier increased its share of the fast SRAM marketplace several years ago by acquiring Inmos. SGS-Thomson made no advance during 1990 into the higher-density SRAM marketplace (e.g., densities of 256K and above). The product direction at SGS-Thomson calls for a strong effort on specialty RAMs such as cache tags and low-power battery-backup devices.

Sony Corporation

Table 1 reveals that Sony, a vertically integrated company that is a somewhat less familiar SRAM supplier for some users—has advanced to a competitive third-place ranking across the board at densities of 256K fast, 256K slow, 1Mb fast, and 1Mb slow SRAMs. Sony's strategy aims for leadership in the 1Mb SRAM segments and a de-emphasis on densities of 256K and below.

The SRAM serves as a key to Sony's product portfolio and long-term IC market strategy. The fast SRAM is a technology-process driver for Sony; however, the supplier also participates in the DRAM business. Users should expect this supplier, which has considerable organizational resources, to make a competitive effort to maintain and advance its growing stature as a global SRAM supplier.

Toshiba Corporation

Toshiba, a vertically integrated manufacturer, continues to rank as a leading player in the slow SRAM marketplace and a force in the fast SRAM segment. Toshiba's strategy for the SRAM business focuses on growth opportunities at densities of 1Mb and greater.

Toshiba pursues a strong strategic focus on megabit-density DRAMs as a technology-process driver, which can periodically cut into capacity for the slow SRAM device. Table 1 shows that Toshiba ranks second in the 1Mb slow SRAM segment and fourth in the 256K slow SRAM segment. The slow SRAM product portfolio includes PSRAMs.

The supplier's vertical structure enables it to keep alert to emerging system applications that drive demand for high-density fast SRAMs. Toshiba ranks eighth in the 16K fast SRAM arena, tenth in 64K fast SRAM business, and eighth in the growing 256K fast SRAM segment.

Supply Base Analysis

This section uses information on SRAM product life cycles and SRAM suppliers to present an evaluation of the supply/supplier base for these devices in the 16K, 64K, 256K, and 1Mb densities in the medium and long terms. Product life cycle analysis serves as the basis for a succinct assessment from the users' viewpoint of the anticipated supply base for each SRAM density. Table 1 serves as the basis for the supplier analysis. This assessment aims to provide users with advice for choosing suppliers.

Supply Base for 16K SRAMs

Users of fast 16K SRAMs face a tighter supply scenario as this product moves through the decline stage of its life cycle. Supply base managers with systems that use 16K fast SRAMs should plan for system redesigns during the 1992 to 1994 period. The phaseout stage of the life cycle for fast 16K SRAMs should stretch to the 1995 to 1996 time frame. Users should note that devices in the x4 configuration should have a somewhat longer life cycle than configurations such as the x8. Why? Suppliers are still drawn to the x4 arena for cache tag applications.

Users can still look to a wide global supplier base for these fast devices; however, users must monitor suppliers' long-term strategies for serving demand. With a focus on each supplier's market strength in terms of device configuration, Cypress (x4, x8), Hitachi (x1, x4), IDT (x4, x8), Motorola (x4), and SGS-Thomson (x1, x4) rank among the leading suppliers.

The supplier base for slow 16K SRAMs should narrow. North American and European users of 16K slow SRAMs should seek possible long-term supply arrangements with companies such as Hyundai Electronics, Sanyo Electric Company Ltd., SGS-Thomson, Sharp Electronics Corporation, UMC, or Winbond. System redesign is a feasible alternative.

Supply Base for 64K SRAMs

Buyers of fast 64K SRAMs continue to face a generally favorable long-term supply situation; however, the more familiar Japan-based suppliers are departing the 64K slow SRAM segment.

Supply Base Outlook for Fast 64K SRAMs

As shown in Figure 2, the life cycle for 64K fast SRAMs is expected to stretch to the end of the 1990s. Users that have designed CMOS fast

64K parts or BiCMOS fast 64K products into systems can expect an ample supply of parts from a wide supplier base. The x4 configuration should have a longer life cycle than organizations such as the x1. The supplier base for devices in the x8 configuration will shift from the more familiar Japan-based and North America-based suppliers to newer entrants such as AT&T (U.S.) and companies in other regions.

Supply of fast 64Kx1 devices should peak during the 1991 to 1992 time frame at an annual level of 25 million units. By contrast, output of fast 16Kx4 SRAMs and fast 8Kx8/x9 SRAMs should expand through 1993. For example, supply of the x4 device should increase from nearly 30 million units during 1991 to 34 million units for 1993. Supply of the 8Kx8 and 8Kx9 devices—which fit some systems' specialty memory needs—should expand from 34 million units for 1991 to 42 million units for 1993. As noted, in addition to mainstream CMOS technology, BiCMOS technology now penetrates the 64K fast SRAM marketplace.

As shown in Table 1, a wide number of suppliers serve demand for fast 64K SRAMs. First-ranked Hitachi's market strengths include the CMOS (x1, x4) segment and the BiCMOS TTL-compatible (x1, x4) and BiCMOS ECL-compatible (x1, x4) segments. Second-ranked SGS-Thomson (which includes Inmos) is very strong in the CMOS 64Kx1 market and a player in other CMOS (x4, x8) arenas. Fujitsu—in addition to its strength in the CMOS (x1, x4, x8) segments—ranked among leading suppliers of CMOS 8Kx9 SRAMs and BiCMOS ECL-compatible (x1, x4) parts. Cypress' market clout centers on CMOS (x4, x8) devices. Motorola's market presence is the CMOS 16Kx4 device in addition to its role in the other CMOS (x1, x8) arenas. Mitsubishi has centered on the mainstream CMOS (x1, x4, x8) segments. By contrast, IDT—which supplies the familiar line of CMOS (x1, x4, x8) devices also serves demand for BiCMOS ECL-compatible (x1, x4). Table 1 shows the full range of suppliers of 64K fast SRAMs.

Supply Base Outlook for Slow 64K SRAMs

The supplier base for slow 64K SRAMs will continue to contract fitfully during the 1991 to 1992 time frame as this product moves through the decline stage of its life cycle. Under direction of guidance from Japan's Ministry of International Trade and Industry (MITI), familiar Japan-based suppliers such as Hitachi, Fujitsu, NEC, and Toshiba are de-emphasizing this segment and migrating to higher-density slow SRAMs.

During the second half of 1990, the following suppliers were the only ones that maintained or increased shipments of 64K slow SRAMs: Goldstar, Hyundai, Samsung, Sanyo, and SGS-Thomson. As shown in Table 1, the top 10 ranking of suppliers includes Sharp and Sony.

Dataquest Recommendation

Based upon SPS client inquiries, users that must continue to use 8Kx8 slow SRAMs basically must choose between Samsung and Hyundai.

Samsung has a longer, more visible, and more dependable track record in terms of supplying memory ICs—DRAM as well as slow SRAM—to users in Asia, Europe, and North America. Samsung has a clear long-term strategy on the role that slow SRAM will play in its product portfolio and is not likely to abruptly depart the marketplace. The edge goes to Samsung.

Hyundai is a younger and potentially aggressive competitor in the IC business. Hyundai has stumbled badly in the semiconductor marketplace but continues to draw upon huge corporate resources to win a long-term stake in the IC arena. Hyundai could become brutally competitive on 64K slow SRAM pricing. Nevertheless, the strategy at Hyundai at the time this article was written does not preclude a switch in product focus, which could mean for users an all-too-quick departure from the 64K slow SRAM segment.

Dataquest recommends that users consider an alternative—redesign systems to accommodate 32Kx8 slow SRAM. The 256K slow SRAM supplier base is much larger, and, despite recent stabilization of pricing, market elements exist such that pricing could again fall during 1992. By contrast, 64K slow SRAM pricing is more likely to rise during 1992.

Supply Base for 256K SRAMs

Users of 256K SRAMs face a favorable long-term supply base. Figure 2 shows that slow 256K SRAMs are moving through the peak maturity stage while fast 256K SRAMs are moving through the growth stage of the life cycle.

Supply Base Outlook for Fast 256K SRAMs

Annual supply of fast 256Kx1 devices should peak during 1993 at a 20 million unit level. Even so, 1995 output volume should be above the 1991 level of 14 million units. Supply of fast 64Kx4 SRAMs and fast 32Kx8/x9 SRAMs should expand through the first half of this decade. The supply of the x4 part should grow from 19 million units during 1991 to 42 million units for 1995. Supply of the 32Kx8 and 32Kx9 devices should expand more robustly—from 19 million units for 1991 to 49 million units for 1993.

Table 1 reveals a large supplier base for fast 256K SRAMs. Some suppliers, such as formerly sixth-ranked National Semiconductor, have departed this competitive business.

The top three suppliers are Japan-based: Fujitsu, Hitachi, and Sony. Top-ranked Fujitsu's market presence in the 256K fast SRAM business includes the CMOS (x1, x4, x8) segment and the BiCMOS ECL-compatible (x1, x4) segment. Second-ranked Hitachi supplies the same two markets as Fujitsu, as well as the BiCMOS TTL-compatible (x1, x4) arena. Cypress, Micron, and Sony center on the CMOS (x1, x4, x8) segments. IDT also focuses on CMOS (x8) products, including 32Kx9 fast SRAMs. Table 1 shows the full range of 256K fast SRAM suppliers.

Users of 256K slow SRAMs face a favorable long-term supply base. Annual supply of slow 32Kx8 devices should peak during 1991 at a 210 million unit level and should not dip below the 200 million unit level through the year 1993. Supply should total 153 million units for 1995.

Although Table 1 depicts a more narrow supplier base for slow 256K SRAMs vis-à-vis the fast SRAM supplier base, users can look to industry giants such as Hitachi, NEC, Sony, Toshiba, Mitsubishi, Fujitsu, Seiko, and Samsung for a steady supply of this part during the 1991 to 1993 time frame.

Supply Base for 1Mb SRAMs

Figure 2 reveals that slow 1Mb SRAMs stand at the growth (or ramp) stage of a life cycle that should extend beyond the year 2000. The figure also shows that the fast 1Mb SRAM product is nearing the ramp stage of the curve. The BiCMOS technology will compete against the mainstream CMOS technology for high-performance applications. The fast 1Mb SRAM life cycle should extend until 2005. As shown in Table 1, Japan-based stalwarts such as Fujitsu, Hitachi, Sony, and Toshiba are staking early leadership positions in the 1Mb fast SRAM marketplace.

Table 1 depicts an expanding supplier base for slow 1Mb SRAMs. Hitachi and Toshiba—whose shares include PSRAMs—are the top-ranked suppliers. When PSRAMs are excluded, the ranking is Hitachi, Sony, NEC, and Toshiba. Supply leadership in this segment mirrors that of the 256K slow SRAM business: In addition to these four suppliers, Fujitsu, Mitsubishi, Oki, and Samsung rank as leading suppliers of 1Mb slow SRAMs. Oki also supplies PSRAMs.

Dataquest Perspective

Users can view the fast SRAM marketplace as a series of micromarkets, although the trend is toward a higher degree of product commoditization. In contrast, the slow SRAM arena, which has been dominated by vertically integrated suppliers from Japan, serves as a classic example of a commodity-type IC segment. European and North American supply base managers for systems manufacturers face a stiff long-term challenge in terms of managing the shifting fast SRAM supplier base and qualifying less familiar slow SRAM suppliers. For example, Dataquest fully expects familiar industry giants such as Hitachi, Toshiba, and NEC to remain major players in the megabit-density slow SRAM marketplace. Even so, users that have not already done so must qualify rising stars such as Japan-based Sony and Korea-based Samsung.

Users of fast SRAMs must plan for several different shifts—or "waves"—among suppliers. First, users can expect to encounter familiar first-tier suppliers—especially Japan-based companies such as Fujitsu and Hitachi—in the first wave when a given density of fast SRAM stands at an early stage of the life cycle (e.g., 1Mb fast SRAM during 1991 and 1992). Less familiar start-up companies such as North America-based Paradigm will also target the leading edge. Later in the product life cycle, however, the first wave of suppliers will migrate and a second wave of suppliers will support users' needs for SRAMs. For example, the 8Kx8 25ns product currently stands at the maturity stage of the life cycle. Users can expect the early set of suppliers—especially Japan-based suppliers—to be replaced by newer entrants from regions ranging from North America (e.g., AT&T) to Taiwan. The same process will occur in the 256K fast SRAM segments within two or three years.

More ominously, users must also prepare for the complete shift—i.e., departure—of suppliers from the SRAM business, as occurred with National Semiconductor and Philips during 1990. In this case, the departure of these fast SRAM suppliers was followed by the market entrance of another set of companies, with the size of the supplier base remaining about the same. For users, an unresolved question becomes the SRAM market's resiliency in attracting newer players to replace players that will inevitably exit the market. ■

By Ronald Bohn

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- September *Market Watch*
- Semiconductor Capacity Update
- Mixed-Signal/Analog IC Update

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 11 August 26, 1991

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.20	0.18	0.18	0.18	0.18	0.13
74AC138	0.34	0.32	0.32	0.31	0.34	0.21
74AC244	0.50	0.42	0.45	0.42	0.48	0.34
74AC74	0.26	0.24	0.24	NA	0.24	0.17
Lead Time (Weeks)	2	3	6	4	5	5
4F00	0.11	0.11	0.10	0.11	0.10	0.10
4F138	0.17	0.18	0.18	0.18	0.20	0.14
4F244	0.24	0.25	0.25	0.27	0.29	0.23
4F74	0.12	0.13	0.11	0.16	0.13	0.11
Lead Time (Weeks)	2	3	5	4	5	5
7805-TO92	0.13	0.18	0.11	0.14	0.14	0.11
CODEC-FLTR 1	1.88	NA	2.50	2.03	2.15	1.35
CODEC-FLTR 2	3.95	NA	5.00	4.17	5.05	NA
Lead Time (Weeks)	4	NA	6	3	4	NA
DRAM 1Mbx1-8	4.10	4.29	4.10	4.75	4.80	4.00
DRAM 1Mbx9-8	39.50	50.76	37.50	41.50	48.00	39.00
DRAM 256Kx1-8	1.75	1.69	1.70	1.50	1.55	1.10
DRAM 256Kx4-8	4.13	4.47	4.10	4.98	4.80	4.00
DRAM 4Mbx1-8	15.88	18.00	16.00	18.45	21.00	16.00
EPROM 1Mb 170ns	3.85	5.01	4.00	5.50	4.00	3.80
EPROM 2Mb 170ns	8.10	12.24	9.00	9.30	8.00	NA
SRAM 1Mb 128Kx8	15.70	15.66	14.00	17.50	19.00	NA
SRAM 256K 32Kx8	4.10	4.07	4.00	4.33	4.80	3.30
SRAM 64K 8Kx8	1.95	1.52	1.65	1.65	1.50	1.20
Lead Time (Weeks)	4	4	4	4	7	3
68020-16	36.00	49.68	37.50	47.25	49.50	NA
80286-16	13.50	14.04	13.50	12.90	12.80	13.50
80386DX-25	154.00	176.39	170.00	NA	193.00	NA
80386SX-16	54.00	65.88	55.00	62.00	63.20	55.00
R3000-25	129.00	147.59	132.00			
Lead Time (Weeks)	4	6	4			

Note: This information appears in the on-line *DQ Monday Report* dated August 12, 1991.
NA = Not available
Source: Dataquest (August 1991)

Market Analysis

August Market Watch: As the Summer Heats Up, the Market Chills Out

The *Market Watch* is a monthly Dataquest report that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Seasonality Sets in, the Book-To-Bill Slumps to 0.96

The continued slippage of the North American book-to-bill ratio from 1.01 to July's 0.96, as shown in Figure 1, may not be as negative as it appears at first glance. Over the past four years, there has always been a June-July drop in this ambiguous market bellwether. What is notable in the figures for July 1991 is that although bookings are only 0.05 percent less (i.e., flat) than those of a year ago (July 1990), the corresponding billings level is 4.2 percent higher than in July 1990. As mentioned in earlier issues of *Market Watch*, the billings bulge that began in the second quarter has now traveled through the shipment pipeline. Current lower semiconductor dollar booking levels are a combination of price reductions and lower unit volume because of the overall sluggish computer market.

Shipment and Order Rates for Computers Show No Growth Over Last Year

Figure 2 illustrates that for the past three months there has been a convergence of the annualized order and shipment rates for computers and office machines as tracked by the Department of Commerce. For June, the 12/12

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

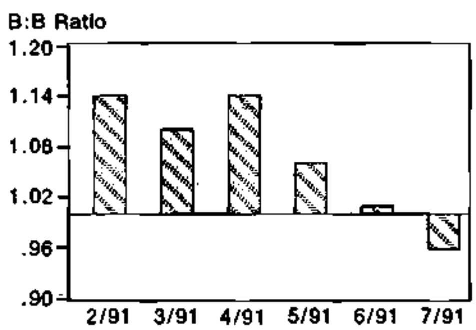


Figure 2
DOC Computer Demand

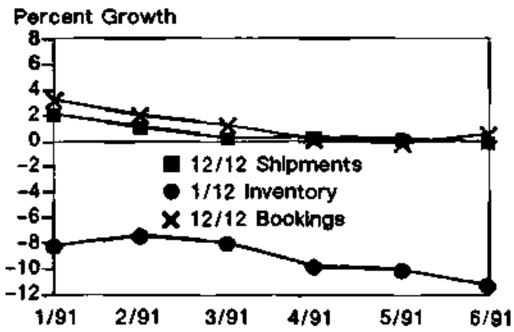


Figure 3
Semiconductor Inventory Level

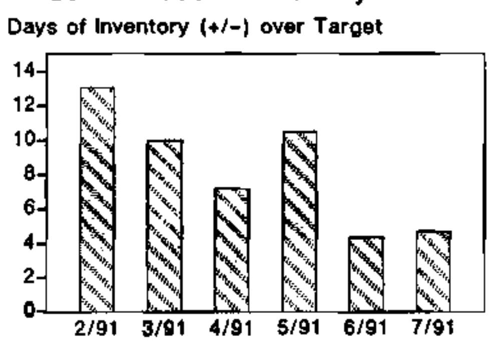
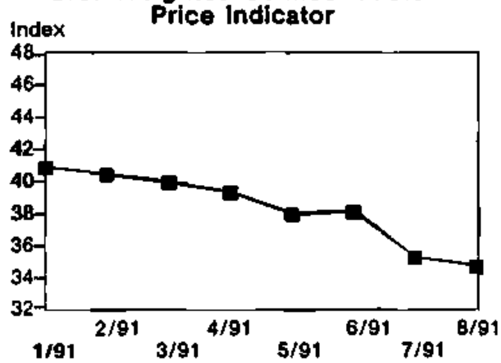


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (August 1991) shipment rate finally had no growth, while the 12/12 bookings rate regained a positive 0.6 percent. Reflecting good inventory control at the systems level that is mirroring sluggish sales, the monthly 1/12 inventory rate is 11.2 percent less than the comparable level of a year ago. Price pressure in the systems markets is also dampening shipment rates even as unit volume, in some cases, is increasing. The more volatile 1/12 booking rate for computers remained positive for a second consecutive month (5.3 percent for June), which is one of the first glimmers of a near-term business uptick seen in over six months.

Semiconductor Inventory Levels Flatten Out

The overall actual-target inventory level delta remained under 5 days (4.7) for an unprecedented consecutive second month! The overall actual inventory level for July rose slightly to 25 days from last month's nadir of 24 days, while the target level remained at 20 days. The trend of reducing the difference between inventory reality to goals continues largely because of the impetus of the slow business environment. Inventory levels continue to be pared to where any sustained business increase will quickly translate into raw material orders. As mentioned last month, Dataquest expected to see continued improvements in inventory control for the rest of this year, and the computer subset of our monthly procurement survey did just that. As noted in this month's *Procurement Pulse*, the target-actual inventory difference for the computer company respondents was less than two (1.3) days! As the summer slows continue, further improvements in inventory levels and delivery scheduling are highly probable.

Semiconductor Prices Match the Market and Slowly Sink

Prices declined only 1.5 percent from last month's average, again reflecting the slow but balanced semiconductor market. Although there are sporadic instances of DRAM spot pricing at 10 to 15 percent below market averages, overall prices for semiconductors continue to decline at a slow and manageable rate. The absence of FMVs has caused some confusion in the near-term pricing of DRAMs and SRAMs, where some "trial-balloon" flat-to-higher pricing of these parts is being tested by Japanese suppliers. As noted in earlier articles, the lack of FMVs has placed more focus on regional pricing differences that would highlight the selling of export products at a lower price than in the home market (i.e., dumping). In the current slow market, improvements in coordinating the regional pricing of Japan and the United States are needed for some Japanese suppliers to remain price competitive. Overall availability remains excellent for most, if not all, semiconductors, and Dataquest expects this trend to remain unchanged for the rest of the year.

Dataquest Perspective

As in the past three to four months, the current slow business climate puts focus on cost-reduction strategies and tactics to a higher degree than during growth periods. Inventories continue to be managed well, order levels are coming more in line with end-market sales, and availability/pricing remains manageable. The lack of a high-volume demand pull is partly because of recessionary fears, but more importantly a perception that, for the most part, many productivity improvements made via electronics (e.g., PCs, faxes) are now more than satisfactory. Additional expenditure to improve on the current installed base will require improved ease of use. Reflecting on the 10-year anniversary of the IBM PC, great improvements have been made in ease of use (remember VisiCalc?). Combining software with hardware at earlier system design stages appears to be needed to rekindle increased interest and demand to a perceived saturated market. The procurement function of a company will become an even more important communication link between the design and marketing groups (noting cost/availability) as this trend develops. ■

By Mark Giudici

New Fabs in Europe

With a unified Europe around the corner, the near-term outlook for construction of wafer fabrication facilities on the continent looks subdued. This article highlights new facilities scheduled to begin production during the 1991-to-1994 time frame and punctuates the manufacturing shift to centers of regional demand.

According to Dataquest's European Semiconductor Application Markets service, electronic equipment production in Europe is forecast to have a compound annual growth rate (CAGR) of 10.6 percent between 1990 and 1994. The data processing segment is expected to have a 14.2 percent CAGR, and the transportation segment should have a 20 percent CAGR over the same period. Semiconductor manufacturers will be there to supply this production growth.

Foreign semiconductor manufacturers have been making considerable capital investments in Europe with a conspicuous pickup in levels of expenditure occurring in 1990.

A Bit of History

The late 1980s were accompanied by a boom in the construction of European production and pilot lines. From a base of 102 in 1987, semiconductor fabrication lines flourished. By 1990, there were 124 fabs—up over 20 percent from 1987 levels. Figure 1 depicts growth in new production and pilot lines from 1987 to 1994.

Leveling Off

Dataquest expects four production and one quick-turn line to begin operation during 1991. Table 1 presents 14 new fab lines by company with planned start dates between 1991 and 1994.

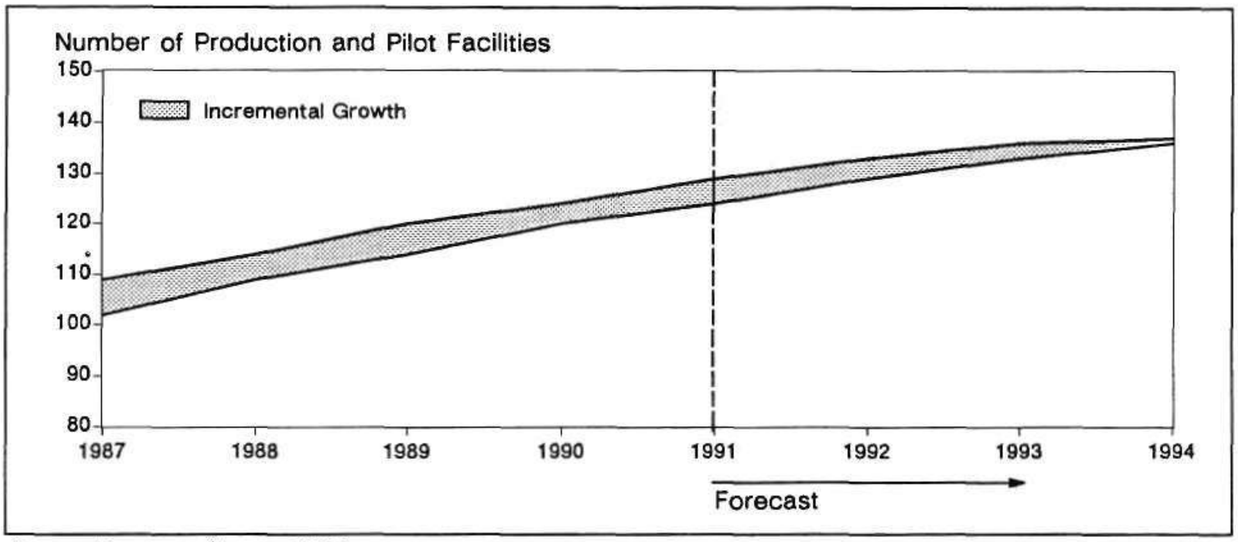
Foreign semiconductor manufacturers have been making considerable capital investments in Europe with a conspicuous pickup in levels of expenditure occurring in 1990. This increase has, in some circles, been perceived as an evasive move to thwart the European Community's (EC's) 14 percent tariff on ICs diffused outside of Europe. *Yet, more importantly, there has been a movement by semiconductor device manufacturers to respond to the needs of their European customer base.* Foreign producers have acknowledged this new directive by transplanting manufacturing facilities to the region of device consumption.

Late Arrivals

Of the top 10 semiconductor manufacturers in 1990, all, with the exception of Matsushita and Toshiba, have announced plans for European production lines.

One decidedly late arrival on the European scene was Intel Corporation, which only last year broke ground on a production wafer fab within the EC. Intel has been operating a plant in Israel, which has enjoyed preferential trading status with the EC since 1987. Dataquest believes that Intel's decision to build a facility in Ireland had little to do with whether the EC will maintain its current relationship with Israel. Its new Irish manufacturing facility will accompany systems manufacturing work. This 200,000-square-foot facility housing a Class 1 clean room represents the state of the art in

Figure 1
European Production/Pilot Lines



Source: Dataquest (August 1991)

Table 1
Planned European Fabs by Company

Company	City	Country	Fab Type	Target Production Date
Fujitsu	Newton Aycliffe	England	Production	1992 1993 1994
Hitachi	Landshut	Germany	Production	1992
IBM	Sindelfingen	Germany	Production	1991
ITT	Freiburg	Germany	Production	1991
Intel	Leixlip, Kildare	Ireland	Production	1993
Mitsubishi	Alsdorf	Germany	Production	1992
NEC	Livingston	Scotland	Production	1991
Qudos	South Yorkshire	England	Quick Turn	1991
SGS-Thomson	Agrate	Italy	R&D	1991
Sharp	Oxford	England	R&D	1991
Siemens	Regensburg	Germany	Production	1991
Texas Instruments	Avezzano	Italy	Production	1992

Source: Dataquest (August 1991)

fabrication facilities. When fully operational, the plant is expected to employ 500 to 1,000 people. Dataquest views Intel's move as strategic in order to address the needs of its European customer base as well as its intracompany demands.

Toshiba, which has assembly and test facilities in Braunschweig, Germany, has yet to announce construction of a diffusion facility on European soil. Matsushita has yet to disclose its plans for production or assembly and test in the EC.

Dataquest Perspective

"To every action there is always opposed an equal reaction . . ."
- Sir Isaac Newton

No new major facilities have been announced other than those highlighted in this article. Dataquest, however, believes that a possibility exists for additional new announcements, and we also believe that there is a major opportunity for strategic alliance between domestic and foreign companies seeking to enter the European market without the added financial barrier of a production facility. ■

(This article was reprinted with the permission of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service.)

By Rebecca E. Burr

Product Analysis

Advice for DRAM Users: Staying Alive in a Competitive, DRAM-Hungry World

Executive Summary

Dataquest estimates that worldwide production of DRAMs totaled 1.4 billion units during 1990, a 1 percent decline from the 1989 level. For users, life is never easy in this DRAM-hungry world, as shown by erratic first-half 1991 trends in the 1Mb DRAM segment. Based on Dataquest's final 1990 DRAM market share ranking, this article evaluates the life cycle stage for DRAMs in 64K through 16Mb densities and assesses the supply/supplier base for these critical products now and in the year 2000.

Overview—DRAM Cost Containment

This article provides DRAM users with practical and strategic information for choosing which devices to use and from which supplier or suppliers. (The articles replace the "DRAM Product Trends" section of the *Industry Trends* binder of the former Semiconductor User Information Service.) Like the other 1991 *Dataquest Perspective* articles in this product trends series, this one contains three sections. The first develops a guide to cost-effective, long-term procurement of DRAMs through the use of product life cycle analysis. The second section on the top-ranked suppliers of DRAMs looks at market positions, technology strengths, and future product strategies of the leading suppliers. The third section combines analyses of DRAM life cycles and the supplier base. The sections blend a discussion of key industry issues affecting DRAM users today and over the long term.

A key element to our strategy for DRAM demand management is for users to match system life cycles with DRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans against DRAM life cycles for the purposes of managing DRAM costs *and* planning for DRAM changeovers in those cases where system/DRAM life cycles do not match.

DRAM Product Life Cycles

This section uses information on DRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over time. This section also states the basis for other analyses based on DRAM life cycle curves.

Typical Life Cycles for DRAM Products

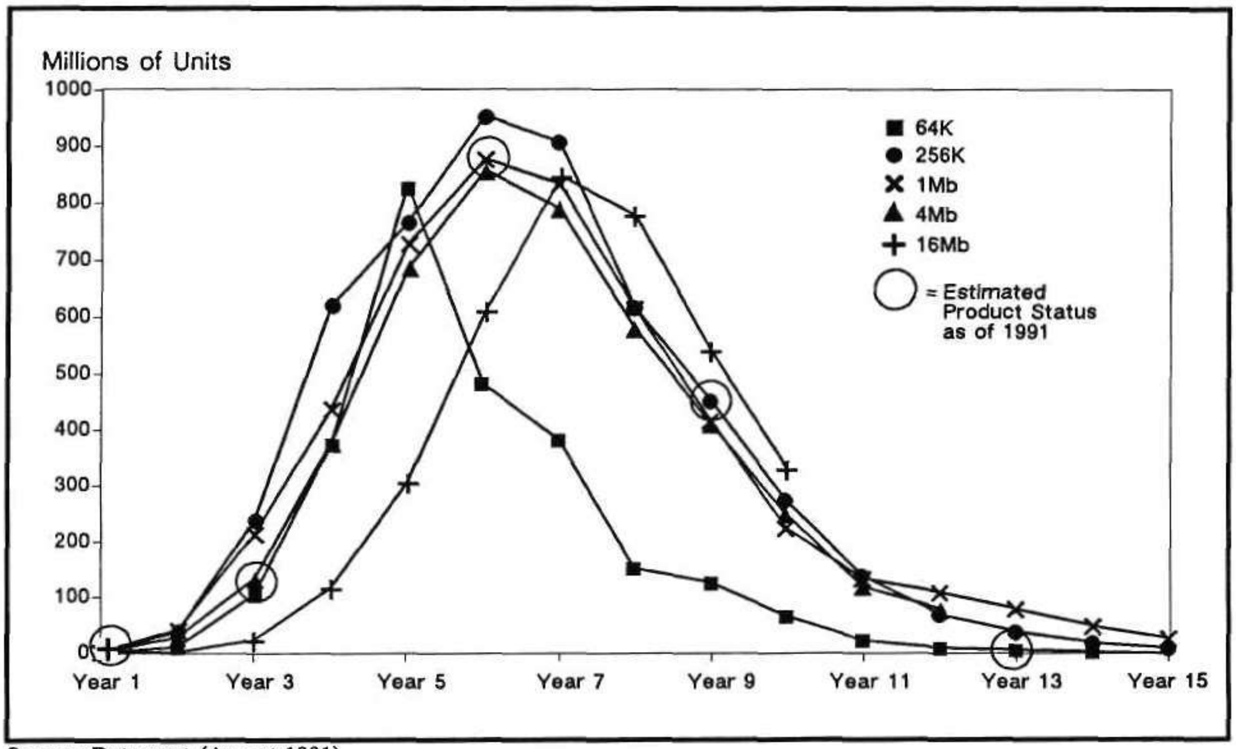
Figure 1 shows a series of curves that map the product life cycle of DRAMs in densities of 64K to 16Mb. This figure is based on Dataquest's historical DRAM unit shipments and forecast information.

Figure 1 reveals that DRAMs typically experience a life cycle of 15 years or more, excluding the R&D phase. The figure illustrates that the DRAM cycle reaches the critical peak stage of unit/supply during its fifth or sixth year.

Factors That Affect DRAM Life Cycle Behavior

The trend is toward longer life cycles for megabit-density DRAMs versus that of the prior generations of lower-density parts. (Factors that affect DRAM life cycle behavior are described in the Semiconductor Procurement *Dataquest Perspective* Volume 1, No. 10, article entitled "Will 4Mb DRAMs Have A Short Life?")

Figure 1
DRAM Product Life Cycles by Density as of August 1991



Source: Dataquest (August 1991)

0011219

DRAM and DRAM Life Cycles by Configuration Over Time

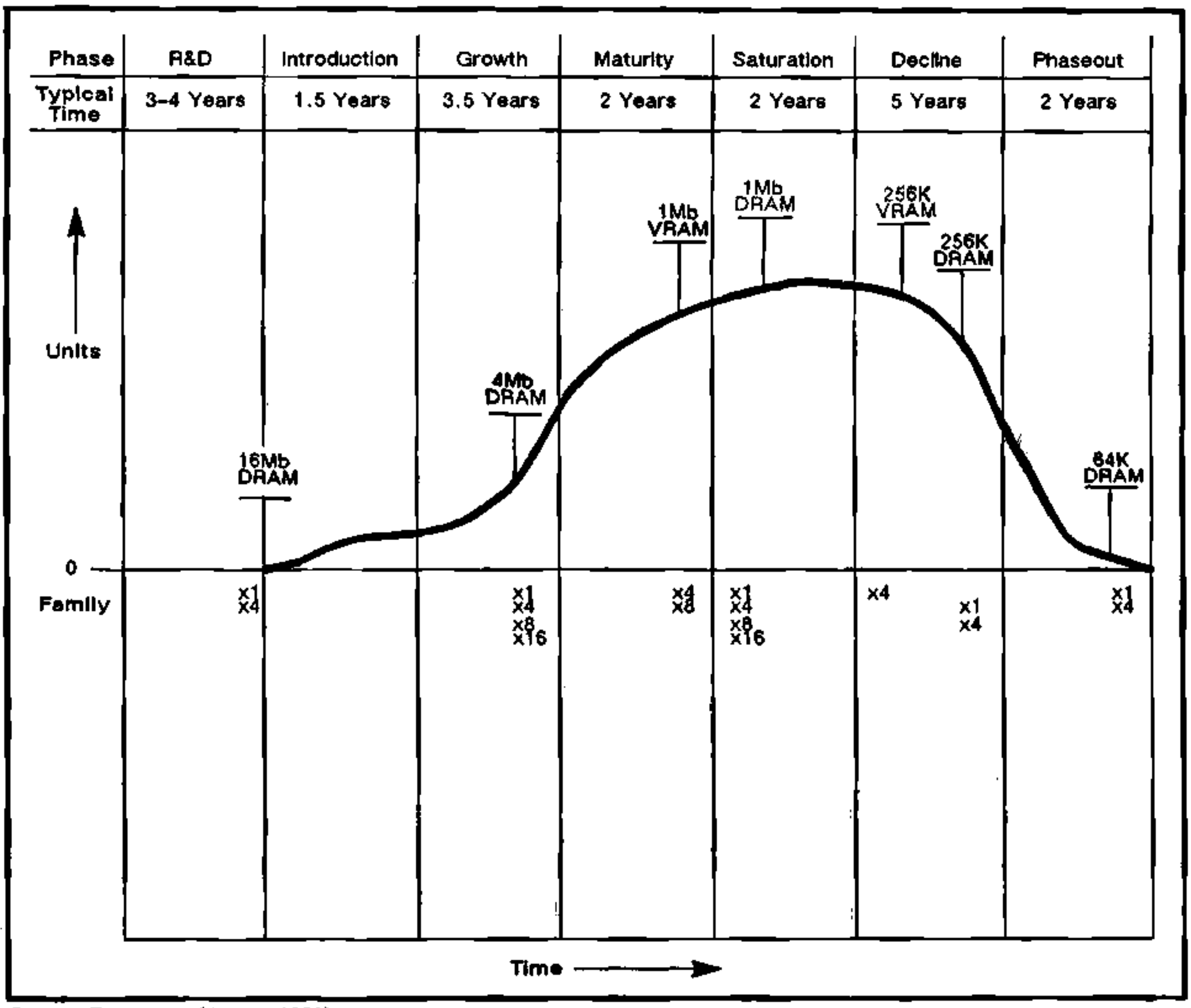
Figure 2 depicts the life cycles for DRAMs and video RAMs (VRAMs) on the basis of organization. The figure breaks each stage into specific time intervals.

DRAM Life Cycle Stages

Figure 2 shows that the DRAM R&D stage occurs over a three- to four-year period. The DRAM introduction and growth stages extend for five years. The maturity and saturation stages total another five years. The decline/phaseout period typically persists for as long as seven years.

Figure 2 reveals that 64K DRAMs have already been phased out by most suppliers. The 256K DRAM continues to move through its decline stage and is now causing heartburn for some users. The 1Mb DRAM life cycle, which should peak during the 1991 to 1992 timeframe, should extend past 1995. Figures 1 and 2 show—as does the cited article on the 4Mb DRAM—that Dataquest expects a long life, extending to the year 2000, for 4Mb DRAMs. Dataquest's worldwide network of DRAM

Figure 2
1991 DRAM Product Life Cycles by Configuration as of August 1991



Source: Dataquest (August 1991)

analyst will continue to monitor the factors that could affect megabit-density DRAM life cycles. As shown in Figure 2, the 16Mb DRAM is nearing the introductory stage of a cycle that will extend well beyond the year 2000.

DRAM Product Configurations

The ×1 design and the ×4 have been the mainstream DRAM organizations. Two DRAM product trends will intensify in the 4Mb segment: a design trend toward wide-word DRAM configurations (e.g., ×8/×9, ×16/18); and a trend toward increased supply/demand for single in-line memory modules (SIMMs) and single in-line packages (SIPs). SIMM life cycles are virtually the same as those of the underlying DRAM devices. By contrast, the VRAM life cycle lags behind the stages of the equivalent-density DRAM by one year (e.g., 1Mb VRAM versus 1Mb DRAM). For the newly emerging wide-word configurations, the life cycle may be somewhat less consistent than for the DRAMs organized in ×1 or ×4 designs.

DRAM Trends in Europe

For a discussion of DRAM product trends in Europe, see the Semiconductor Procurement *Dataquest Perspective* Volume 1, No. 6, article entitled "European DRAM Market Update—Welcome to the 4Mb."

Supplier Analysis

This section analyzes the product and market strategies of leading DRAM suppliers. It covers each company's DRAM market ranking, product/technology positioning, strategic direction, and related issues.

To minimize supply line disruption, users should be prepared to forge long-term supply arrangements with current suppliers or qualify new suppliers.

Current or prospective users of megabit-density DRAMs must be aware that the highly competitive early stages of the DRAM product life cycles—an intense R&D period followed by a short introductory phase—often mean a sharp competitive advantage for early entrants, which are able to enjoy premium pricing through the introduction and growth phases. The extended maturity phase eventually tips the competitive balance to low-cost producers. This reality serves as the background on analysis of the 1Mb and 4Mb DRAM supplier base.

Table 1 shows the 1990 worldwide ranking of DRAM suppliers as measured in dollarized units. The table presents each company's ranking in terms of units for densities from 64K through 4Mb. It also shows which suppliers have sampled 16Mb DRAMs as of July 1991.

As noted, early leadership for the next-generation product often signals future DRAM market leadership. Dataquest restates what we said previously: For users looking ahead, Dataquest expects the 1992 to 1993 total ranking to be strongly influenced by 4Mb DRAM ranking.

Toshiba

As shown in Table 1, which is based on 1990 worldwide dollarized units, first-ranked Toshiba holds first-place ranking in 1Mb DRAMs and second in the 4Mb product area. The industry giant held the number one spot in the 4Mb segment during 1989; however, during 1990 Toshiba adjusted to a 4Mb DRAM market shift from a 350-mil-wide device—the 4Mb part with which it started—to the now industry-standard 300-mil part. Toshiba should remain a leader in the DRAM market for the foreseeable future.

As shown by Toshiba's huge state-of-the-art DRAM fab network, this vertically integrated supplier positions itself at the leading edge of DRAM technology. In the 1991 to 1992 time frame, the company will emphasize the 4Mb DRAM density and de-emphasize 256K DRAMs and 1Mb DRAMs. The product portfolio includes high-speed DRAMs (60ns or faster), wide-word configurations (e.g., ×8, ×9, ×16, ×18), and SIMMs. As of midyear 1991, 16Mb DRAM samples are available. Toshiba is a leading supplier of 1Mb VRAMs (e.g., 256K×4, 128K×8) and should be a major player in the 4Mb VRAM segment as that market emerges.

Samsung

Second-ranked Samsung of the Republic of Korea continues an impressive advance in the global DRAM marketplace, moving one notch higher in the ranking during 1990 versus its third-place ranking for 1989. Table 1 reveals that Samsung ranks first in the older 64K and 256K segments, which is no surprise, but somewhat surprisingly ranks second in the maturing but still mainstream 1Mb segment. A key factor is that the company has used its vertically integrated structure to emerge as a low-cost DRAM producer.

Table 1
Top Worldwide DRAM Suppliers[1]

Supplier	1990 Total Ranking[2]	64K	256K	Ranking by Density[3] 1Mb	4Mb	16Mb[4]
Toshiba	1		12	1	2	S
Samsung	2	1	1	2	6	S
NEC	3		2	3	3	S
Hitachi	4		12	6	1	S
Fujitsu	5		9	4	4	S
Texas Instruments	6	2	4	5	10	S
Oki	7	3	3	9	7	S
Mitsubishi	8		8	8	5	S
Micron	9	4	7	10		
Motorola	10		18	7	11	
NMB	11		5	12	12	S
Siemens	12		16	11	8	
Matsushita	13	5	14	12	8	S
Hyundai	14		6	15		
Intel	15		16	14		
Vitelic	16		10	18		
Goldstar	17		11	18		
Sharp	18		15	17		
Sanyo	19		19	16		
Total (Million of Units)		24	617	728	30.3	0

[1]In terms of "dollarized units," which represent the sum of all units sold by a company weighted by each DRAM density's 1990 worldwide ASP
[2]Includes VRAMs
[3]In units
[4]Samples as of July 1991
Source: Dataquest (August 1991)

Samsung strives to position itself as a DRAM technology leader. As shown by its sixth-place ranking in the 4Mb segment, Samsung still lags leaders such as Hitachi and Toshiba. A strategic factor—the goal of maintaining a reputation for DRAM product quality—partially accounts for the sixth-place ranking. The sound strategy caused Samsung to be conservative in terms of bringing the complex 4Mb DRAM device to market during 1990.

Users can continue to look to Samsung for 1Mb DRAMs during 1991 and 1992. The product portfolio includes SIMMs (e.g., 1Mbx8, 1Mbx9), and some users of 64K DRAMs and 256K DRAMs can forge long-term supply arrangements with this supplier. Users can expect a competitive 4Mb DRAM product line from Samsung including wide-word configurations (e.g., x8, x9, x16, x18) and SIMMs. Table 1 shows that 16Mb DRAM samples have been available as of midyear 1991.

In order to protect its long-term position in the worldwide DRAM arena, Samsung must avoid trade friction, which will be challenging. For example, this supplier, along with other Korean companies, is being investigated for alleged dumping in Europe.

NEC

NEC, ranked third overall, holds third-place ranking in the 1Mb DRAM and 4Mb DRAM segments and second ranking in the declining 256K arena, as shown in Table 1. Users can expect NEC to de-emphasize 256K and 1Mb DRAMs during the 1991 to 1992 period.

In line with prior history, NEC continues to act from a DRAM technology "catch-up position" in a learning-curve-dominated segment of the semiconductor business. The vertically integrated company has in the past successfully executed this somewhat risky strategy by supporting superior manufacturing planning with "deep-pockets" financial strength. An early leader in the 4Mb market, NEC should remain a top worldwide DRAM supplier.

NEC's strategy for 1991 and beyond focuses on success at DRAM densities of 4Mb and greater. Users of 4Mb DRAMs can look to NEC for a competitive product portfolio: high-speed 4Mb DRAMs, wide-word configurations (e.g., ×8, ×9, ×16, ×18), and SIMMs. NEC should make an orderly migration from 1Mb VRAMs such as the 256K×4 device to 4Mb VRAMs in line with market demand trends. Samples of 16Mb DRAMs from Hitachi are available now.

Hitachi

Hitachi ranks fourth among DRAM suppliers—the same ranking as in 1989—but ranks *first* at the critical 4Mb level (see Table 1). As with other leading Japan-based suppliers, users can expect Hitachi to de-emphasize 256K and 1Mb DRAMs during 1991 and 1992. Users can look to Hitachi for 256K VRAMs (e.g., 64K×4), 1Mb VRAMs (e.g., 256K×4, 128K×8), and SIMMs (e.g., 1Mb×8, 1Mb×9). The supplier will make an orderly move to the 4Mb VRAM when demand grows.

As a former top player in the DRAM business, Hitachi's strategy calls for an aggressive effort to win the 4Mb market battle and the concomitant market stature. Along with DRAM design know-how, manufacturing prowess, and marketing skill, users can expect Hitachi to display the device speed and packaging technology expertise that previously enabled the company to achieve effective DRAM product differentiation.

Hitachi's competitive 4Mb DRAM product portfolio offers wide-word configurations (e.g., ×8, ×9, ×16, ×18), SIMMs, and high-speed DRAMs. Samples of 16Mb DRAMs reflect Hitachi's future strategic direction.

Fujitsu

Table 1 shows that Fujitsu held the same ranking in 1990 as in 1989—fifth place. As a vertically integrated supplier, a high percentage of captive DRAM demand shields Fujitsu somewhat from DRAM merchant market volatility. Users can look to Fujitsu for VRAMs (e.g., 64K×4) and SIMMs (e.g., 1Mb×8, 1Mb×9, 256K×36). This company will place less emphasis on 256K and 1Mb DRAMs during 1991 and 1992.

As indicated by its fourth-place ranking, to some extent Fujitsu is playing catch-up in the 4Mb segment. In terms of technology, the supplier emphasizes the thin small-outline package (TSOP) for the 4Mb and 16Mb devices in line with the market trend toward higher pin-count packages.

Although not the 4Mb DRAM technology leader, users can look to Fujitsu as a dependable and competitive supplier of 4Mb DRAMs during 1991 and 1992. The product portfolio will be familiar and competitive: SIMMs, wide-word configurations (e.g., ×8, ×9, ×16, ×18), and high-speed choices.

Texas Instruments

Sixth-ranked Texas Instruments (TI) continues to hold the same ranking as in 1989. Table 1 reveals that this company ranks second in the 64K segment, fourth at the 256K density, fifth in the 1Mb arena, and tenth in the critical 4Mb business. It pursues the same strategic direction during the second half of 1991 as other leading DRAM suppliers—to emphasize 4Mb DRAM production and de-emphasize lower-density devices.

TI's strategy calls for the forging of alliances and other arrangements for sharing the risks and benefits of participation in this worldwide business.

The company is leaving the 64K business. Current TI customers that use 256K devices should be able to forge special supply arrangements. TI will be de-emphasizing the 1Mb device during the 1991 to 1992 period; however, the pace of the trend will depend on events in the 4Mb arena. If the market moves quickly to the 4Mb product, the 1Mb part will be more quickly de-emphasized. If the 4Mb trend stalls—as has already occurred at times—TI will likely shift some support to users of the 1Mb device.

The supplier offers a competitive 4Mb DRAM product portfolio that includes wide-word configurations (e.g., ×8, ×9, ×16, ×18) and SIMMs. As the market shifts over time to 4Mb VRAMs, TI will migrate from the current line of 256K VRAMs (e.g., 64K×4 devices) and 1Mb VRAMs such as the 256K×4 part. Currently, 16Mb samples are available.

To maintain its long-term stake in the competitive megabit-density DRAM market, TI's strategy calls for the forging of alliances and other arrangements for sharing the risks and benefits of participation in this worldwide business. One example is an alliance among TI, Hewlett-Packard, Canon, and the government of Singapore for production/consumption of DRAMs in Singapore. Another example is a prior venture between TI and the Italian government on a megabit-density DRAM fab in Italy. At the time this article was written, the TI-Acer fab in Taiwan had just started 4Mb DRAM production.

A second prong of TI's DRAM strategy calls for aggressive protection of its DRAM/IC patent portfolio via litigation or negotiation toward the goal of collecting royalty payments.

Oki

Oki has consistently ranked seventh or eighth among worldwide DRAM suppliers since 1988. Table 1 reveals that seventh-ranked Oki ranks third in the 64K and 256K segments, ninth at the 1Mb density, and seventh in the emerging 4Mb arena.

Users can expect Oki to be a leader in the migration of the market to 4Mb SIMMs.

In addition to 4Mb DRAMs, Oki's strategy emphasizes SIMMs, with a trend toward SIMMs based on the 4Mb device. Users can expect Oki to de-emphasize 64K DRAMs and 256K DRAMs. The 1Mb device will also be de-emphasized, except for some use in SIMMs.

For example, Oki's 1Mb SIMM product portfolio includes modules organized as follows: 1Mb×8, 1Mb×9, 1Mb×32, and 1Mb×36 as well as 2Mb versions (e.g., 2Mb×36). The trend is toward expanding use of 4Mb DRAMs in these SIMMs. For example, in prior years the 1Mb×8 SIMM used eight 1Mb×1 DRAMs. Increasingly, Oki and other SIMM suppliers base this module on two 1Mb×4 DRAMs and one 1Mb×1 DRAM.

Users can expect Oki to be a leader in the migration of the market to 4Mb SIMMs (e.g., ×8, ×9, ×32, ×36, and evolving organizations). Oki also offers 16Mb DRAM samples.

Mitsubishi

Table 1 shows that Mitsubishi, ranked eighth overall, ranks eighth in the 256K and 1Mb segments but fifth in the critical 4Mb arena. This supplier's overall DRAM ranking has declined somewhat in recent years, which might be deceptive.

Dataquest restates what we stated in the *DRAM Product Trends* service section dated August 1990: "The competitive advantage of Mitsubishi's process and packaging technology expertise is likely to grow more significant as the industry moves to the 16Mb and 64Mb densities." Success in the 4Mb DRAM business can serve as a long-term indicator of long-term survival—and the Mitsubishi strategy to some extent already signals 4Mb success.

Mitsubishi's typical but competitive 4Mb DRAM product portfolio includes high-speed DRAM and wide-word configurations (e.g., ×8, ×9, ×16, ×18). Currently, 16Mb DRAM samples are available.

Micron

As shown in Table 1, ninth-ranked Micron ranks fourth in the 64K DRAM segment, seventh in the 256K density, and tenth in the 1Mb market. The company broke into the top 10 tier of DRAM suppliers in 1990.

One prong of Micron's strategy calls for cost-oriented competitive ability, meaning that the product portfolio is weighted toward mature DRAM devices with densities of 1Mb and below. For these mature devices, the market typically favors low-cost producers such as Micron. Users of 256K DRAMs, 1Mb DRAMs including 64K×16 configuration, VRAMs (e.g., 256K×4, 128K×8), and SIMMs (e.g., 1Mb×8, 1Mb×9, 256K×9, 256K×36) can look to Micron during the 1991 to 1992 period. Users of 64K DRAMs should be able to forge special long-term supply arrangements with Micron.

As indicated by the 4Mb DRAM ranking, Micron is not a DRAM technology leader like Hitachi or Toshiba. Even so, a second prong of the company's strategy—to serve specialty applications—is leadership in a sense. For example, in addition to mainstream 1Mb devices, users can look to Micron for 64K×16 DRAMs, 256K×4 VRAMs, and 128K×8 VRAMs. Users can also expect Micron to become an increasing force in the 4Mb DRAM segment as the product nears the maturity stage of the life cycle.

Motorola

Tenth-ranked Motorola slipped one notch during 1990 from its ninth-place position in 1989. As shown in Table 1, Motorola ranks seventh in the 1Mb segment and eleventh in the 4Mb market. Motorola departed the mainstream 256K arena. SIMMs such as the 1Mbx8, 1Mbx9, 256Kx9, and 256Kx36 modules represent a key aspect of the product portfolio.

Motorola has used an alliance with Toshiba as part of its DRAM strategy. The agreement started for product densities of 4Mb and below and eventually also applied to densities of 16Mb and above. The industry giant will emphasize 4Mb DRAMs but can remain responsive to market demand for 1Mb products.

NMB

Eleventh-ranked NMB positions itself as the leading supplier of high-speed DRAM devices that operate at speeds of 60ns and faster, which conforms nicely with the DRAM market trend. Table 1 shows that NMB ranks fifth in the 256K DRAM arena and twelfth in the 1Mb and 4Mb segments.

NMB relies heavily on a shifting set of strategic alliances for design technology and foundry service. The list of its alliance partners over time has included Alliance Semiconductor, Intel, Inmos (now owned by SGS-Thomson), Ramtron, and Vitelic.

Siemens

Twelfth-ranked Siemens slipped from the top 10 tier of DRAM suppliers during 1990. Table 1 shows that Siemens ranks eleventh in the 1Mb DRAM segment and eighth in the critical 4Mb business—an augur of future challenge.

A major strategic response for Siemens was the IBM alliance on 16Mb DRAMs that was announced in July 1991. This alliance augments a prior agreement between Siemens and IBM on 64Mb DRAMs. Even so, the 1991 to 1992 period will be critical in terms of Siemens' ability to grow its share of the European market for 1Mb/4Mb DRAMs and penetrate the North American marketplace.

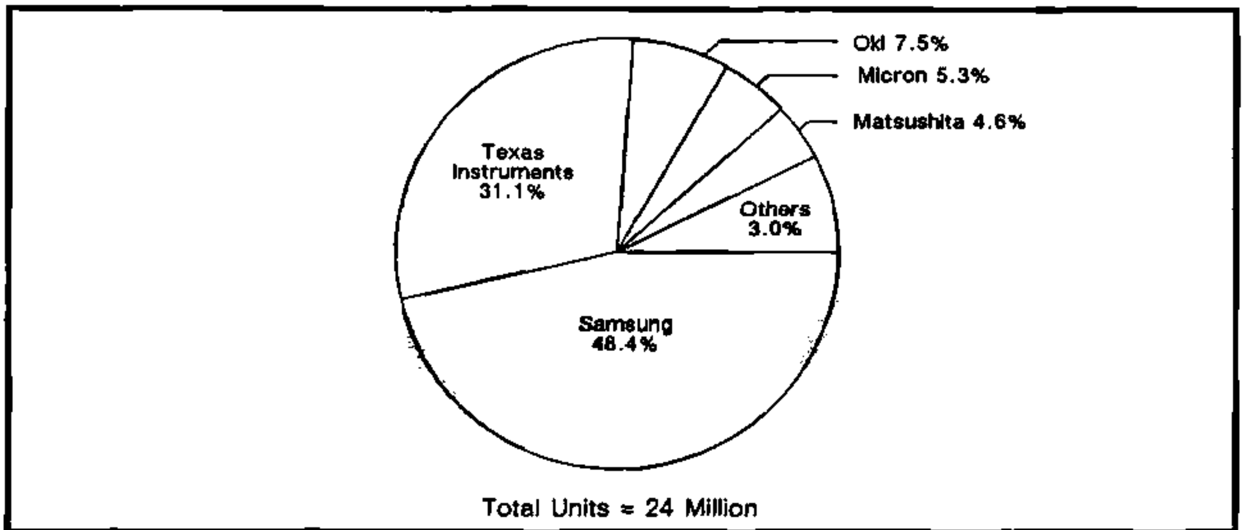
Supply Base Analysis

This section uses information on DRAM life cycles and suppliers to present a density-by-density evaluation of the supply base for these devices in the medium to long term. Figures 3 through 6 show the 1990 total market size in unit shipments and the shares of the leading suppliers of each density. This information correlates with information presented in Table 1.

Supply Base for 64K DRAMs

The 64K DRAM device is being phased out. Figure 3 shows that production of 64K DRAMs during 1990 totaled 24 million units—less than half of the 1989 volume.

Figure 3
64K DRAM Supplier Base



Source: Dataquest (August 1991)

Dataquest recommends that users migrate from this device in system designs lacking a long-term procurement arrangement. Figure 3 shows that the leading suppliers are Samsung and TI; however, TI likely will limit support, if any, to long-term customers.

Supply Base for 256K DRAMs

Figure 4 lists the top-ranked 256K DRAM suppliers based on 1990 unit shipments.

Figure 4 shows that leading suppliers in descending order are Samsung, NEC, Oki, TI, NMB, Hyundai, Micron, Mitsubishi, Fujitsu, Vitelic, and Goldstar. Table 1 shows the full spectrum of suppliers.

Periodic Spot Shortages

Figures 1 and 2 show that the 256K DRAM product is moving through its decline stage. Worldwide production of 256K DRAMs for 1991 is expected to total 450 million units—that number may seem impressive, but in fact it is just half of the peak volumes of 1988 to 1989. Annual supply should exceed 100 million units through the year 1993; however, users should expect periods of spot shortage as suppliers make production cutbacks during the 1991 to 1993 time frame. For example, at the time this article was written, planned cutbacks in production of 256K DRAMs by some suppliers signaled a supply crunch for late 1991 or early 1992.

Dataquest Recommendation

To minimize supply line disruption, users should be prepared to forge long-term supply arrangements with current suppliers or qualify new suppliers. The other alternative is to migrate to megabit-density DRAMs.

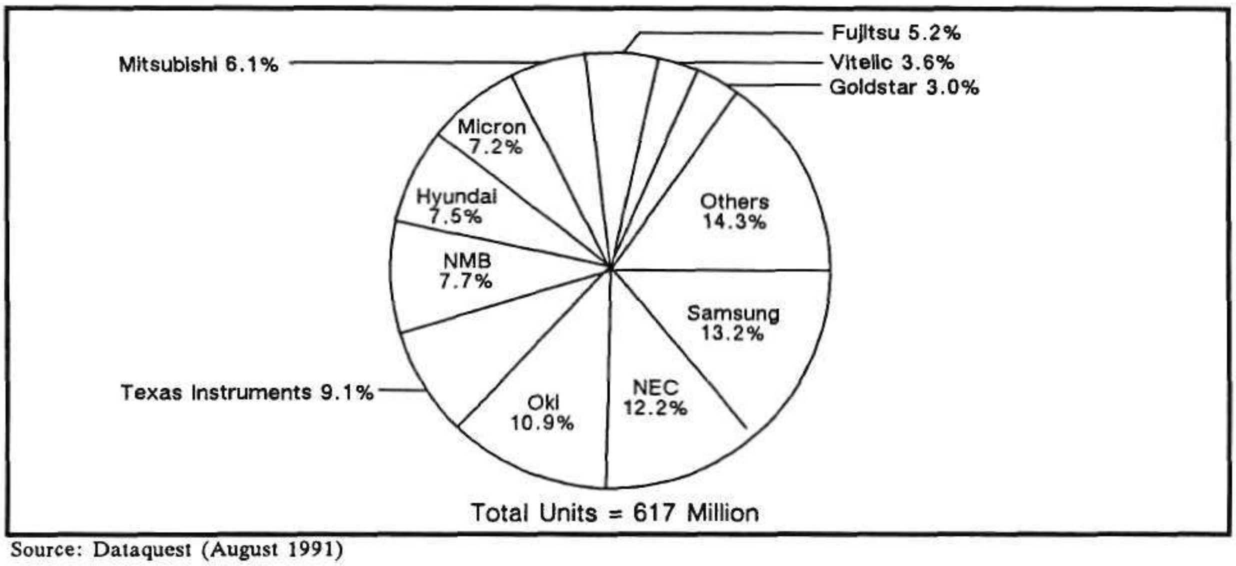
Users can expect the 1Mb DRAM to reach the peak stage—or saturation stage—of its life cycle during the 1991 to 1992 period.

Suppliers likely to remain committed to the 256K segment include the following Korean companies, which increased market share during 1990: Goldstar, Hyundai, and Samsung. Micron has maintained its share of the 256K market and is likely to consider special supply agreements for some users. The life cycle for high-speed DRAMs lags general DRAM life cycles, so NMB should remain supportive to users of high-speed 256K DRAMs.

Supply Base for 1Mb DRAMs

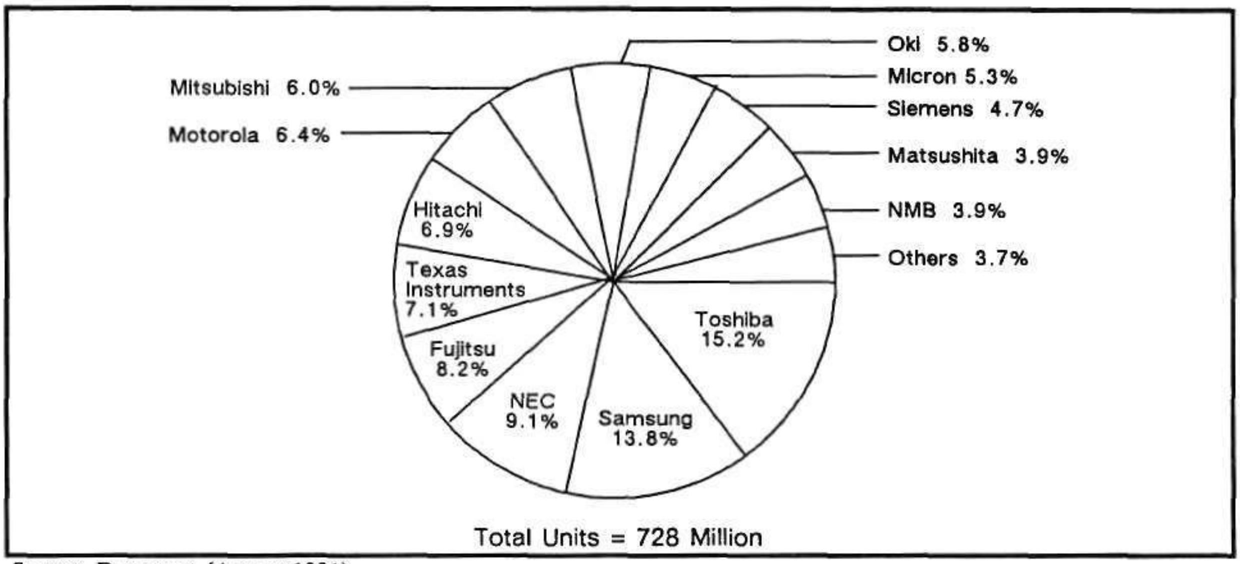
Figure 5 presents the top-ranked 1Mb DRAM suppliers based on 1990 unit shipments.
Figure 5 shows that the top-ranked suppliers in descending order are Toshiba, Samsung, NEC, Fujitsu, Texas Instruments, Hitachi, Motorola,

Figure 4
256K DRAM Supplier Base



Source: Dataquest (August 1991)

Figure 5
1Mb DRAM Supplier Base



Source: Dataquest (August 1991)

Mitsubishi, Oki, Micron, Siemens, Matsushita, and NMB. Global production of 1Mb DRAMs totaled 728 million units in 1990.

An Adequate Supply of 1Mb DRAMs?

Users can expect the 1Mb DRAM to reach the peak stage—or saturation stage—of its life cycle during the 1991 to 1992 period with output exceeding 800 million units each year. Supply should decrease thereafter as the device moves along the decline stage of the curve, but it should still exceed 200 million units for the year 1995. Users can expect an adequate supply of 1Mb products during the 1990s, but only to the extent that users accurately forecast and "spec" product demand *and* also align themselves with an appropriate set of suppliers.

For example, under guidance from Japan's Ministry of International Trade and Industry (MITI), some Japan-based suppliers have shifted and will continue shifting capacity to 4Mb DRAMs. Other suppliers vacillate but will continue to support users of 1Mb DRAMs as warranted by market demand and price trends. Another set of suppliers fully intend to increase their share of the 1Mb DRAM marketplace during the 1991 to 1992 time frame.

User Alternatives to 1Mb DRAMs

The first alternative for users is to redesign systems and migrate to 4Mb DRAM, as many users are doing. For systems where redesign might be feasible although not urgent, the use of SIMMs provides a hedge alternative, especially with the 4Mb DRAM market still somewhat unsettled.

Some older system applications remain profitable, such that any system redesign might not be a feasible alternative. The following recommendation is targeted for users that expect to continue using 1Mb DRAMs.

Dataquest Recommendation to Users of 1Mb DRAMs

To establish a dependable supply of 1Mb DRAMs at competitive prices, users should forge annual purchase contracts and special supply commitments. Otherwise, users must be prepared to buy on the 1MB DRAM spot market, which is likely to be highly volatile and erratic.

Users must *now* reevaluate the 1Mb DRAM supplier base, deciding whether to keep or drop current suppliers and requalify new suppliers. In order to target 1Mb DRAM suppliers, look for suppliers that have recently increased or decreased market share. For example, the following suppliers increased market share by more than 2 percent in 1990: Fujitsu, Micron, Motorola, NEC, and Samsung. The Japan-based suppliers are likely to de-emphasize 1Mb output. Micron, Motorola, and Samsung are likely to continue emphasis on the 1Mb device during 1991 and 1992. Some suppliers also are likely to remain committed to serving demand for the 1Mb part—these supplers are Goldstar, Hyundai, Intel, Matsushita, NMB, and Sanyo. These companies increased market share, albeit by less than 2 percent, during 1990.

By contrast, the following suppliers lost more than 2 percent of market share during 1990: Hitachi, Mitsubishi, Oki, and Toshiba. Their emphasis will be on the 4Mb DRAM device. Sharp, Siemens, and Texas Instruments lost ground during 1990, but by less than 2 percent of market share. Siemens and Texas Instruments are increasing their roles in the 4Mb DRAM market but are watching 1Mb DRAM supply/demand trends.

Supply Base for 4Mb DRAMs

Figure 6 lists the top-ranked 4Mb DRAM suppliers in terms of 1990 unit share.

The 4Mb DRAM life cycle should extend to the end of this decade.

In descending order, the leading suppliers of 4Mb DRAMs are Hitachi, Toshiba, NEC, Fujitsu, Mitsubishi, Samsung, and Oki. Siemens, Matsushita, Texas Instruments, Motorola, and NMB hold less than 1 percent of 1990 market share. Other suppliers such as Micron are joining the fray. Although the 4Mb DRAM race is just ramping up, Hitachi and Toshiba have positioned themselves early for long-term success.

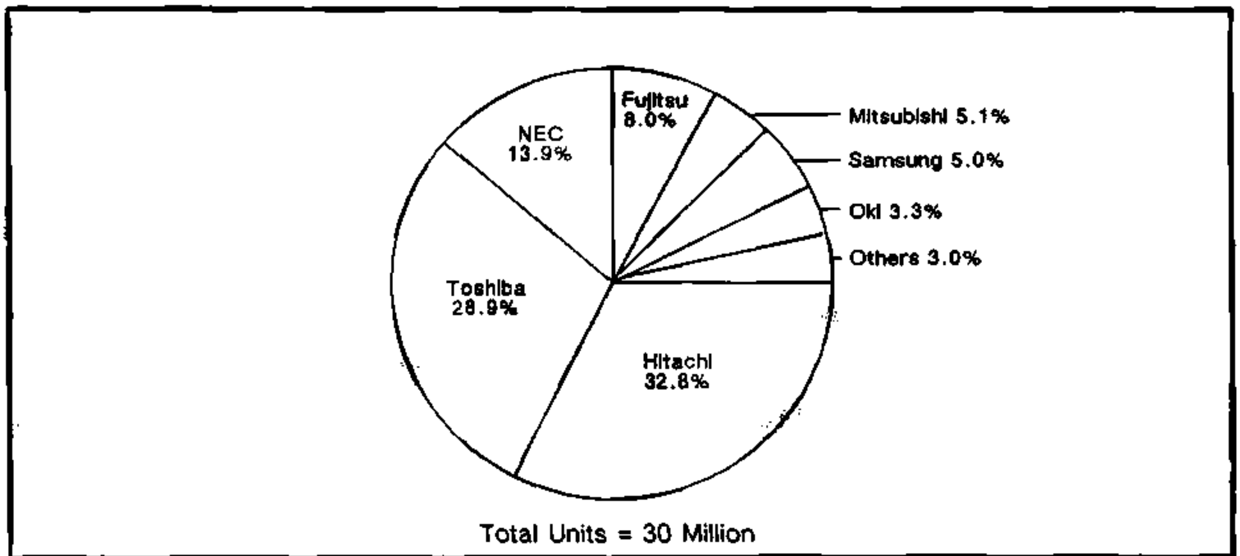
As shown in Figure 6, global 4Mb DRAM production totaled 30 million units in 1990. The life cycle curves in Figures 1 and 2 show that the 4Mb DRAM device is now moving through the growth stage of the life cycle. Supply should exceed 100 million units during 1991. The peak maturity stage of the life cycle should be reached during the 1994 to 1995 time frame, when annual output should exceed 800 million units. The 4Mb DRAM life cycle should extend to the end of this decade.

Dataquest Recommendation to Current and Prospective Users of 4Mb DRAMs

Dataquest strongly advises users to carefully and *continuously* monitor the 4Mb DRAM supplier base during 1991 and 1992 for signs of early market exit by any suppliers that may conclude they cannot win the 4Mb DRAM market battle—and might migrate more quickly to 16Mb DRAMs or rethink their DRAM strategies.

In addition to supplier selection, a major challenge for users will be the choice and designation of product specification. As noted, the 4Mb DRAM product line will include wide-word DRAMs (e.g., ×8, ×9, ×16, ×18) and a profusion of SIMMs and VRAMs. The 4Mb DRAM packages will include less familiar versions such as

Figure 6
4Mb DRAM Supplier Base



Source: Dataquest (August 1991)

zigzag-in-line package (ZIP), thin small-outline package (TSOP) in two types, and tape-automated bonding (TAB).

Supply Base for 16Mb DRAMs

The life cycle curves in Figures 1 and 2 show that the 16Mb DRAM product is now moving from the R&D stage toward the introductory stage of its cycle. Table 1 shows which suppliers offer 16Mb DRAM samples as of mid-August 1991 and which suppliers have 16Mb samples on the way. As shown in Figure 1, the product life cycle of this part should extend beyond the year 2005.

Dataquest Perspective

DRAM cost management represents the stiffest challenge for many of Dataquest's SPS clients. This article lays out a strategy based on system/DRAM life cycle analysis, coupled with a evaluation of the supplier base at each density of DRAM, for cost-effective management of DRAM demand now and through the year 2000. A key element of the strategy invites users to assess system migration paths against Dataquest's DRAM life cycle forecasts.

A strategic recommendation is that purchasing managers, component engineers, and system designers use the DRAM supplier base/life cycle assessment to coordinate system and DRAM life cycles during this decade.

DRAM users face a host of risks that can be reduced to two extremes. The first and most immediate risk is the all-too-familiar scenario of DRAM spot shortages and erratic prices, which may affect *some* users of 256K DRAM as this product moves through the decline stage of its life cycle during the second half of 1991 and in 1992.

A second risk entails a long-term mismatch between a system's specific DRAM requirements in the face of a shifting global supplier base. Regarding megabit-density DRAM, the latter risk will not manifest its results for several years; however, this threat can be managed today through careful DRAM life cycle and supplier base evaluation.

Dataquest Recommendations

Life will remain challenging in our DRAM-hungry world. However, users should be able to minimize, if not avoid, the impact of periodic DRAM supply constraints.

A strategic recommendation is that purchasing managers, component engineers, and system designers use the DRAM supplier base/life cycle assessment to coordinate system and DRAM life cycles during this decade. SPS analysts can provide support toward this goal through the inquiry service.

As noted, users of 256K DRAMs should expect periodic spot shortages during the 1991 to 1993 time frame, perhaps as soon as by late 1991 or early 1992. Users can either forge supply relationships with suppliers such as Goldstar, Hyundai, Micron, and Samsung or migrate to higher-density DRAMs.

Many users are migrating now from 1Mb DRAMs. Dataquest recommends that users in general be prepared to make the migration during the 1992 to 1994 time frame in line with declining supply of this device. For users of 1Mb DRAMs that have no alternative but continue to use 1Mb DRAMs in the long term—through 1993 and beyond—Dataquest advises that the following suppliers be targeted for special long-term supply arrangements: Micron, Motorola, and Samsung. NMB should be targeted for higher-speed DRAMs. A less visible set of suppliers—Goldstar, Hyundai, Intel, Matsushita, Sanyo, and Sharp—also can be targeted.

Hitachi and Toshiba have taken the early but often critical lead in the 4Mb DRAM, with NEC again playing catch-up. Dataquest strongly recommends that users monitor the 4Mb DRAM supplier base via the *On-Line Dataquest Monday* service or by inquiry for clarification of any reports of either new market entrants or early market exits. ■

By Ronald Bohn

Company Analysis

IBM and Siemens Sign Agreement to Manufacture 16Mb DRAMs

Summary

On July 4, 1991, IBM and Siemens signed an agreement to manufacture 16Mb DRAMs at IBM's fab in Corbeil-Essonnes (France). This agreement will capitalize on the technology of both companies and enable them to implement the latest semiconductor manufacturing technology in Europe. This agreement is part of an ongoing effort to strengthen an independent European electronics industry, and it will also allow both companies to transfer this technology to other manufacturing sites.

Dataquest believes that the 1990s will bring a substantial amount of joint-venture activity. This increase in activity is being driven by escalating fab and equipment costs.

In 1990, both companies introduced 16Mb DRAM samples. However, as a result of this agreement, 16Mb DRAMs with increased functionality will be developed at a Siemens facility in Munich. Dataquest estimates that Siemens will contribute between $400 million and $600 million for design and equipment, and IBM will contribute the manufacturing process technology and fab. This is IBM's biggest joint-manufacturing agreement and exemplifies the action that major semiconductor manufacturers are taking to reduce the risk and cost associated with a new submicron state-of-the-art fab.

Manufacturing Plans

Manufacturing will begin by the end of this year with shipments scheduled to begin in the second half of 1992. An existing IBM facility is being upgraded to handle the strict contamination control required to manufacture these devices. The upgrade is based on Dr. Ohmi's ultraclean technology. A Dr. Ohmi-specified fab includes a Class 1 clean room; electrostatic discharge control; and high-purity chemical, gas, and DI water delivery systems. Dataquest estimates that a Dr. Ohmi-specified clean room costs about $2,900 per square foot. When fully operational, the facility will employ a total of 600 people, roughly 300 from each company.

The manufacturing process is based on existing IBM process technology developed at Corbeil-Essonnes. Dataquest estimates that between 375 and 525 process steps are required to manufacture a 16Mb DRAM. The manufacturing test vehicle used to bring up the line will be an IBM device. However, this device was designed for mainframe computer applications. Therefore, after the line is up and running, the newly designed Siemens 16Mb DRAM with increased functionality will be manufactured. When fully equipped, the fab will have the capacity to start 12,000 8-inch wafers per month. The fab will also have the capability to produce ASIC products that feature linewidths of 0.5 micron.

Where the Chips Are Going

IBM plans to retain the chips for captive use, and Siemens plans to sell the chips on the merchant market. This strategy will enhance Siemens' product line and guarantee its customers DRAM availability. If excess capacity is available, participation by other companies will be allowed in this agreement.

Last year, IBM and Siemens also entered into a 64Mb DRAM agreement. This agreement is of strategic importance to both companies; the following section analyzes its strategic importance.

Last Year's 64Mb DRAM Agreement

On January 23, 1990, IBM and Siemens signed an agreement to develop 64Mb DRAMs. This agreement focused on process-technology development and chip design. Both IBM and Siemens decided that the cost of developing the new process technology required to make leading-edge DRAMs is too risky and costly to do alone. As a result, IBM and Siemens entered into an agreement in which they would share equally in 64Mb DRAM technology development costs. They each dedicated 100 engineers to this project. No financial transaction took place between the two companies.

The goal of the agreement is to introduce a 64Mb DRAM into volume production in about 1995. Before this agreement, Siemens' goal was to complete 64Mb DRAM development by 1995. With IBM's help, this goal could be achieved one year early, which is of strategic importance because time to market is critical in today's environment. In the DRAM market, the best profit margins occur during the first year a chip is in volume production. This is the point at which demand is strong and supply is tight.

As a starting point for this agreement, each company disclosed its strengths and weaknesses as they relate to DRAM production. Although a common process and product are being developed, each company will manufacture and market the 64Mb DRAMs separately. IBM plans to manufacture the 64Mb DRAMs in Essex Junction, Vermont, and Siemens plans to manufacture in Munich and Regensburg, Germany. As with the 16Mb DRAM agreement, IBM will use the chips for captive purposes and Siemens will expand its device product line offering.

IBM and Siemens both use a trench capacitor for the 64Mb DRAM process rather than the stack capacitor process. The trench capacitor will most likely be used for higher-density designs. This deal is not a technology-transfer arrangement but a codevelopment arrangement that will give both companies equal ownership in the process and base product.

Joint Ventures—A Way of Life

Dataquest believes that the 1990s will bring a substantial amount of joint-venture activity. This increase in activity is being driven by escalating fab and equipment costs. Even the giant semiconductor manufacturers are managing their financial resources more carefully than in the past. This section briefly describes two other unrelated recently announced joint ventures that illustrate this point.

A significant joint venture was announced in April 1991. Texas Instruments, Hewlett-Packard, Canon, and the Singapore Economic Development Board announced that they will form a venture that will use submicron CMOS manufacturing technology to manufacture DRAMs. The fab being constructed for this venture will also have the capability to manufacture advanced logic if market demand shifts.

Also in April, a joint-development agreement was reached between AT&T Microelectronics and NEC that will have a positive impact on U.S.-Japan trade relations. The purpose of this agreement is to reduce the risks and costs associated with developing a 0.35-micron process. Twenty-six research teams were assembled to carry out this agreement. AT&T plans to incorporate the results of this agreement into its new fab in Orlando, Florida, which will incorporate microenvironments. The most important aspect of this agreement is that AT&T and NEC will have the same process and tool set, which means that they can second-source each other's products. This is truly second-sourcing for ASIC customers.

As semiconductor manufacturing complexity increases, agreements of this nature are mandatory to survival.

In 1990, Dataquest ranked NEC number 1 with semiconductor revenue of $5 billion, and AT&T was ranked number 20 with semiconductor revenue of $830 million. It is evident that if these financially sound companies are entering into agreements to reduce cost and risk, the others will have to follow.

Dataquest Perspective

The Siemens/IBM 16Mb DRAM agreement increases the chances of Siemens remaining a contender in the fiercely competitive DRAM market. This is of strategic importance because Europe does not want to become dependent on foreign sources for its DRAMs. However, before this agreement, it was questionable if Siemens would have survived in the DRAM market by itself.

As semiconductor manufacturing complexity increases, agreements of this nature are mandatory to survival. Forces that make these agreements mandatory include the mammoth R&D investment required to design a chip such as the 16Mb DRAM, the huge initial capital investment required for manufacturing equipment and facilities, and the cost of capital. ■

(This article was reprinted with the permission of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service.)

By Jeff Seerley

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- Packaging trends update
- SRAM product update
- September *Procurement Pulse*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 10 August 12, 1991

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.20	0.16	0.18	NA	0.18	0.13
74AC138	0.34	0.31	0.32	NA	0.34	0.21
74AC244	0.50	0.42	0.45	NA	0.48	0.34
74AC74	0.26	0.23	NA	0.24	0.24	0.17
Lead Time (Weeks)	2	3	6		5	5
4F00	0.11	0.11	0.10	0.09	0.10	0.10
4F138	0.17	0.17	0.18	0.15	0.21	0.14
4F244	0.24	0.25	0.25	0.22	0.30	0.23
4F74	0.12	0.12	0.11	0.10	0.13	0.11
Lead Time (Weeks)	2	3	5	6	5	5
7805-TO92	0.13	0.18	0.11	0.15	0.14	0.10
CODEC-FLTR 1	1.85	NA	2.50	NA	2.15	1.35
CODEC-FLTR 2	3.85	NA	5.00	NA	NA	NA
Lead Time (Weeks)	4		6			
DRAM 1Mbx1-8	4.20	4.15	4.10	4.63	5.05	4.10
DRAM 1Mbx9-8	39.50	49.36	37.50	43.00	49.00	40.00
DRAM 256Kx1-8	1.75	1.65	1.70	1.30	1.55	1.14
DRAM 256Kx4-8	4.25	4.26	4.10	5.00	5.05	4.10
DRAM 4Mbx1-8	16.13	17.71	16.00	19.75	21.00	16.50
EPROM 1Mb, 170ns	3.90	4.65	4.10	5.50	4.00	3.80
EPROM 2Mb, 170ns	8.30	9.66	9.00	NA	8.00	NA
SRAM 1Mb, 128Kx8	15.75	16.10	14.00	NA	19.00	NA
SRAM 256K, 32Kx8	4.15	4.04	4.00	NA	4.80	3.30
SRAM 64K, 8Kx8	1.93	1.51	1.65	NA	1.50	1.20
Lead Time (Weeks)	4	4	4	4	7	3
68020-16	36.50	46.14	37.50	44.50	49.50	NA
80286-16	13.50	13.95	13.50	NA	12.80	13.50
80386DX-25	155.00	171.67	170.00	NA	NA	NA
80386SX-16	54.00	63.30	55.00	64.00	63.20	55.00
R3000-25	130.00	146.64	132.00	NA	NA	NA
Lead Time (Weeks)	4	6	4	NA	NA	NA

NA = Not available
Note: This information appears on the on-line *DQ Monday Report* dated July 29, 1991.
Source: Dataquest (August 1991)

Market Anaylsis

August Procurement Pulse: Lead Times And Orders Fall, Inventories Stabilize

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Semiconductor Order And System Sales Outlook Mixed

As seen in Figure 1, this month's respondents expect to order an aggregate 6.3 percent fewer semiconductor dollars in August than was forecast last month. This month's forecast in order activity is nearly half of the 11.1 percent rise in orders that were expected to be made in July. The average six-month system sales outlook remains upbeat at a current 11.3 percent, which is over 2 points higher than in the forecast given last month. The expected slowing rate of semiconductor order activity is not coinciding with a higher system sales forecast. This month's semiconductor price declines range from 0 to negative 5 percent, averaging at negative 2.4 percent, which is consistent with

Figure 1
Averaged Monthly Semiconductor Orders

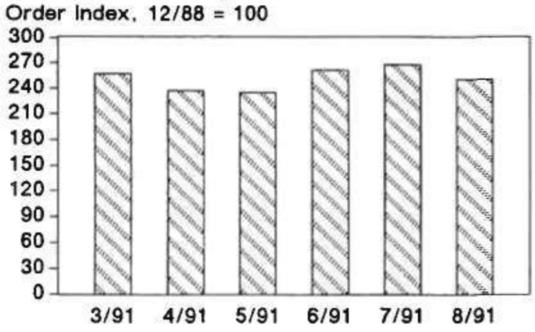


Figure 2
Averaged Semiconductor Lead Times

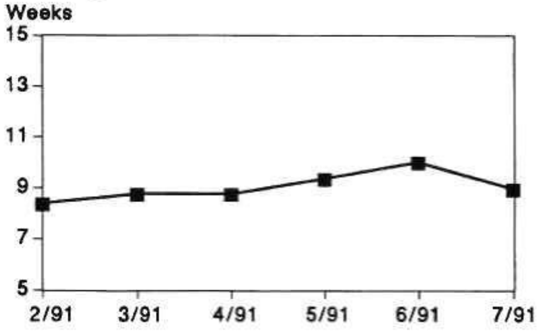


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

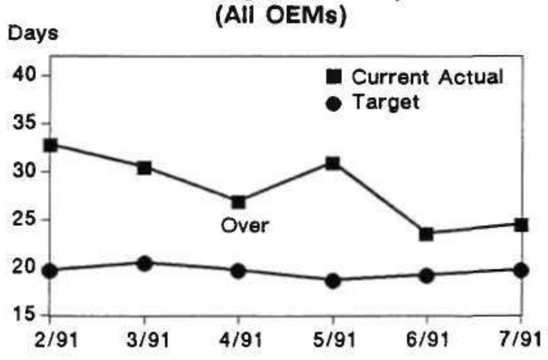
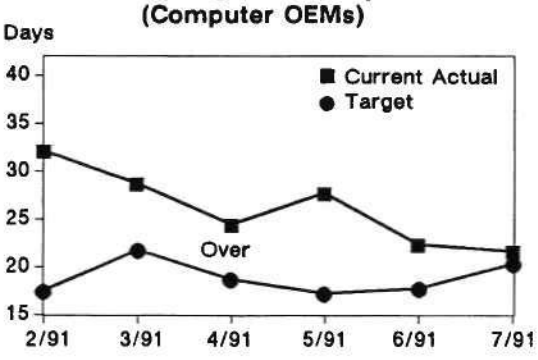


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (August 1991)

last month's 2.1 percent drop. Even expected price declines in raw materials do not totally explain expected higher system revenue (especially so in the current price-competitive electronics market). In discussions with clients, there are pockets of business strength, but the overall lackluster systems market is dampening the supply chain.

Lead Times Correct Themselves Down to Nine Weeks

Average semiconductor lead times declined to 9.0 weeks from last month's 10.1-week level primarily because of lower order activity making parts easier to obtain. Figure 2 illustrates how the current average is more in line with the past six-month trend and correlates with the 4- to 12-week range in lead times currently being reported. Aside from an isolated problem with poor x32 DRAM SIMM availability, there were no availability problems for any semiconductor family. The cut in lead times reiterates the balancing act going on in the current stagnant market as suppliers adjust their delivery mix to meet a cautious demand schedule. Quite a few issues were noted in this month's survey, ranging from the above-mentioned SIMM problem to end-of-life buys for parts. An additional DRAM issue involved the new U.S.-Japan Semiconductor Trade Arrangement. Regional price differences between U.S. and Japanese markets are now to be noted in some contracts so that in order to avoid dumping accusations, parts bought in the United States from Japanese suppliers must be at or above the equivalent device price in Japan. It is conceivable that companies with offshore procurement offices could take advantage of any price differential between the two regions.

Semiconductor Inventories Managed to the Max

Figures 3 and 4 highlight that the continued tight control on inventory levels reflects the current tight market condition. The overall average targeted inventory level rose 0.6 days from 19.3 to a current 19.8 days. The overall average actual level rose from a historic low 23.6 days to a respectable (and still low) 24.5 days. The current 20/25 day target/actual ratio, is still below the historical 20/30 day ratio, which may rise again as business picks up. The responses from the computer segment of our sample noted a slight rise in targeted inventory levels from 17.8 to 20.4 days, while the actual average inventory level slipped to 21.7 days from 22.4 days. For the first time in years, one respondent (computer segment) was *below target* on inventory. Controlling inventory levels remains a very visible means to effect cost control in the current market. Dipping below targeted inventory levels increases the pressure put on suppliers to adhere to commitments and on buyers to ensure that shortages do not appear.

Dataquest Perspective

Availability, delivery, and semiconductor pricing all remain very manageable in the current flat market. Focus remains high on inventory costs to keep them in line with business levels. There are no problem products to deal with, other than the potential for some price differentials for Japanese memory in the U.S. and Japanese markets. As the price negotiation cycle for next year approaches, the focus of many companies is to control the intangible cost factors (i.e., customer support with end-of-life buys and adherence to delivery schedules). The tangible cost control areas (e.g., price, quality, and inventory) are being well managed. Maintenance (or improvement) of current performance levels while raising the bar in other areas of the total cost equation will be the goal of many semiconductor users in the upcoming months. ■

By Mark Giudici

SAMonitor: Today's PC Industry—A Victim of Circumstances

The *SAMonitor* is a monthly update that closely monitors changes in key electronic equipment markets. It presents important tactical leading indicators of semiconductor business activity and discusses the potential impact of equipment market fluctuations on chip orders and shipments.

The Business Climate

Even the most cynical economic forecasters now believe that the U.S. economy has begun to recover. Indeed, the U.S. Department of Commerce's estimate of real GNP growth in the second quarter was 0.4 percent. GNP shrank 2.8 percent in the first quarter and 1.6 percent in the fourth quarter of 1990.

Most economists dolefully expect the expansion to be moderately paced compared with previous recoveries. (Typically, the economy has grown 4 to 6 percent in the first two years of recovery.) However, a recovery that is moderate by historical standards is appropriate and solid by today's standards, given the dynamics of the recession and the economy's low underlying or potential long-term trend growth.

To place the recent recession and nascent recovery into proper perspective, it is important to remember two points:

- *Shallow recessions are followed by weak recoveries.* Real GNP has declined only 1.1 percent through the second quarter. By comparison, real GNP declined an average of 2.3 percent in the eight previous postwar recessions.
- *Today's growth potential is much lower than it was earlier in the post-WWII period:* 2.2 percent versus about 4 percent, respectively. This situation exists because productivity growth has slowed significantly in the last 20 years, as has labor force growth.

The implication is that a 1.1 percent decline in real GNP would have left the economy 5.1 percent below trend during the 1950s and 1960s, but only 3.3 percent below trend given today's sluggish potential. The upshot is that because the uphill climb in the expected recovery will be much shorter than was historically typical, the rate of ascent is appropriately less steep. If full recovery takes three years, then average growth of 3.3 percent per year (2.2 percent trend plus 1.1 percent catch-up) would be about right. Growth greater than this would risk reigniting the fires of inflation.

Equipment Markets

Dataquest's July survey of major OEM semiconductor procurement managers indicates expectations of short-term production. Overall six-month systems sales are expected to grow 9.0 percent, down slightly from 9.8 percent in June. Data processing OEMs' expected six-month growth is up a bit to 10.0 percent, compared with 9.2 percent in June. Six-month growth expectations ranged from 20 percent growth in computers to zero in automotive electronics.

Computers and office equipment orders growth for the three months ended in May was 2.9 percent *below* year-earlier orders, compared with negative 4.9 percent growth in April (see Figure 1). Shipments growth for the same period was 1.9 percent below year-earlier shipments, compared with negative 2.1 percent growth in April. Year-to-date orders and shipments growth are negative 1.3 and negative 2.0 percent, respectively. Inventories are at 8.5 weeks in May, down 0.7 weeks from May 1990 levels, a good sign that marginal orders are being filled from inventory, not incremental production.

The U.S. economic recession has hit computer manufacturers especially hard this time for the following reasons:

- *Two-thirds of desktops have computers on them.* After 30 years of innovation and booming sales, there are inevitably fewer opportunities for investment.
- Computers' share of U.S. capital investment more than doubled, from less than 3 percent in 1977 to about 7 percent in the mid-1980s, but has remained unchanged since then.
- Previously, new products—*without close substitutes*—enabled the computer industry to increase its share of capital spending faster than overall investment fell.

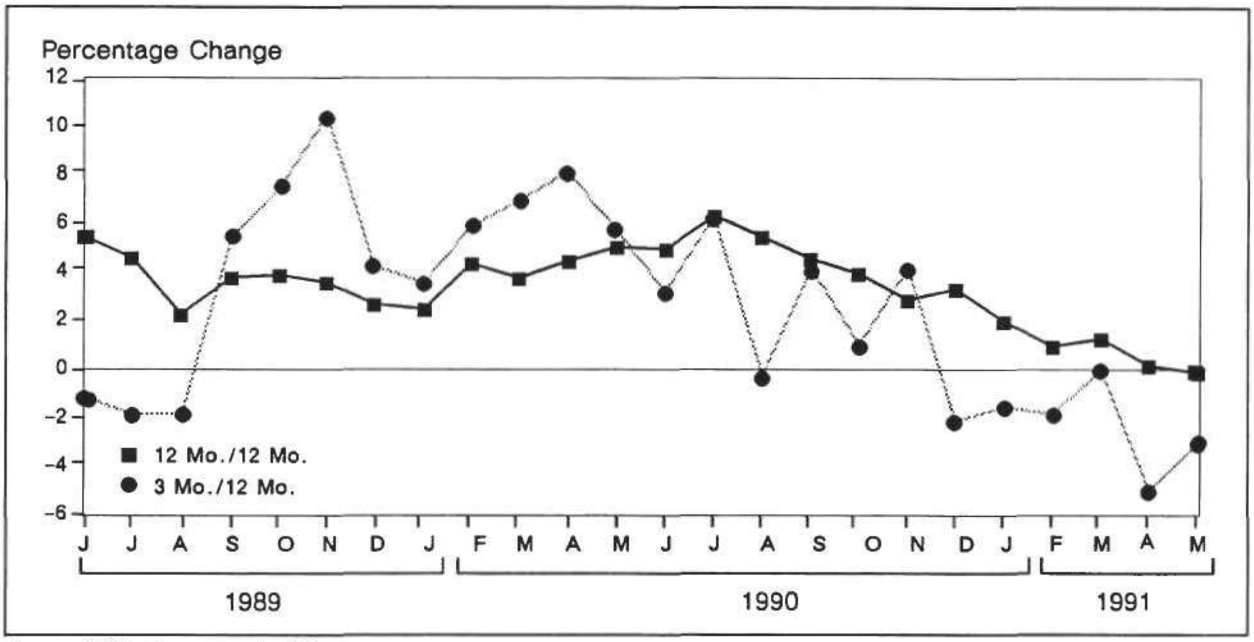
The last point is illustrated in Figure 2. Product innovation is alive and well in the PC business: Worldwide unit growth of portable PCs (defined as transportable, laptop, notebook, pen-based, and hand-held computers) is expected to be a respectable 34.6 percent in 1991. However, portables also are expected to account for only 18.9 percent of total PCs shipped in 1991. Furthermore, notebook, pen-based, and hand-held units, the fastest-growing portion of the portable market, account for only 4.9 percent of total PCs in 1991. By 1995, these three package types are expected to account for 47.1 percent of all PCs shipped.

The point is that chance circumstance made the timing of the introduction of these portable systems coincide with the economy's downturn, and thus their unit volumes are insufficient for their superlative growth to offset the decline in overall capital spending.

Communications equipment orders growth for the three months ended in May was 5 percent below year-earlier orders, compared with 1 percent growth in April. Inventories were at 6.6 weeks in May, down 0.4 weeks from year-earlier levels.

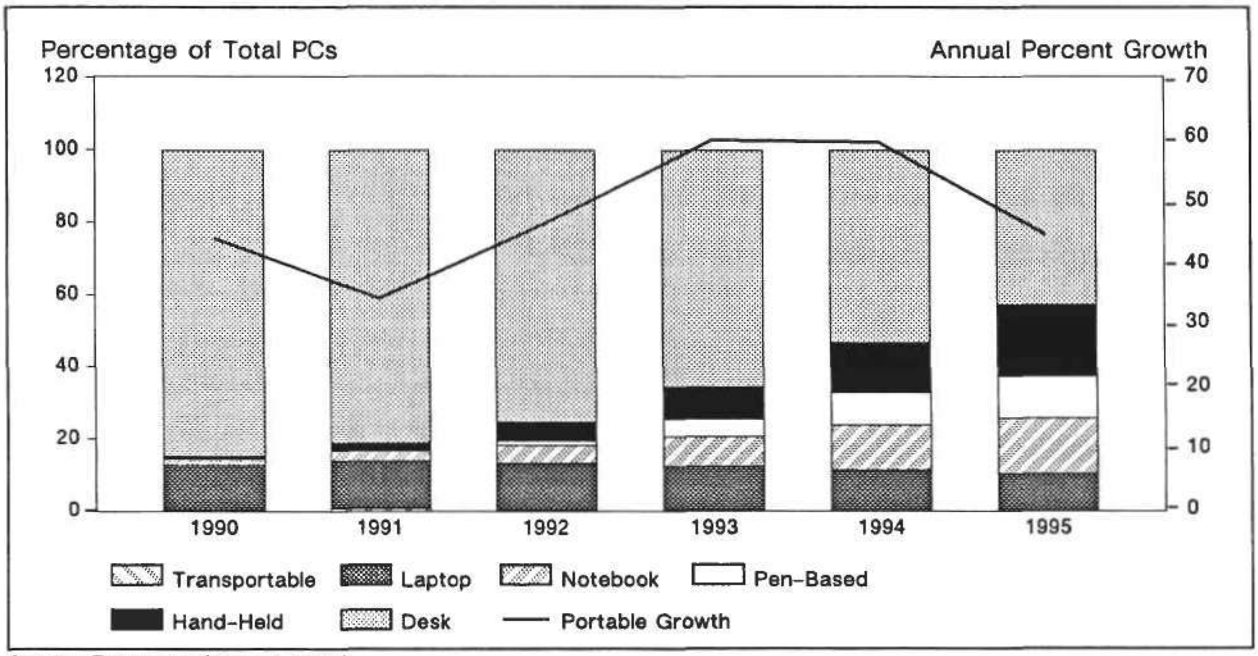
Orders growth for the three months ended in May was 21.3 percent below year-earlier orders for search and navigation equipment, versus negative 11.7 percent in April; 7.4 percent below year-earlier orders for measuring and

Figure 1
U.S. Computers and Office Equipment Orders Growth (1989-1991)



Source: U.S. Department of Commerce

Figure 2
PC Market Dynamics—Worldwide Units



Source: Dataquest (August 1991)

controlling devices, versus negative 5.6 percent in April; and 6.6 percent above year-earlier orders for medical instruments, versus 2.4 percent in April.

Dataquest Perspective

With emerging PC products in the high-growth/low-volume introductory phase of their life cycles, combined with relative market saturation by more mature technologies, systems manufacturers have had to cut prices to gain market share. Even as business' overall capital equipment spending resumes expansion during the remainder of 1991, systems manufacturers and their chip suppliers will be faced with a tough row to hoe. Only those chip manufacturers that have the right chip at the right place and at the right time and are the *most price competitive* are going to share in what little hard-to-get growth remains through the rest of 1991. ■

(This article is reprinted with the permission of Dataquest's Semiconductor Application Markets service.)

By Terrance A. Birkholz

A Midyear 1991 Perspective on Europe as Seen through North American Eyes

Executive Summary

A midyear 1991 trip to European cities such as London, Helsinki, and Munich revealed that practical day-to-day concerns dominate the list of concerns of European users of ICs even as Europe moves closer to a higher level of economic and political integration. Such concerns include: "Which companies supply slow 64K SRAMs?" "How can Semiconductor Procurement service (SPS) information be used to price a cell-based IC?" With an eye on the short term, Dataquest addresses users' immediate tactical issues but also considers the longer-term strategic implications of Europe 1992 and thereafter. This article presents our current perspective on European procurement issues and IC market trends.

The following list shows select tactical procurement issues confronting European users of ICs as of midyear 1991:

- What are users doing as of midyear 1991 in terms of increasing, maintaining, or decreasing the size of their IC supplier base?
- Which companies still supply slow 64K SRAMs and from which companies should we buy?
- How can European users estimate today—*before design-in*—the price of a cell-based IC (CBIC) or gate array produced in 1992 and thereafter?

Dataquest's advice and recommendations for solving these procurement challenges—as well as the supporting analysis and insight—are presented in the following paragraphs.

Preview

There are two sources for the procurement and component engineering issues analyzed in this article. The first source consists of inquiries asked by SPS clients of Dataquest analysts in London or San Jose. The second source consists of Procurement Roundtable discussions that were held in London in June.

The Downsizing of the Supplier Base

The first procurement issue—"What are users doing as of midyear 1991 in terms of increasing or decreasing the size of their IC supplier base?"—is a question that was posed by Dataquest analysts to panel members in Roundtable Procurement discussions that were held in London (June 1991) and San Jose (May 1991). The following analysis is based on the comments made by panel members at one of two sessions of the London Procurement Roundtable. The panel members in this session were mostly from United Kingdom and Scandinavia. The trends on supply-base management analyzed here do *not* necessarily reflect trends in other European countries or other world regions. (For related Semiconductor Procurement *Dataquest Perspective* articles on supply base management trends in North America, please see the articles entitled "Users' 1991 Perspective on Managing Supplier Relationships," Vol. 1, No. 3; April 22, 1991, and "Procurement Roundtable Overview: Technology, Quality, and Supply Base Are Key Management Issues," Vol. 1, No. 9; July 22, 1991. The latter article reports on the Procurement Roundtable held in San Jose.)

A Leaner Supplier Base

Panel members report that the clear and strong trend during the past several years has been a reduction of the supplier base. The future trend is for these users to achieve the right mix of suppliers. There may be a possible *mild* increase in the number of suppliers for users as users search for the right replacement suppliers, but the supplier base will remain much leaner than it was just five years ago.

Why?

The reduction was described by some panel members as a slashing of the supplier base with dramatic decreases of even more than 50 percent for some users in the last three years alone. With the trend so prevalent among the panel members, the next question is: "Why?" The rationales reflect a combination of long-term corporate strategic objectives and day-to-day procurement tactics.

Several users report cost control as the key motivation and benefit for reducing the supplier base. From a strategic viewpoint, users view the choice of their IC suppliers as an *investment*—read "money"—on which the entire daily and long-term quality programs of the system manufacturers depends.

From a tactical perspective, users report noticeable administrative expense savings by having fewer suppliers. In addition to administrative cost savings, users reported another practical benefit of a smaller supplier base: Less time is devoted to "invoice fighting" and time is added for more productive procurement and component engineering activities.

What kinds of more-productive activity? Specifically, working more closely with key suppliers on quality, on-time delivery, and cost-control issues. Users report this corollary to the "supplier-as-investment" perspective: A change in suppliers typically means a negative change in IC product quality. Once a supplier has been qualified—especially for key products—users are averse to breaking the user-supplier "investment bond" except in the face of deteriorating IC quality or delivery results.

Users report another reason behind the recent reduction in their supplier base. The purchasing/component engineering department has moved to the front end of the supplier-qualification cycle during the past several years, which translates into more organizational control over the number of qualified suppliers. Procurement managers and component engineers now provide specific direction to system design engineers as to which IC supplier set to use.

Watch for These Future Trends

In general, users in the United Kingdom, Scandinavia, and North America should expect several trends to emerge from this set of market conditions. Dataquest analysts will continue to monitor events in other European countries and world regions to determine whether the following supply base management trends are currently in place or likely to take hold there.

Get The Right Supplier Mix

Having cut the supplier base, the panel members in London reported that the next step in supply base management is to achieve the right mix of suppliers. These users believe that they now have the right number of IC suppliers, but not yet the right selection. As noted, the size of the supplier base *might* increase during this good supplier/bad supplier sorting process because some replacement suppliers will be required. The increase should be mild and is *not* to be interpreted as a return to industry conditions of a decade ago.

Greater Responsibilities of Key IC Suppliers

Systems manufacturers in Northern Europe and North America evince a growing recognition of the corporate need to invest in a relatively small network of key suppliers on which depends the manufacturer's entire system-quality program. Systems manufacturers, in exchange for the investment, currently demand from key suppliers programs such as electronic data interchange, which reduce administrative costs. The trend toward closer user-supplier relationships—which some panel members describe as "partnerships" and others deem as "marriages"—will entail deeper responsibilities for the limited number of suppliers that win user qualification.

For example, users are demanding an increased role by IC suppliers in systems R&D efforts. That trend will continue, with systems manufacturers now or soon seeking from IC suppliers some *sharing* of systems R&D costs. Another example is that systems manufacturers will expect the small critical set of IC suppliers to share the economic turbulence of the systems end markets. Specifically, users will demand that IC suppliers give ground on component pricing during periods of end-market recession or price battles. Users, in return, will forge longer procurement contracts—a minimum of one year to as long as three years—versus the current industry standard that ranges from spot market deals to one year.

Procurement Strategies for Users of Slow 64K SRAMs

The next procurement issue—"Which companies still supply slow 64K SRAMs and from which companies should we buy?"—has been raised recently by clients in both Europe and North America.

The background reality is that the slow 8Kx8 SRAM product is moving through the decline stage of its life cycle. European, North American, and Asian users of this IC face a challenging, if not unfavorable, situation in terms of steady supply. Japanese suppliers—under guidance from Japan's Ministry of Trade and Industry (MITI)—are in the process of departing the marketplace, if they have not already done so. Although *some* long-term customers have contracts with Japanese suppliers that ensure supply until 1993, these contracts are the exception and not the rule. Only two suppliers, both Korean—Samsung and Hyundai—have intentionally increased their market share within the past two years.

Recommendations

For users that *must* continue using 8Kx8 slow SRAMs, the choice is between Samsung and Hyundai. At this time the preference should be for Samsung. Why? Samsung certainly has a longer and more visible track record in terms of supplying memory ICs—DRAMs as well as slow SRAMs—to users in Asia, Europe, and North America. The company presents a clear long-term strategy on the role that slow SRAM will play in its product portfolio. Samsung has been competitive in prices and dedicated to quality enhancement and is not likely to abruptly depart from the marketplace.

Hyundai is a younger name but also is a potentially aggressive competitor in the IC business. Hyundai stumbled in the semiconductor marketplace but continues to draw upon huge corporate resources to win a long-term stake in the IC arena. The company needs to win some qualifications in order to optimize its memory fab capacity. Hyundai—if pushed—could become brutally competitive on 64K slow SRAM prices. The company could go out of its way for customers toward the goal of establishing its name as a dependable global supplier of 64K slow SRAMs and other ICs.

Even so, some unanswered questions remain concerning Hyundai on supplier-qualification issues such as delivery and service. In addition, Hyundai's strategy for serving the IC marketplace continues to evolve, which does not preclude the possibility of a switch in strategic focus. For users, a switch could mean a somewhat abrupt loss of their 64K slow SRAM supplier.

Dataquest recommends that users consider an alternative: to redesign systems in order to accommodate 32Kx8 slow SRAM. The 256K slow SRAM supplier base is much larger, and, despite recent price stabilization, market elements exist that could cause pricing to fall again below the $4 level during 1992. By contrast, 64K slow SRAM prices are likely to rise to $2.20 or higher during 1992. System memory needs tend to expand, and it is likely that some systems using 64K slow SRAM today will effectively utilize 256K slow SRAM during 1992 and 1993.

Price Estimates on CBICs and Gate Arrays

The third procurement issue—"How can European users estimate today—*before design-in*—the price of a CBIC or gate array produced in 1992 or thereafter?"—has also been brought forth recently by clients in Europe and North America.

Admittedly, this inquiry is as much a matter of how to use Dataquest information as a tactical procurement issue. However, the fact that users are now consistently seeking *in advance* the estimated price of CBICs and gate arrays indicates that pricing of these user-specific ICs is taking on some of the hallmarks of commodity devices that lend themselves to apples-versus-apples price comparisons. For years, pricing CBICs and gate arrays for most users was a murky process at best and an impossible apples-versus-oranges comparative exercise at worst. As of midyear 1991, estimating today the price of CBICs and gate arrays that will be produced next year or later is becoming a mainstream tactical procurement issue.

Dataquest is not saying that pricing for gate arrays or CBICs has become the same as DRAM pricing, a process in which users can compare the price of a 1Mbx1 100ns DRAM SOJ from Supplier 1 against the price from Supplier 2. Even so, current and prospective users of gate arrays and CBICs can turn to SPS analysts on an inquiry basis for support toward the goal of making meaningful price estimates on these complex ASICs. For this reason, the next section of this article illustrates the sources and methodology used by SPS analysts to assist European and North American users of CBICs and gate arrays in developing price estimates.

The price tables referred to in the following paragraphs are found in the Semiconductor Procurement *Source: Dataquest* binder behind the "Market Statistics" tab in the article entitled "North American Semiconductor Price Outlook: Third Quarter 1991" dated June 1991 (hereafter, June 1991 *Source: Dataquest* article). For SPS clients that use the SPS on-line service, the prices presented here correlate with the price tables dated June 1991 in the SPS on-line service.

Based on *user* client recommendations, the price tables presented in the June 1991 *Source: Dataquest* report for CMOS gate arrays and CBICs have been structured to separate price per gate as measured in millicents per gate from nonrecurring engineering (NRE) charges which are measured in thousands of dollars. The tables are structured to track prices for six specified density ranges as measured in thousands of gates and for four specified line geometries. In addition, the price tables specify benchmark volumes—10,000 units per year for CMOS devices—and packages, which depend on the device density. The tables also state Dataquest assumptions on utilized and theoretical gate counts and standard and commercial testing.

The following two examples, which are based on actual inquiries that have been altered to protect client confidentiality, illustrate the requirements and methodology for making useful CBIC and gate array price estimates. The next section is most closely intended for current or prospective users of these devices; however, the IC industry of the 1990s is steadily moving closer to the day when pricing for application-specific products will more readily lend itself to manageable apples-versus-apples pricing comparisons.

A Simple Example

At the London Procurement Roundtable, Dataquest analysts noted the critical role that CBICs are playing and will continue to play in European systems. A major reason is that CBICs more easily incorporate the analog and mixed-signal functions needed by European telecom systems.

If life were simple—and the complex ASIC world seldom is—some European client would send the following inquiry to the SPS analysts in San Jose: Provide the price estimate during 1992 for an IC of 1.5-micron CMOS CBIC, 5,000 gates, 84-pin PLCC, volume of 10,000 units per year, standard commercial test only.

The CBIC price trend tables (see Table 24 in the June 1991 *Source: Dataquest* article) show that the estimated 1992 North American bookings price for a device as specified *precisely* in the example is 80 millicents per gate. For the 5,000-gate device, the price per unit excluding NRE would be $4.00 ($0.0008 x 5,000). The estimated 1992 NRE charge as shown in the tables is $45,500. Total price equals *$85,500*, or $40,000 (i.e., $4.00 per unit x 10,000 units) plus the $45,500 NRE charge.

To date, Dataquest has not seen the kind of glaring regional price differentials for users of CBICs or gate arrays in Europe versus other world regions such as North America as occurs with devices such as DRAM. Via client discussions, Dataquest analysts can fine-tune the price estimate for issues such as regional trends or conservativeness/aggressiveness of assumptions.

The More Typical—Meaning Complicated—Example

More typically, Dataquest receives CBIC and gate array price inquiries that do not conform neatly to our benchmarks and assumptions. The pricing structure—with some additional work—can still provide users with meaningful price estimates. A more complicated example would be a 1.0-micron CMOS gate array, 17,500 gates, 144-pin PPGA, volume—25,000 units per year, standard commercial test only.

The gate array price trend table (see Table 23 in the June 1991 *Source: Dataquest* article) reveals that the estimated 1992 price for a device as specified in the sample inquiry is 67 millicents per gate, but with several *caveats*. First, the volume in the table is 10,000 units, but the example calls for a volume of 25,000 units. Second, the table specifies a 160-pin PQFP as the benchmark for a gate array of this density, and the example specifies a 144-pin PPGA.

Ignoring volume and package differentials, the estimated 1992 price per unit for the part, excluding NRE, is $11.73 ($0.00067 x 17,500). The estimated 1992 NRE charge as shown in the tables is $43,250.

As noted, several adjustments must be made to reflect premiums or discounts for the differences in volume and package. Dataquest analysts are often asked about discounts for volumes that are higher than the specified SPS base volume. In this example, the discount to go from the SPS base volume of 10,000 units to a volume of 25,000 units would typically run in the 20 to 30 percent range. For the purpose of this analysis, we assume a 22 percent discount. Taking this unit-volume discount into account, the estimated 1992 price per unit for the part becomes $9.15 ($11.73 x 0.78).

The next adjustment—for the different package—is more complicated; however, SPS analysts make this adjustment for clients on an inquiry basis throughout the year. The first step is to locate SPS information on package cost differentials. (The information can be found in the Semiconductor Procurement *DQ Perspective* article entitled "Semiconductor Cost Trends" (Vol. 1, No. 1; March 22, 1991) in Table 2.) The table shows that the cost of 144-pin PPGA in 25,000 volume is $7.04.

Table 2 in the "Semiconductor Cost Trends" article also shows that the cost of 160-pin PQFP (JEDEC) in 100,000 volume is $2.60. Working toward the goal of an equivalent 25,000-to-25,000 volume comparison, the 160-pin PQFP cost of $2.60 at 100,000 volume must be increased to account for the lower volume of 25,000. For purposes of this example only, we assume a 75 percent higher cost.

At the 25,000 volume, this translates into a cost for 160-pin PQFP of $4.55 ($2.60 x 1.75). In turn, this means a package adder of $2.47 ($7.02 minus $4.55) for use of the more expensive 144-pin PPGA versus the 160-pin PQFP that is specified in Table 23 of the June 1991 *Source: Dataquest* article. Taking this package adder into account, the estimated 1992 price per unit for the gate array becomes $11.62 ($9.15 plus $2.47). Total price equals *$333,750* or $290,500 ($11.62 per unit x 25,000 units) plus NRE charge of $43,250.

Dataquest Perspective

A midyear 1991 look at Europe reveals that the resolution of some fundamental economic/political issues for the unified Europe of 1992 and beyond will be deferred till December 1991. On December 1, 1991, headlines might say that resolution of these issues will be delayed until December 31, 1991. Regardless, business continues in Europe—especially for procurement managers and component engineers—as shown by issues presented at the London Procurement Roundtable and client meetings as well as by inquiries made to Dataquest analysts in London and San Jose.

Two trends now confronting users in the United Kingdom and Scandinavia—the downsizing of the IC supplier base and growing interest in CBIC/gate array pricing trends—echo similar concerns of North American users. With the future business structure of Europe still uncertain, Dataquest cannot yet say that procurement trends now prevalent in the United Kingdom or the United States are extending to other countries such as France, Germany, and Italy.

Dataquest *does* know that users in Northern Europe and North America report solid financial and business benefits by paring the supplier base. The trend toward a leaner supply base means challenge—but also opportunity—for global IC suppliers. Systems manufacturers in the United Kingdom, Scandinavia, and North America recognize their need to invest in a smaller network of key suppliers—for sole-sourced devices such as CBICs or gate arrays—in exchange for a deeper level of supplier commitment to product quality, technology leadership, and, in times of system price wars, IC price competitiveness.

Recommendations

Long-term strategic considerations aside, Dataquest makes these recommendations. First, users that *must* continue using 8Kx8 slow SRAMs, should evaluate Samsung and Hyundai with the current preference being for Samsung. Samsung has a more visible track record in the global memory markets and a clearer long-term strategy for serving the slow SRAM marketplace. Hyundai, a newer, younger name for IC users, is a potentially aggressive competitor. Hyundai needs qualification wins and might go out of its way for customers. Nevertheless, unanswered questions concerning Hyundai remain.

Second, current and prospective users of CBICs and gate arrays must take a more active role in managing supplier price quotes. For too long, users have had only a murky idea at best of how and why CBIC and gate array price quotes were generated, although they received a clear final bill. ASIC suppliers need good long-term customers. Users, in effect, are making an investment each time they order a gate array or CBIC. The global network of ASIC suppliers continues to expand product capabilities, meaning that the supplier choice is becoming more open. By working with Dataquest analysts on an inquiry basis, users in Europe and North America can remove some of the past mysticism and murkiness associated with ASIC pricing. Users now must learn to do the homework that will be required of them *on their part* during the 1990s in terms of making meaningful CBIC and gate array price estimates. ■

By Ronald Bohn

Product Analysis

Will 4Mb DRAMs Have A Short Life?

Introduction

When plummeting 64Kb and 256Kb DRAM prices in the 1985 semiconductor recession caused major chipmakers to restrain capital investment, only Toshiba continued aggressive investment in 1Mb DRAMs; later, it dominated the market. Now Dataquest sees more competition in the 4Mb DRAM market. Hitachi has a slight lead, closely followed by Toshiba, NEC, Mitsubishi Electric, and Fujitsu. Slow growth of 4Mb demand appears to help narrow the difference. Empirical evidence shows that chipmakers that dominated the DRAM market invariably enjoyed a significant growth in semiconductor revenue, and in order to recover their gigantic investment, 4Mb chipmakers are engaged in a serious race for survival.

This year is supposed to be the year for 4Mb DRAMs. However, with volume production of 16Mb DRAMs scheduled in 1992 and as development of 64Mb DRAMs is accelerated, some say that 4Mb DRAMs may have a short life. If so, it would certainly be a life-and-death matter for DRAM suppliers that are behind in 16Mb development. A short life for 4Mb DRAMs would cause some companies to withdraw from the DRAM business. This article examines the potential life of 4Mb DRAMs.

The 4Mb DRAM Life Cycle

Since the birth of 16Kb DRAMs in 1977, the semiconductor industry has introduced a new generation to the market every three years. Although this technological tradition is expected to continue up to the 64Mb DRAM generation, the pace of volume production growth has slowed steadily from one generation to the next (see Figure 1). In particular, the initial growth of 4Mb production has obviously lost the momentum seen in past generations.

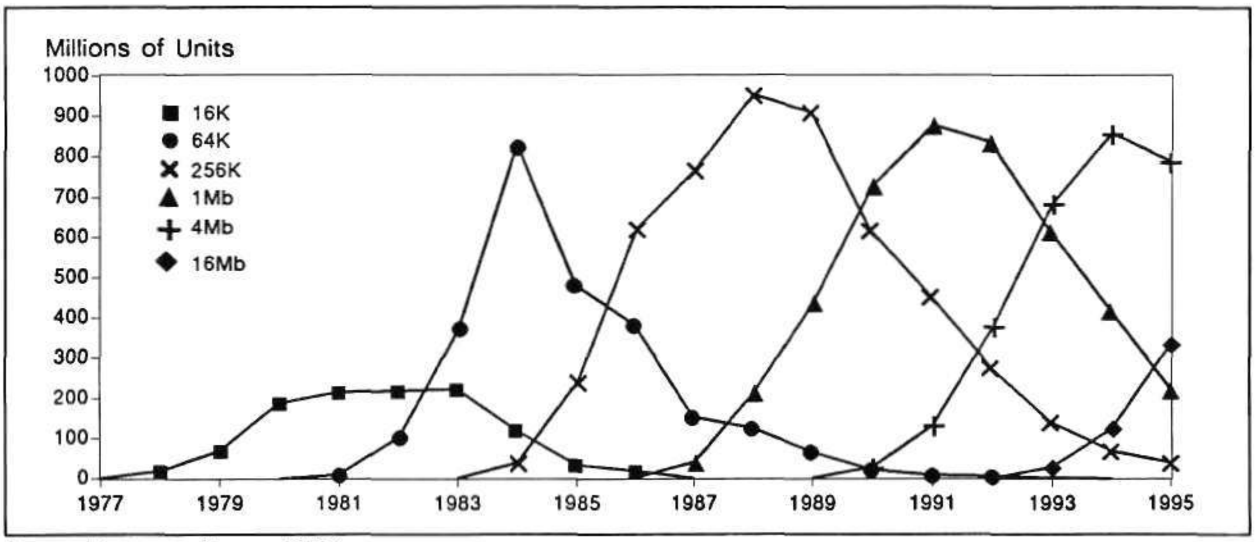
Dataquest looks at the peak of DRAM production in each generation. Assuming that a new generation of DRAMs is introduced every three years and production peaks every four years, the life cycle becomes longer for later generations. If applied to 4Mb DRAMs, production will reach a peak level between 1994 and 1995, at which time more than two generations will be in the market. Dataquest believes that this situation is likely because DRAMs, the demand for which has previously been governed by computer market growth (e.g., PC booms in 1984 and 1988) will find a wide range of applications including facsimiles, telephones, automobiles, VCRs, and TVs; therefore, consumption of DRAMs with smaller storage capacity will continue in the foreseeable future. Coexistence of several generations is already seen in non-DRAM memories, and DRAMs are not likely to be an exception to such a trend.

PC Evolution and DRAM Consumption

The PC market absorbs one-half of DRAM supply. Based on shipment data, peak production exceeded that of the previous generation up to 256Kb DRAMs, but was down in 1Mb DRAMs (see Figure 1). A probable cause is that the increase in DRAM storage capacity has outpaced that of PC memory capacity, leading to a slowdown in DRAM consumption. PCs use main memories with 1 or 2MB (see Figure 2), which can be satisfied by much cheaper 1Mb DRAMs. Nevertheless, with main memory capacity expected to increase with wider use of Windows and other factors, the shift to 4Mb is likely to be accelerated. This is further evident in several types of laptops recently introduced to the market.

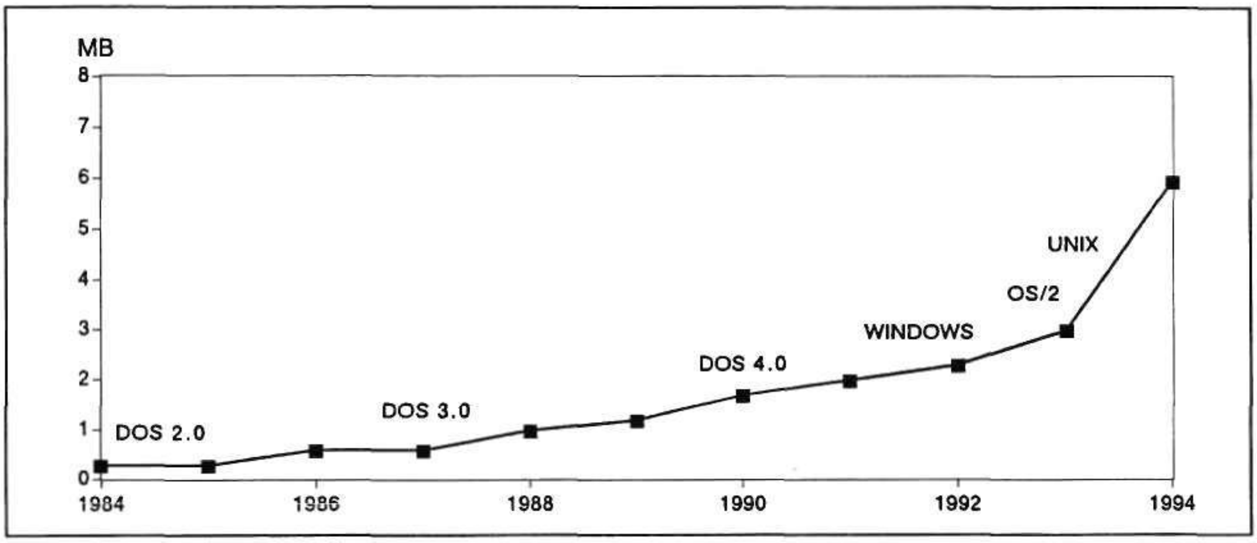
Another factor to consider in increasing memory capacity is the constant increase in data volume handled by large general-purpose computers and PC-application programs. Because the maximum capacity of PC main memories is largely governed by the operating system and CPU architecture, the relationship between the average capacity of PC main memories and OS has been examined by the industry in general. In 1983, the wide use of DOS 2.0 boosted the average memory capacity to 512KB, consuming a large amount of 64Kb DRAMs. Then in 1985, emergence of DOS 3.0 pushed main memory capacity up to 640KB and spurred consumption of 256Kb DRAMs. Today, the average memory capacity is 1.5MB, using 1Mb DRAMs. However, current OS will limit the increase in the main memory capacity, driven by the upgrading of OS versions and improvement of application software from 2MB to 3MB until 1993. Although OS/2, which is capable of handling a 16MB address space, is expected to drive a significant increase in main memory capacity, it will take more than three years before the new OS becomes widely used. Until then, Dataquest believes that 4Mb DRAMs will be the mainstream device, and the shift to 16Mb will take place after 1994.

Figure 1
DRAM Life Cycle
(Millions of Units)



Source: Dataquest (August 1991)

Figure 2
PC Main Memory
(Megabytes)



Source: Dataquest (August 1991)

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Improvement of CPU performance is also an important factor in determining the direction of DRAM consumption. Currently, 32-bit CPUs are at the leading edge and will be the mainstay of PCs for upcoming years, ending the CPU evolution from 4- to 8- to 16- to 32-bit devices. This evolution will affect DRAM consumption, which has been growing with CPU performance improvement. Dataquest therefore concludes that current needs are satisfied by 4Mb DRAMs, and consumption is not likely to grow significantly in the next few years.

Diversification of 4Mb DRAMs

DRAM makers have to provide many types of DRAMs including different packaging, different speed, and different organizations because of diversified applications.

Although the computer main memory capacity will continue to increase in the future, it does not necessarily mean that all systems require such large memory. Dataquest expects consumption of x4, x8, and x16/18 types of DRAMs to grow rapidly; if 4Mbx1 versions are used for the main memory of a 16-bit PC, 16 units of 4Mbx1 DRAM are required and 32 units in case of a 32-bit CPU-based PC. A 16-bit PC using a 1Mbx4 DRAM would require 4 units of 1Mbx4 DRAM. A 16-bit PC using a 256Kbx8 DRAM would require 2 units of 256Kbx8 DRAM. These wide-bit DRAMs minimize the need for replacement with 16Mb DRAMs in order to save space.

16Mb DRAMs and 4Mb Shrink Versions

The 16Mb DRAM will be initially marketed as x1 and x4 versions in a 475-mil package. Dataquest believes that the market will not be ready to accept these products because the high price and large package are likely to discourage users from replacing 4Mb DRAMs just because of quadrupled storage capacity. The industry has experienced this phenomenon with the 350-mil SOJ package of 4Mb DRAMs; the full-fledged 16Mb DRAM market will likely have to wait until the second-generation version of 400-mil SOJ is introduced.

With the current cycle of introducing x1 commodity products with higher integration every three years, the available memory capacity may exceed the growth of per-bit demand for DRAMs by system products, leading to production decrease. This problem cannot be avoided if DRAMs continue to rely on being used in computers. Thus, the industry must explore other uses for DRAMs or reduce production costs to improve profitability.

One solution is to manufacture 4Mb shrink versions by using 16Mb DRAM technology; chipmakers plan to introduce this shrink-version device as their third-generation version. By using a 0.5-micron process, the chip size can be made one-half the size of the first-generation versions, reducing the price significantly and using smaller packaging. Many chipmakers anticipate that, by operating the 16Mb DRAM production line for 4Mb shrink versions, they can offer favorable foreign market values (FMVs) once 16Mb production begins to dominate the market. This intention is clearly reflected in aggressive investment by leading DRAM chipmakers on 16Mb facilities. In this sense, 4Mb DRAMs play a key role in surviving the next-generation DRAM market.

DRAM Price Trends

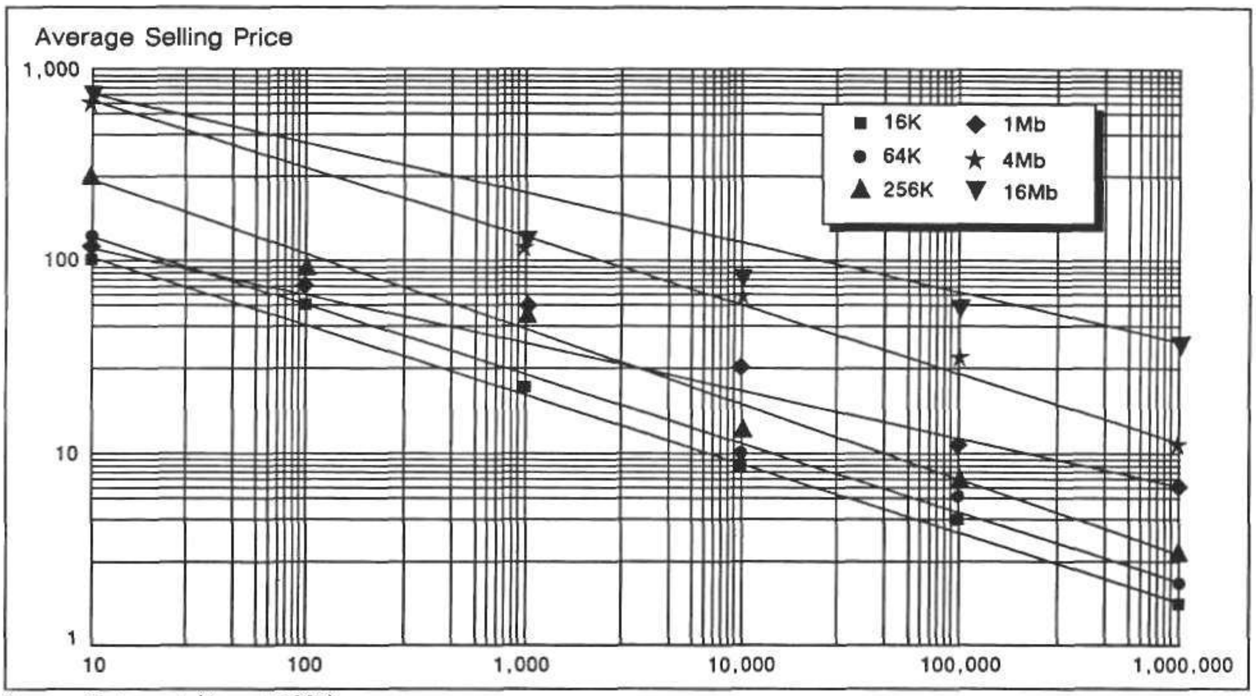
DRAM price trends, from market introduction to total shipments of 1 billion units, are examined for each generation. Although prices declined in a similar pattern from the 16Kb to the 256Kb generation, the rate of price decline became moderate for the 1Mb and 16Mb generations (see Figure 3). Prices for the 1Mb DRAM remained at a high level in 1989 and declined relatively late. However, our analysis suggests that 16Mb prices are likely to follow a similar pattern.

Now that the pace of increase in memory capacity of memory ICs has exceeded that of memory capacity of system products, users will shift their focus of interest from space-saving merit to price advantage. As long as 16Mb prices are high, the life of 4Mb DRAMs will be prolonged accordingly.

Dataquest believes that 16Mb prices will not fall as much as users expect and thus will not follow the learning curves experienced in 256Kb and older products for the following reasons:

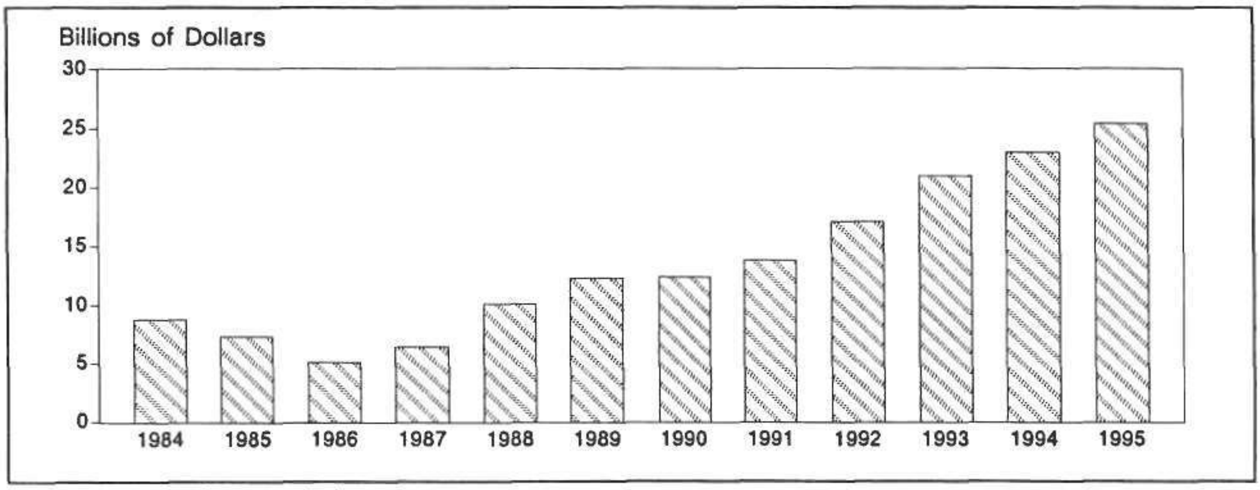
- The increase in the number of processes will increase the influence of particles and contamination on slowing the pace of yield improvement.
- DRAM makers are delaying the shift to wafer processing from 6 to 8 inches.
- Increases in development costs will create a diverse product mix.
- The increase in product line will make it difficult to achieve cost reduction through volume production of a small product line.
- Value-added products including low voltage, low power consumption, and high speed will increase.
- Capital spending will continue to increase (see Figure 4).

Figure 3
Price Learning-Curve Comparison



Source: Dataquest (August 1991)

Figure 4
Worldwide Capital Spending
(Billions of Dollars)



Source: Dataquest (August 1991)

All of these factors will work to fend off the shift from 4Mb to 16Mb devices.

Dataquest Perspective

From an analysis of the factors affecting 4Mb DRAM consumption, Dataquest draws the following conclusions:

- In terms of life cycles, 4Mb, 16Mb, and later generations are expected to have a longer product life.
- 4Mb prices will decline at a faster pace than 16Mb prices.
- Increasing applications will keep products in the market longer, where a few generations of products will coincide.
- 4Mb DRAMs will dominate the PC market, with main memory capacity up to 6Mb.
- Increasing use of Windows and OS/2 will boost main memory capacity, serving as momentum for the shift to 4Mb DRAMs.
- Various technological hurdles must be cleared before volume production of 16Mb DRAMs begins.
- 4Mb shrink versions will be used for early recovery of investment on 16Mb production facilities while acting as a spearhead for exploring the 16Mb market.

Dataquest believes that these findings indicate a long life for 4Mb DRAMs. ■

(This article is reprinted with the permission of Dataquest's Japanese Semiconductor Industry service.)

By Akira Minamikawa

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- August *Market Watch*
- DRAM product/supplier trends
- Semiconductor market forecast update

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Dataquest Perspective

Special Edition

July 22, 1991

Market Analysis

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Market Analysis

Dataquest's 1990 Electronics Industry Market Shares

Every year, Dataquest surveys both vendors and users in most major high-technology industries to collect market share and market sizing data. This article presents a summary of the 1990 market share results and is designed to provide an overview of the major players and major events of 1990 in the high-technology markets of telecommunications; semiconductor equipment, manufacturing, and materials; semiconductor devices; business and technical computer systems; personal computers; software; document imaging systems; CAD/CAM/CAE; computer storage; display terminals; electronic printers; and plain paper copiers.

The Markets

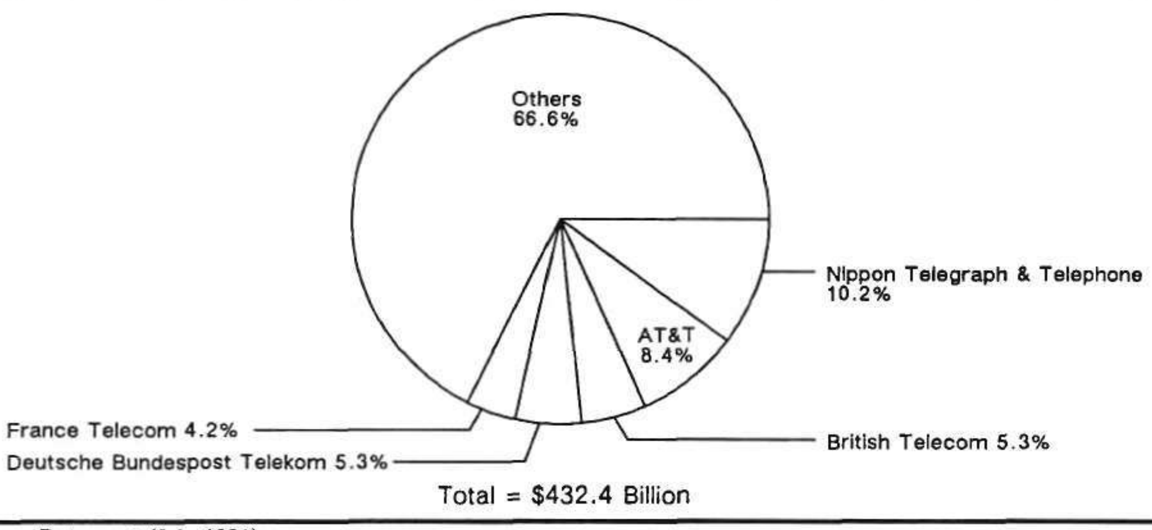
Telecommunications

The revenue market shares shown in Figure 1 reflect the total telecommunications market, including network services and equipment sales. The total available market for telecommunications was $432.4 billion in 1990. As is typical in this industry, the vast majority (more than 78 percent) of revenue is attributed to network services such as local, long distance, and international telephone calls. Because of this revenue imbalance, the market share leaders are representative of network providers—postal, telegraph, and telephone organizations (PTTs)—and not equipment manufacturers. As a point of comparison, the top five equipment providers (in alphabetical order: Alcatel, AT&T, NEC, Northern Telecom, and Siemens) have a combined equipment-related revenue of slightly more than $44 billion, which is almost exactly the total telecommunications-related revenue of NTT (see Figure 2).

The staggering size of the telecommunications market, combined with the necessity for communications standards and network capability, highlights the international character of this industry, which therefore demands a global perspective. Of the five companies shown in Figure 1, five countries are represented as worldwide leaders. Expanding the list to the top ten, the RBOCs start appearing along with Alcatel and Bell Canada (which includes Northern Telecom). Then seven different countries are represented in the top ten market leaders.

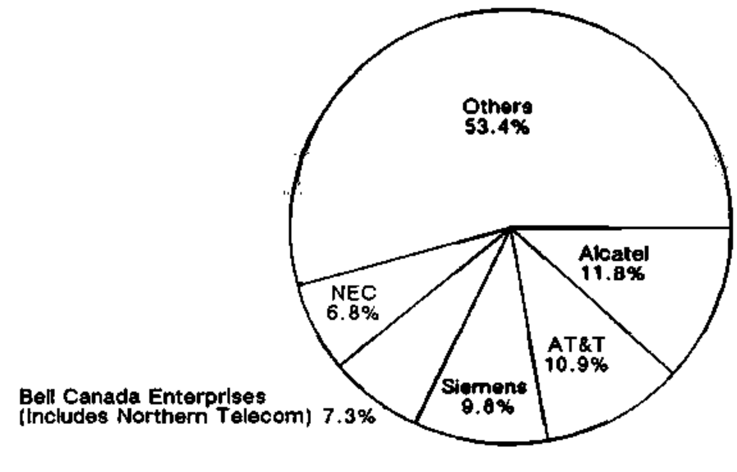
The 1990s will be an exciting time for the telecommunications industry, especially in the area of personal communications. The continuing globalization of the industry, utilization of communications standards such as ISDN, and

Figure 1
Estimated 1990 Worldwide Telecommunications Equipment and Services Revenue



Source: Dataquest (July 1991)

Figure 2
Estimated 1990 Worldwide Telecommunications Equipment Revenue



Source: Dataquest (July 1991)

ongoing mergers and acquisitions set the stage for an intense and dynamic business environment.

Semiconductor Equipment, Manufacturing, and Materials

In 1990, the worldwide market for semiconductor wafer fab equipment was $5.8 billion, down 3 percent from its 1989 level of $5,996 million. Figure 3 displays the top five participants by percent of market share in 1990.

In 1990, four of the top five players in the semiconductor equipment market were of Japanese origin. Applied Materials, a U.S. company that ranked number two with revenue of $462 million, was the only non-Japanese company in the top five. In the 1960s and 1970s, the wafer fab equipment market was dominated by U.S. companies. As the industry matured in the 1980s, however, one of the major trends that emerged was a steady gain in worldwide market share for Japanese equipment companies. The steady gain was due to the growth of a vigorous domestic semiconductor device manufacturing industry in Japan. In 1990, this industry accounted for $2.9 billion of a $5.8 billion worldwide wafer fab equipment market.

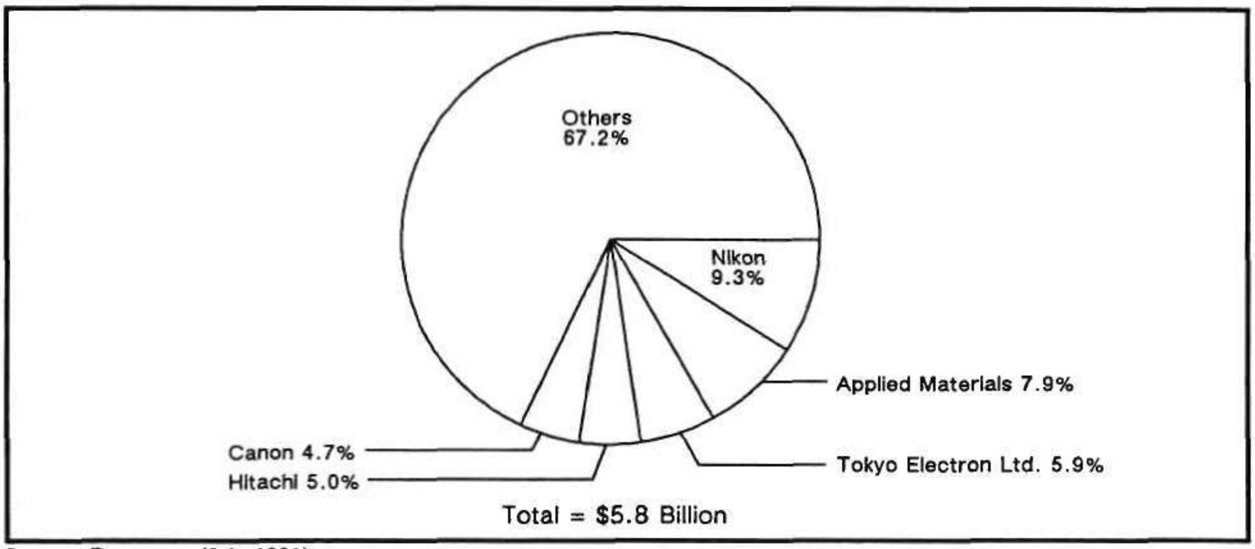
Semiconductor Devices

The number one rule of the semiconductor game asserted itself forcefully in 1990: What goes up must come down. Companies that derive large portions of their revenue from highly volatile commodity products eventually will see their business decline and their market share decrease as rapidly as they had previously grown. A case in point is MOS memory, which was responsible for much of the semiconductor industry's growth in 1988 and 1989. The market share gains made by memory suppliers in those years fell by the wayside (in most cases), allowing other companies to move up in the ranking list (see Figure 4).

Although the memory market did not disappear in 1990, steep price declines made it an unpleasant market to be in. The top three semiconductor vendors in 1990—NEC, Toshiba, and Hitachi—each derived 35 percent or more of their 1989 semiconductor revenue from MOS memory products. In 1990, this ratio slipped 3 to 6 percentage points. Although the same effect can be seen for the fourth- and fifth-ranked companies—Motorola and Intel—these companies received only 12 and 18 percent, respectively, of their 1989 revenue from MOS memory.

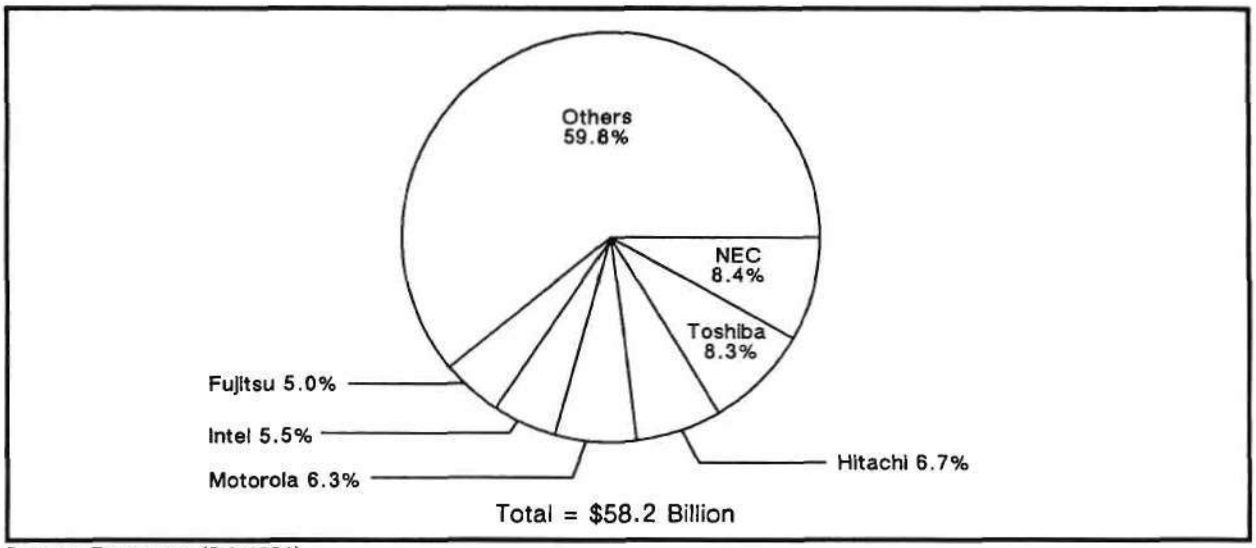
In 1990, these top five companies increased the percentage of total semiconductor revenue from MOS microcomponents. In the case of Intel, which went up in the rankings from number eight to number five, the portion of total semiconductor revenue that came from microcomponents grew from 79 to 86 percent. If it were not for the dramatic growth of microcomponents, the semiconductor industry would have

Figure 3
Estimated 1990 Total Semiconductor Equipment, Manufacturing, and Materials Factory Revenue



Source: Dataquest (July 1991)

Figure 4
Estimated 1990 Total Semiconductor Factory Revenue



Source: Dataquest (July1991)

declined by 2 percent in 1990, rather than having grown by 2 percent.

It is very clear that vastly different product strategies are being followed by each regional grouping of companies. The largest portion of North American companies' 1990 revenue—27 percent—came from microcomponents, while the largest portions of Japanese companies' revenue were from MOS memory (28 percent) and the combined grouping of bipolar digital, discrete, and optoelectronics (29 percent). European companies, on the other hand, are heavily dependent on bipolar digital, discrete, and optoelectronics (36 percent) and analog (30 percent); their revenue from the fastest-growing segments (in the long term) of the semiconductor industry—MOS memory and microcomponents—totaled only 21 percent of their semiconductor revenue. The Asia/Pacific companies' revenue was very heavily skewed in favor of memory, with 63 percent of their revenue coming from that product category.

The memory market eventually will recover, and companies with major commitments in this market will have a chance to regain semiconductor market share. However, in 1990, Dataquest saw that a strong marketing strategy in other product areas can pay off handsomely. We continue to believe that companies with balanced product portfolios in conjunction with volatile commodity exposure will gain market share over the long term.

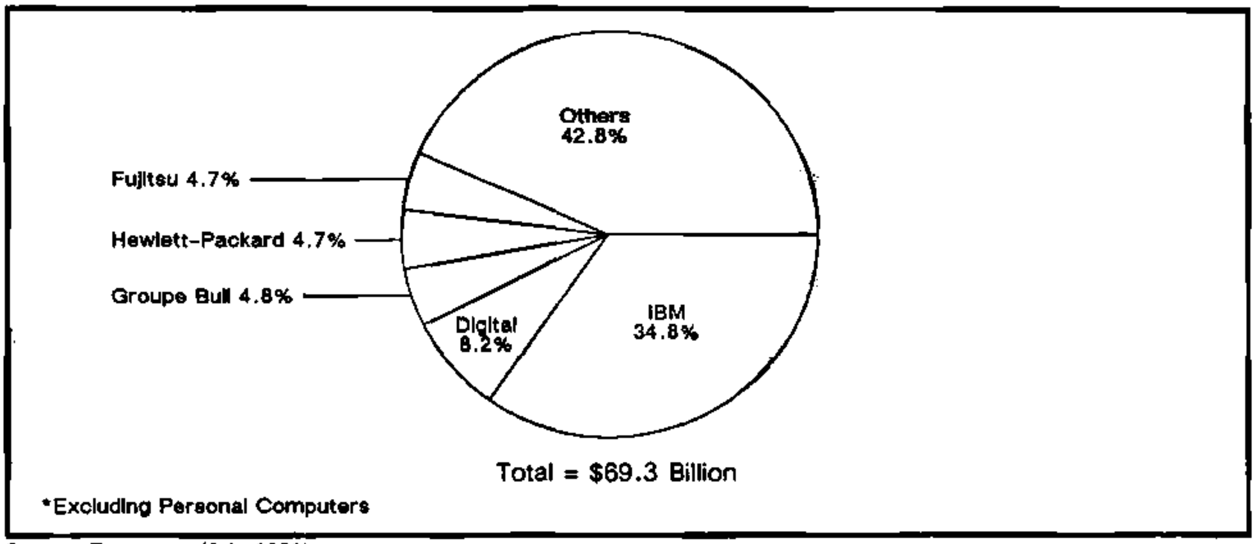
Business and Technical Computer Systems

The year 1990 was a tough one for the computer systems industry. The economic downturn in the United States and the threat of war in the Middle East combined with economic slowing in all regions of the world to slow the worldwide computer systems market growth. In total, the market grew only 6.4 percent over 1989, a rate lower than the 7.9 percent forecast for 1990.

The top five vendors' estimated 1990 factory revenue and market share are shown in Figure 5. IBM continued to hold the lead but lost about 1.4 percent in market share over 1989. With many major vendors having flat or declining revenue for the year, a number of the top vendors lost market share. Although remaining in the second-ranked position, traditional minicomputer vendor Digital Equipment Corporation has seen its share fall from 9.0 percent in 1989 to 8.2 percent in 1990. Digital struggled to maintain the traditionally profitable proprietary VAX line while transitioning to more open UNIX-based systems that have much narrower margins.

Of the top five vendors, only Hewlett-Packard and Fujitsu increased their market share from 1989 to 1990. Fujitsu went from 4.5 percent in 1989 to 4.7 percent in 1990. If the acquisition of ICL had been completed in 1990, Fujitsu's total computer systems revenue would have been $4.0 billion, moving Fujitsu into third place with a 5.8 percent market share. Other vendors making gains in 1990 were Hitachi and Sun Microsystems. Hitachi's gain was fueled by growth in the mainframe product segment. From 1989 to 1990, Hitachi's mainframe revenue increased 12.5 percent (including revenue from HDS in both 1989 and 1990). Sun Microsystems' move into the top ten has been based on the strength of virtually a single product line—workstations. The workstation product segment has been the hottest segment of the market for a number years, and Sun has been at the top of the workstation market for the last several years.

Figure 5
Estimated 1990 Worldwide Business and Technical Computer Systems Factory Revenue



Source: Dataquest (July 1991)

Personal Computers

In 1990, the Notebook PC gained notoriety. At COMDEX/Fall '90, 37 vendors introduced "notebook" computers. Also in 1990, prices fell the fastest in the shortest period of time. See Figure 6 for a display of the market leaders in 1990.

As 1990 came to a close, the market was left with an unstable pricing structure, shaky margins for vendors and dealers, and an economy struggling to stay on the positive side of growth.

HP validated the hand-held computer market with a bang. In April, the HP 95LX was introduced; Dataquest estimates that 300,000 could be sold by year-end. Pen-based PCs are the newest interest, with GRiD expanding the GRiDPad line and NCR entering the market. Operating systems are fueling the excitement with GO Corporation introducing the PenPoint operating system and Microsoft introducing PenWindows. By the end of the year, Dataquest expects several more entrants as PC vendors scramble for positioning in this potentially large market.

The desktop PC market is expected to crest in the United States, as portables eat into an already sluggish market and replacement sales continue to decrease.

The notebook PC market should be the most difficult market this year, as intense competition and obsolescence are precariously balanced. The 80386SL microprocessor will rapidly replace the 80386SX in the notebook segment. Vendors must balance demands for today's notebook sales with the risk of holding warehouses of 80306SX-based notebooks when the 80386SL-based notebook PC is available in volume.

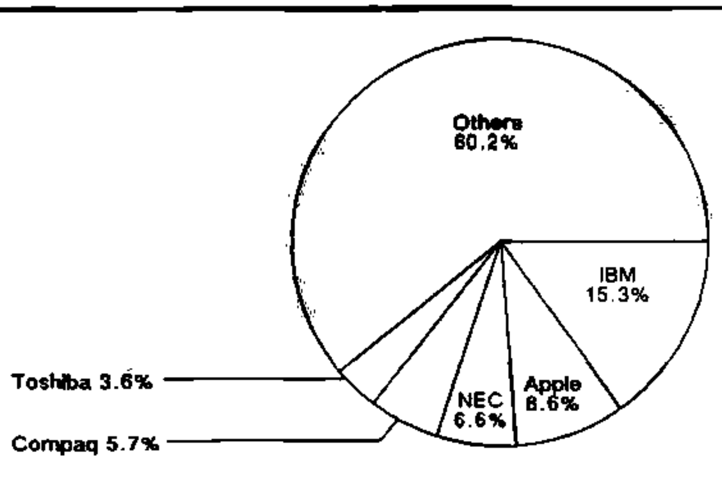
In the laptop DC and notebook segments, entropy is growing, causing further price confusion.

Dataquest expects Apple to increase its market share by units with new, lower-priced PCs and Compaq to increase market share with its notebook and high-end PCs. We also expect HP to increase market share with its new hand-held PC, IBM to increase market share with its assault on distribution channels, and Zenith Data Systems (a company of Groupe Bull) to increase market share as it emerges from a sleepy 1990 with new, well-designed laptop and notebook PCs.

Software

Windows was the star of the show in 1990, grabbing the attention of users and driving vendors to provide Windows products. Also monumental in that year was IBM and Microsoft's fight over the fate of operating software. IBM was intent on providing its own Presentation Manager (PM), not using Windows as the ubiquitous graphical user interface. It is interesting to note that while Microsoft is

Figure 6
Estimated 1990 Worldwide Personal Computer Factory Revenue



Source: Dataquest (July 1991)

aggressively promoting Windows over PM and implementing a strategy of cross-platform availability, it is still actively maintaining its present relationship with IBM. See Figure 7 for a display of the major players in 1990.

In 1990, Borland embarked on an aggressive marketing campaign in the spreadsheet market that successfully wooed a large part of the Lotus 1-2-3 installed base to Borland's QuattroPro. Through its dynamic marketing actions, Borland changed the competitive etiquette of this market, catching Lotus completely off guard. To no one's surprise, Lotus lost significant market share as a result. Also, Borland applied its new marketing techniques to Paradox, its relational database, with success. Other companies are copying Borland's style.

Also on the cutting edge of change, Borland broke away from traditional methods of selling products in this market. The company continued to sell products via the two-tier channel, while concentrating on direct sales through an aggressive direct-mail marketing campaign. Borland's innovation proved fruitful.

Of all the important events in 1990, Dataquest believes that Windows 3.0 will have the most significant effect on PC software for years to come. PC software as a market will be impacted by Borland International's product design and marketing innovations. The increasing growth of the direct market indicates that PC software is becoming more of a commodity.

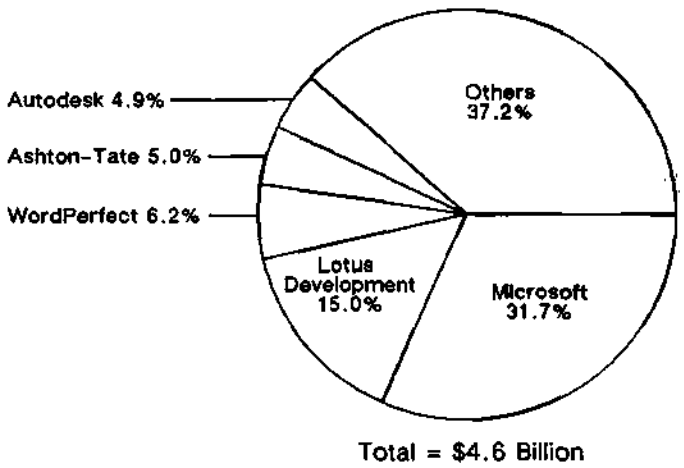
Document Imaging Systems

Dataquest defines document image management systems (DIMS) as computer systems that convert paper documents into digital images via scanning that can be viewed at a workstation, stored on random-access media, transmitted across networks, and printed. During tight times such as these, when many businesses must make cuts in budget and staff to stay afloat, DIMS seem to offer a viable way to be more productive using fewer resources. In the business document imaging system market, several key vendors' introduction of software enabling PCs to run document imaging applications promises to extend image management capabilities deeper into organizations.

To date, only IBM, Digital Equipment, and Wang Laboratories among the computer systems vendors have had measurable success in document imaging. Others, such as Bull, Hewlett-Packard, NCR, and Unisys, are moving slowly but steadily. FileNet, a company that specializes in providing document imaging systems, ranked second in terms of DIMS revenue in 1990 (see Figure 8).

Technical document image management systems (TDIMS) are used to image wide-format drawings and documents. TDIMS shipments grew by nearly 14 percent between 1989 and 1990, and revenue skyrocketed by 46 percent. The top five market leaders in this marketplace are Optigraphics, Intergraph, GTX, Litton/Integrated Automation, and FormTek (see Figure 9).

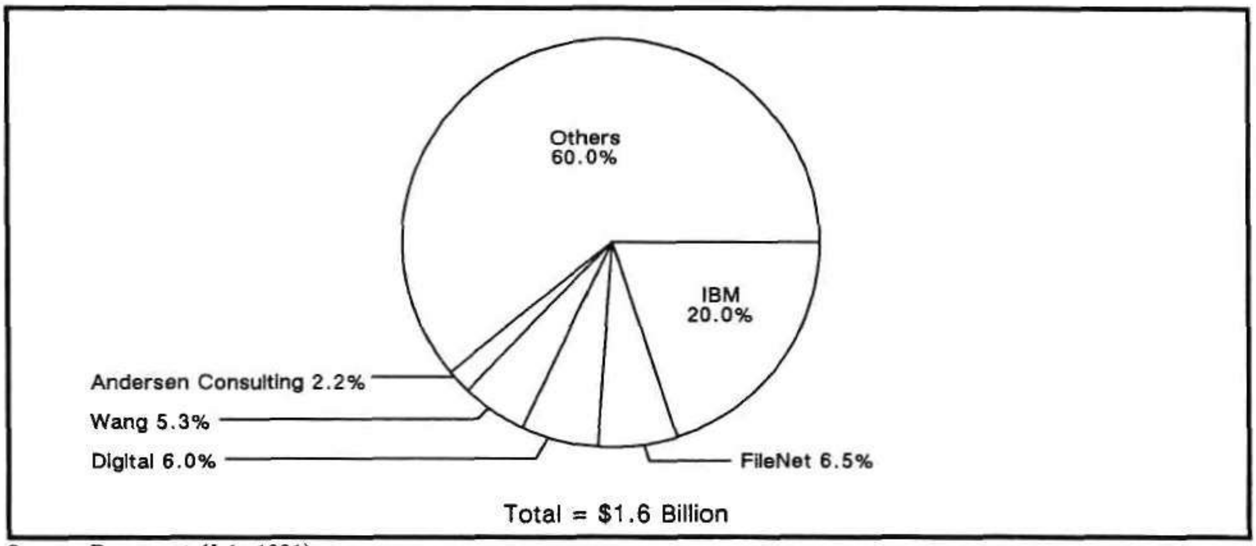
Figure 7
Estimated 1990 Worldwide PC Software Factory Revenue*



* Includes only shrink-wrapped single-user revenue

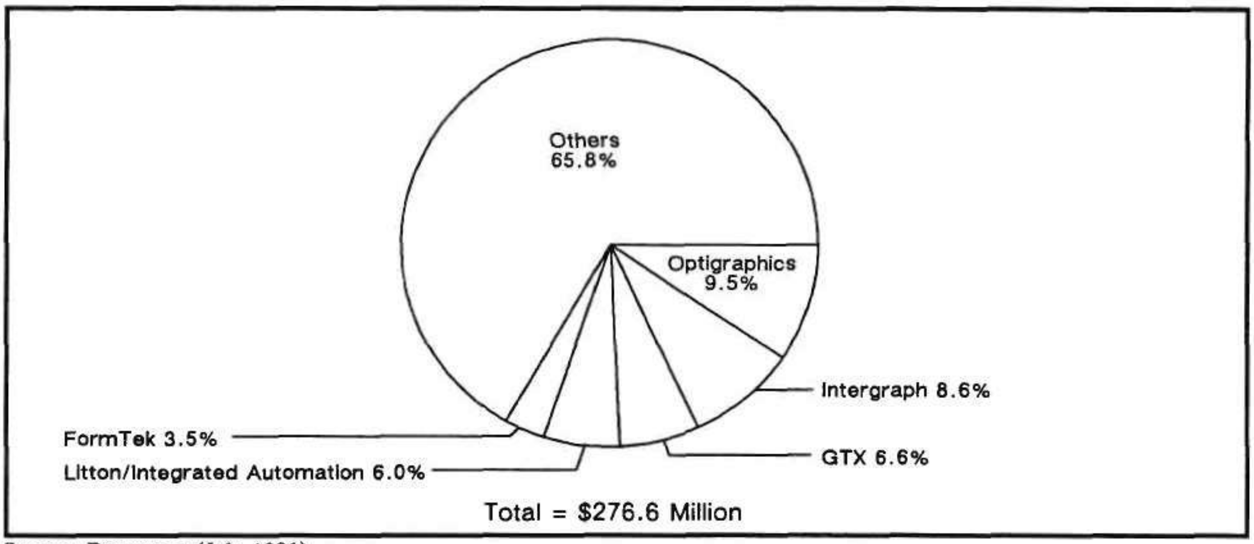
Source: Dataquest (July 1991)

Figure 8
Estimated 1990 Vendor Revenue—Business Document Image Management Systems



Source: Dataquest (July 1991)

Figure 9
Estimated 1990 Vendor Revenue—Technical Document Image Management Systems



Source: Dataquest (July 1991)

Although some of the industries served by TDIMS are experiencing hard times, this enabling technology continues to make inroads into engineering and document management groups across a broad number of industries.

Despite a year that was slower than expected in terms of overall TDIMS shipments, revenue was much higher than anticipated, and the TDIMS market continues to build momentum. This is a time when most TDIMS vendors and integrators are still getting it together—learning from pilot installations, building second-generation products, continuing to improve enabling technologies such as raster-to-vector conversion, and building a systems-implementation knowledge base.

CAD/CAM/CAE

In 1990, the CAD/CAM/CAE market grew 14.6 percent to $14.4 billion. The biggest gains in this market went either to vendors that had established CAD/CAM/CAE market share or to vendors that were very innovative. The biggest CAD/CAM/CAE vendors benefited from the growing importance placed by users on long-term supplier viability; buyers were willing to commit to using more design tools, but not without strategic alliances with leading vendors. The year was not a study in big vendors getting bigger, however. Users were also active in testing and buying some of the newest technology from all vendor sources, big and small. See Figure 10 for the major TDIMS vendors' 1990 market share.

The fastest-growing and best niche vendors in this maturing market reaped the rewards of developing joint marketing agreements with the top systems integration vendors. Products that enhance design, analysis, and quality control functions grew particularly well.

Instability in the electronic design automation (EDA) industry continued to create market uncertainty that affected growth. Several major players in the EDA industry weathered significant product transitions, others began to attack new markets, and many are being forced to revamp their business models.

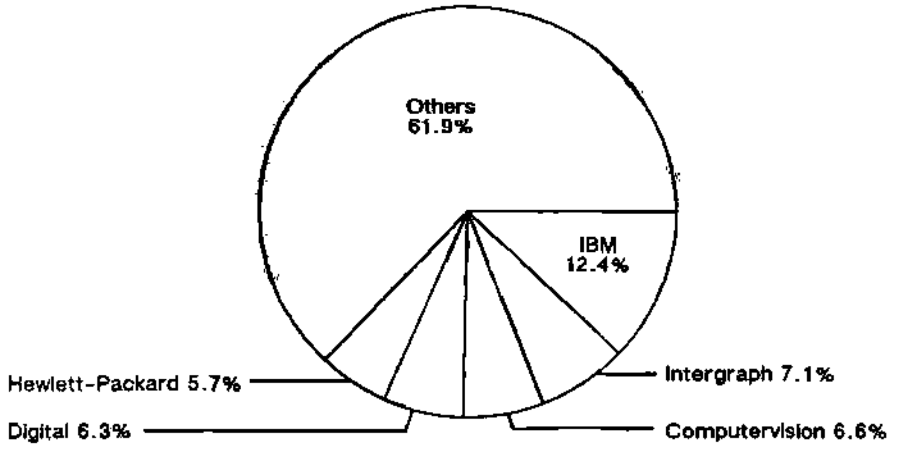
The European market continued to grow faster than expected, and it should continue to grow faster than the worldwide average. Opportunities for CAD/CAM/CAE in Eastern Europe will grow as the area moves to a Western-style, market-driven economy. Opportunities include both sales to existing companies for design of products to satisfy the enlarged domestic market and tool sales to Eastern European companies to assist their drive toward greater productivity and competitiveness.

Computer Storage

The computer storage market ended the year ahead of our previous projections. Worldwide factory revenue grew to $21.1 billion, an increase of 18 percent. Sales of 3.5-inch rigid disk drives (RDD) exploded beyond expectations, driving 1990 revenue in this segment to $5.6 billion, up 78 percent over 1989 revenue. The 3.5-inch RDD segment is the largest segment of the computer storage market and also the fastest growing.

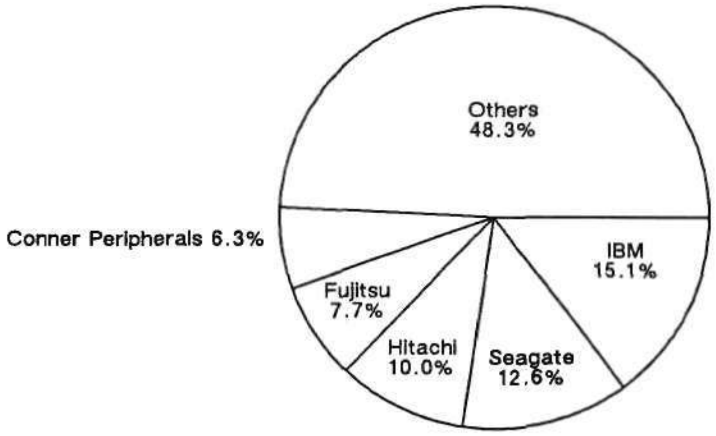
Figure 11 shows the estimated 1990 computer storage market shares. The top five companies are the same as in 1989; however, significant changes occurred during 1990. IBM remained in first place, albeit with a lower share than the previous year because of a large portion of its sales in the slower-growing high-end markets. Seagate overtook Hitachi for the number two spot, largely due to the growth of the 3.5-inch

Figure 10
Estimated 1990 CAD/CAM/CAE Worldwide Market Shares



Source: Dataquest (July 1991)

Figure 11
Estimated 1990 Worldwide Computer Storage Factory Revenue



Source: Dataquest (July 1991)

RDD market and an increased share of the 5.25-inch RDD market. Fujitsu does not participate in the 3.5-inch RDD market and lost market share during 1990. Conner Peripherals grew from 4 percent market share in 1989 to 6.3 percent in 1990.

Dataquest expects the 3.5-inch RDD segment to grow from its current 27 percent of the computer storage market to nearly 55 percent by 1995 and to greatly influence future total computer storage market shares. The key players in the 3.5-inch RDD segment are Conner, IBM, Maxtor, Quantum, Seagate, and Western Digital (in alphabetical order). The list of key players for 1991 will show the same names, but the positions will vary again.

Display Terminals

The top five leading worldwide display terminal vendors captured 52.3 percent of the total market (see Figure 12). IBM led this market with 22.6 percent market share, resulting from the continued success of its AS/400 product lines and the growth of its ANSI terminal business. Wyse, together with its subsidiary Link Technologies, maintained its leadership position in the still growing ASCII/ANSI/PC sector of the display terminal market.

Dataquest believes that the ASCII/ANSI/PC sector will continue to grow in market share. Color will play an increasingly significant role in the IBM 3270 and 5250 markets, but only a minor role in the ASCII/ANSI/PC market. The total ASCII/ANSI/PC market is expected to have a 5.9 percent compound annual growth rate (CAGR) through 1995.

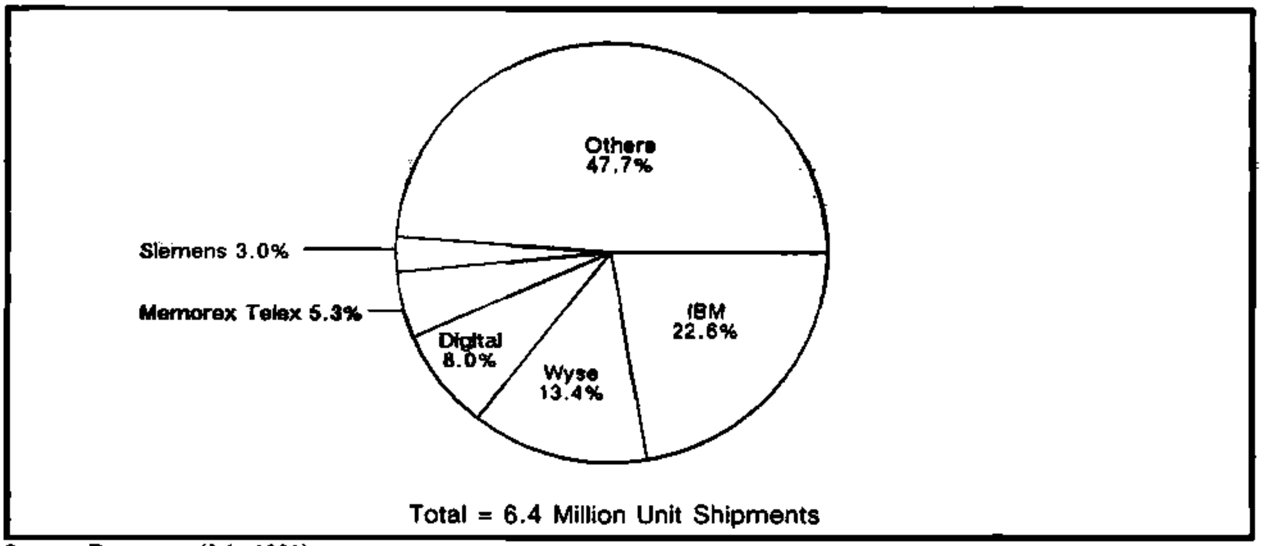
Electronic Printers

In some respects, the 1990 North American electronic printer market was a mirror image of 1989. There was only a slight growth in total factory revenue, and the market leaders and their rankings remained the same as in 1989. Figure 13 shows factory revenue of the major vendors of electronic printers.

In other respects, 1990 was a pivotal point in the market. It demonstrated Dataquest's previous assessments of the market. The serial printer market leveled off—serial dot matrix printers were being replaced by serial ink jet printers. Serial printers (which dominated the market in the 1980s) were being replaced by page printers. Page printers have become the dominant force in the printer market because they enable the user to advance to faster and higher-quality printing.

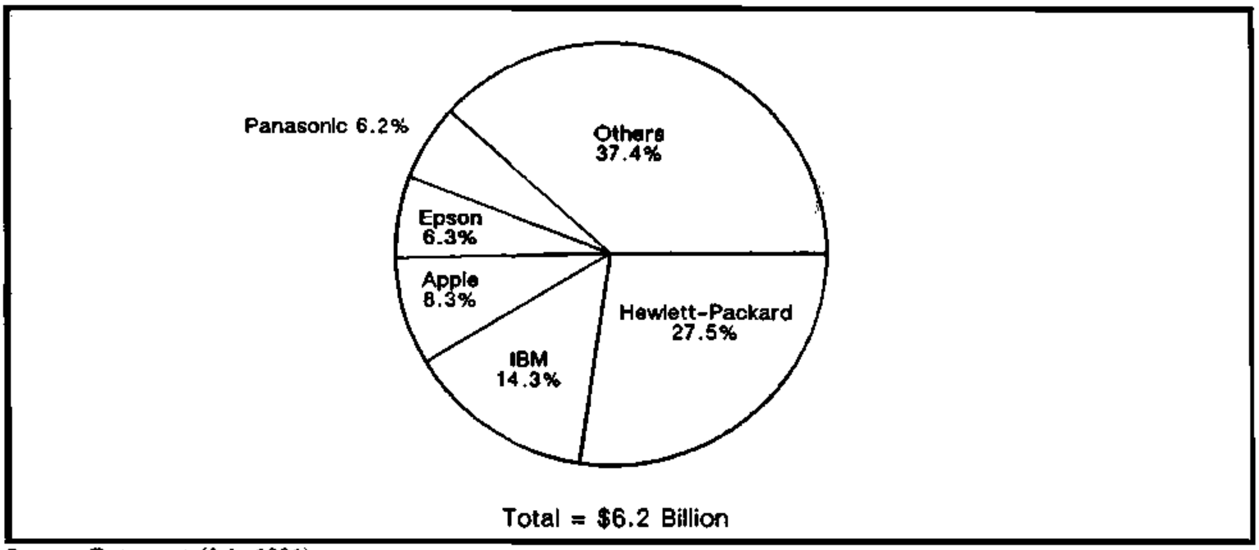
During 1990, page printers surpassed the 50 percent mark of total North American market revenue, and our projections are that this portion will expand to 60 percent by 1995. The

Figure 12
Estimated 1990 Worldwide Display Terminal Shipments



Source: Dataquest (July 1991)

Figure 13
Estimated 1990 North American Electronic Printer Factory Revenue



Source: Dataquest (July 1991)

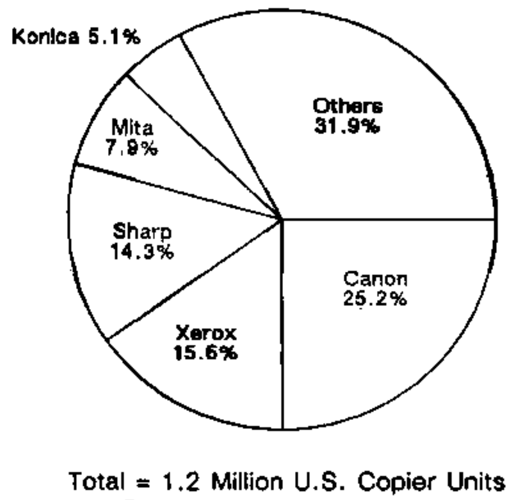
top three players in the total market (HP, IBM, and Apple) were also the market leaders in the page printer market—with 70 percent of that market.

Again in 1990, HP was clearly the winner in market share. HP had the dominant market share in both the ink jet and page printer markets, the fastest-growing segments of the electronic printer market.

Plain Paper Copiers

Once again, the clear winner in unit placements/shipments was Canon, followed by Xerox and Sharp. Canon's strength has traditionally been in the very low end of the copier market,

Figure 14
Estimated 1990 U.S. Plain Paper Copier (Placements)



Source: Dataquest (July 1991)

but the company is making a pronounced transition into a powerhouse in the midrange and upper end of the market. Xerox posted its seventh straight year of market share improvement. Although this improvement averages only about 1 percent per year, it does indicate a company that has made a remarkable turnaround in improvement of its market position. Sharp, which traditionally has had a good reputation in the low end of the market, expanded its capabilities in the midrange of the copier market. Figure 14 shows Dataquest's estimates of the 1990 U.S. market shares.

Although it is a relatively mature marketplace, there are still a number of dramatic changes taking place in the copier market. In the high end of the market, digital front ends that can be networked as output devices are being incorporated in order to improve the economies/efficiencies of the way documents are produced in high volume. This charge is being led by Xerox and Kodak.

In the midrange segments, traditionally dominated by independent dealers, we see increased competition as these dealers try to maintain their viability in the market. In the low end (a commodity market with little or no hardware differentiation), severe price cutting has led to margin erosion, with the result that dealers are giving less emphasis to this segment.

Dataquest's 1991 Electronics Industry Forecast

The electronics industry will continue to experience basic structural changes as we progress into the 1990s. These fundamental structural changes are being driven by globalization of telecommunication networks, maturation of sectors of the computer industry, ongoing expansion in the Asia/Pacific region, and continued company consolidations and alliances.

Although the 1990s started slowly with a burdening recession and war in the Persian Gulf, things are appearing to pick up according to significant indicators. Dataquest believes that the recession has hit rock bottom and is bouncing upward to recovery. This optimistic outlook is supported by the following U.S. government announcements of economic and business activity for the month of May:

- Industrial production is up 0.5 percent, the second consecutive monthly increase.
- Capacity utilization is up 0.2 percentage points to 78.7 percent.
- Nonfarm payrolls are up 58,000, which is the first increase in 11 months.
- Housing starts are up 0.1 percent.

- Retail sales are up 1.0 percent.
- Consumer borrowing is up 2.8 percent.

According to The Dun & Bradstreet Corporation, real gross national product (GNP) is expected to grow at only 0.2 percent in 1991, down from 1 percent in 1990. However, to get a true picture of 1991 GNP growth, we need to examine the quarterly data. The Gulf War was the major culprit in the first quarter, forcing first-quarter GNP growth to decline by 2.6 percent. However, things should begin to heat up in the remaining quarters: 1.5 percent for the second quarter, 3.8 percent for the third quarter, and 3.6 percent for the fourth quarter. Furthermore, real GNP will increase to 3.4 percent in 1992, the highest it has been in the past three years. A recovering GNP should lead to reduced inflation rates, a decline in unemployment, and increased consumer confidence.

In addition, government reports have suggested that the housing market is beginning to recover (housing starts were up 0.1 percent in May), companies are planning more hiring activities, and factory orders are beginning to build momentum. Also, according to the federal government, there is a steady drop in the number of people who are seeking unemployment benefits. This fact implies that new hires are beginning to offset layoffs.

In 1991, according to Dun & Bradstreet, capital equipment spending growth over 1990, as a percentage of GNP, is forecast to be a negative 0.8 percent. However, a closer examination of this figure is also needed to get an accurate picture. Growth for the first quarter was negative 18.2 percent; second quarter, 2.8 percent; third quarter, 7.5 percent; and fourth quarter, 10.1 percent. Apart from the strong dip in the first quarter, these figures clearly display the building momentum of capital equipment spending. This positive trend will continue; equipment spending is forecast to jump up to 8.3 percent for 1992.

The Markets

Telecommunications

Whether it be voice, text, or data, communication is key to business as we know it; therefore, by association, so is the telecommunications industry. Irrespective of international boundaries, the companies positioned to fulfill both the continuing and newly emerging demands for telecommunications will prosper well into the next century.

Forecast growth for the telecommunications industry as a whole remains mixed. Overall, the telecommunications market should grow at a compound annual growth rate (CAGR) of 7.1 percent until 1995 (see Table 1). The greatest influence on this market's growth is attributed to local and long distance calling services. In 1991, this segment will generate $150.6 billion, accounting for 86 percent of all North American telecommunications revenue. Although smaller, the equipment side of this market will grow more rapidly at a CAGR of 8.6 percent. Of this segment, customer premises equipment will grow faster than public equipment, at a CAGR of 14.8 percent compared with 4.1 percent. In Europe, total telecommunications sales are expected to parallel the U.S. rate. Also, equipment revenue growth is expected to be about half that of the United States.

The primary factors driving the telecommunications industry include globalization of worldwide networks, markets, and standards; rapid movement to a digital telecommunications network; transition from an engineering perspective to a marketing focus; and continued consolidations and alliances.

In the last decade, the telecommunications landscape was altered drastically: It became truly international. The ramifications of recent events taking place in Europe, alone, are monumental. Meeting the needs of these dynamic markets

Table 1
Worldwide Telecommunications Forecast by Region (End-User Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	207,431	220,932	285,387	6.6
Europe	110,066	118,652	157,274	7.4
Japan	56,853	60,407	77,458	6.4
Asia/Pacific-ROW	58,019	63,076	90,331	9.3
Total Worldwide	432,370	463,067	610,450	7.1

Source: Dataquest (July 1991)

will require the globalization of networks and standards. Dataquest believes that outstanding opportunities exist for expansion in Europe and the Pacific Rim regions.

Furthermore, digitization of the networks creates strong opportunities. As a result of a digital network, bandwidth (data-carrying capability) will no longer be an issue or constraint. Simultaneous video, data, and voice transmission sharing the same medium will become a reality once the needed standards are passed and in place.

The acceptance of the Integrated Services Digital Network (ISDN) has been slower than anticipated. However, its use is expected to increase at a steady pace from the existing 206,000 access lines in service in 1991 to 1.1 million lines in service in 1995, representing a CAGR of 52 percent. ISDN is broadly supported by the industry, all critical standards have been implemented, field trials are presently being conducted in selected locations, and initial "pockets" of local services are currently available.

As we move into the new decade, the telecommunications industry will continue to shift its engineering focus to a more predominant marketing focus. The elements of success will be determined by customer service and support, solution-based applications, personal communications, strategic distribution, and account management.

Further mergers, acquisitions, and alliances will continue in the 1990s. These consolidations will occur partly as a result of competition, but also as a result of globalization.

Semiconductor Equipment, Manufacturing, and Materials

For the wafer fabrication equipment market, Dataquest is cautiously optimistic about the near-term outlook. The short-term outlook is clouded by the current worldwide macroeconomic and political uncertainties. However, in the long term, Dataquest believes that the wafer fabrication equipment market will enjoy healthy growth through 1995. Wafer fabrication equipment companies with global presence, financial muscle, and innovative customer-driven technology solutions can be optimistic about their long-term future in an increasingly chip-pervasive world.

Japan is the largest regional wafer fabrication equipment market in the world. In 1990, the market for wafer fab equipment in Japan was $2.94 billion, up 5 percent from its 1989 level of $2.80 billion. Japan represents the leading production region for high-volume advanced devices such as 4Mb DRAMs, 1Mb SRAMs, gate arrays, and embedded microcontrollers for Japan's burgeoning equipment industry. Hence, the Japanese wafer fab equipment market drives the requirements of high throughput and leading-edge process technology. Through sheer size and momentum, the Japanese wafer fabrication equipment market is expected to continue to prevail as the largest during the next five years, although it will grow at the slowest rate among the four major geographical markets.

North America as a region did not add many large production fabs in 1990. The 1990 wafer fab market in North America was $1.60 billion, down 4 percent from its 1989 level of $1.64 billion. Fab capacity expansion, upgrades, and offshore Japanese fabs in North America accounted for the bulk of the 1990 market. The United States is expected to continue to be the second largest wafer fab equipment market in the world.

In 1990, the wafer fab equipment market in Europe was $758 million, up 5 percent from the 1989 market of $720 million. In 1990, most of the wafer fab equipment market activities revolved around offshore Japanese and North American fabs locating in Europe to better serve their customer base and to position themselves as potential partners for 1992. These offshore European fabs were typically clones of parent North American and Japanese fabs. The European wafer fab equipment market will enjoy healthy growth during the next five years as Japanese, U.S., and Asian semiconductor companies set up Europe-based fabs to cater to a unified European market as well as large blocs of countries in Eastern Europe.

Semiconductor Devices

Dataquest believes that the long-term trend toward slower growth will continue for the semiconductor market in the 1990s. We are forecasting a worldwide CAGR of 12.6 percent from 1990 to 1995 (see Table 2). In addition, we believe that the cyclicality of the industry, although still in evidence, will abate considerably in magnitude. We do not foresee annual growth approaching even the 25 to 30 percent range in any one year. Key events and assumptions driving our short- and long-term forecasts are based on the following factors:

- Memories, microcomponents, and MOS logic are leading the industry recovery in 1991.

Table 2
Worldwide Semiconductor Consumption Forecast by Region
(Factory Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	17,386	18,761	28,001	10
Europe	10,661	12,274	20,764	14.3
Japan	22,508	26,354	40,762	12.6
Asia/Pacific-ROW	7,670	8,834	16,004	15.8
Total Worldwide	58,225	66,223	105,531	12.6

Source: Dataquest (July 1991)

- Fluctuations against the U.S. dollar are skewing 1991 dollar growth upward.
- The European and Asian semiconductor markets are the hotbeds of activity for both the near and long term.
- As electronic equipment becomes an ever-larger component of the worldwide economy, semiconductor growth rates are slowing.
- The historical cyclicality of the industry, while still visible, has moderated.

Dataquest expects the next market peak to occur in 1992 or 1993, in keeping with historical cyclicality and the traditional market drivers of U.S. presidential elections and the Olympic games. We believe that the market will soften slightly in 1994 and 1995. Although semiconductor penetration is expected to increase in electronic equipment, the overall electronic equipment market is maturing and experiencing slower growth, and relationships between semiconductor suppliers and users are smoothing out the traditional volatility in the demand curve.

Throughout the forecast period, we expect Europe and Asia/Pacific-Rest of World (ROW) to consistently outperform North America and Japan. Europe and Asia will be driven by growing economies, communications standardization, and both new industrialization and reindustrialization. The applications with greatest opportunity will be personal communications, personal data processing equipment (such as laptop and palmtop PCs, and personal faxes), workstations, and—particularly in Europe—transportation.

Competitive pressure in the semiconductor industry is increasing as well. More and more microprocessors have become proprietary, with only a few vendors producing state-of-the-art devices.

Business and Technical Computer Systems

In the near term, the computer systems industry is not expected to perform much better than it did in 1990. Dataquest believes that Europe will not continue to experience the explosive market growth that it did in the recent past. However, we expect Japan to grow at a slightly higher rate than North America and Europe, fueled by the workstation and supercomputer product segments. Over the next five years, we believe that the market will grow at a 5.3 percent CAGR (see Table 3).

The supercomputer segment will show the second highest growth rate of any product segment, with a CAGR of 12.0 percent. Supercomputers will remain a small portion of the total market, with growth most likely fueled by a flow of systems into Eastern Europe assisted by U.S. and Japanese government subsidiaries.

The workstation segment will show the most growth over the next five-year period, with a CAGR of 25.8 percent. The gain in this segment will be apparent in both the technical and commercial markets. Growth in the commercial workstation market is projected at 62.4 percent over the next five years. However, this growth is dependent on the availability of applications and development of distribution channels. Workstations will continue to face stiff competition from PCs as PC functionality increases, forcing workstation prices even lower.

The mainframe market is expected to decline by the end of 1995, with a CAGR of negative 1.1 percent. Dataquest believes that big-ticket purchases will continue to be postponed and even canceled. Many users instead will be opting for lower-cost solutions such as PCs and workstations.

The midrange segment will continue to grow slowly, with a 3.0 percent CAGR over the five-

Table 3
Worldwide Business and Technical Computer Systems* Market Forecast by Region (Factory Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	29,350	29,860	36,851	4.7
Europe	24,479	25,106	31,354	5.1
Japan	13,245	13,547	17,145	5.3
Asia/Pacific-ROW	2,272	2,577	4,350	13.9
Total Worldwide	69,346	71,090	89,700	5.3

*Excluding personal computers
Source: Dataquest (July 1991)

year period. Within the midrange market, we expect to continue to see falling ASPs. This segment is being squeezed by both workstations and networked PCs. As the large midrange suppliers—namely Digital and Hewlett-Packard—transition their product lines from the older proprietary systems to the newer open systems, margins will become ever smaller.

Software

Over the course of the last year, several hardware vendors—among them Digital Equipment Corporation, Wang Laboratories, and Apple Computer—have stated that they are repositioning themselves as software companies. Yet other vendors—including Sun Microsystems and Compaq—are looking to reduce their reliance on hardware products. A surge in software activity, often in the form of alliances with existing software vendors, has begun.

Another significant trend that has increased the impetus of the course of the last year has been the development of strategic software architectures. Ranging from relatively proprietary initiatives like SAA within IBM to much more open and esoteric strategies like that from Patriot Partners, software architectures have the potential to significantly impact the software industry. Particularly when they encompass object management capabilities, these software architectures will revolutionize the way that software is written and, as a consequence, vastly increase the number of software packages that are developed.

Dataquest primarily focuses on two specific segments of the software market: Personal Computer Software and Office Software. Personal computer software is utilized by more individuals than any other group of software products. Office software is highly strategic to the end-user community that implements it and to the vendor community that supplies it.

PC Software

In 1990, Windows grabbed the attention of the market, compelling major vendors to provide Windows products. Dataquest expects Windows-based DOS to exceed character-based DOS in worldwide unit sales after 1993. Windows 3.0 will have the most effect on PC software technology in the years to come.

Microsoft has reached a point where it believes that it can position itself in direct conflict with IBM's intentions. IBM wants the Presentation Manager (PM), not Windows, to be the graphical user interface used on every desktop. Although Microsoft is still facilitating a relationship with IBM, it is at the same time aggressively promoting Windows over the PM and is implementing a strategy of cross-platform availability. Dataquest believes that Microsoft will be successful. Through the mechanism of OS/2, Microsoft 3.0 will place the Windows interface on any computing environment that comes into use, whether it be its own or another vendor's.

Ashton-Tate, the Torrance, California-based publisher of dBASE IV, was recently purchased by arch-rival Borland International. Ashton-Tate used to be the market leader in relational database software, but release of a malfunctioning dBASE IV in late 1988 caused several bad quarters for the company. Though in the process of recovery, Ashton-Tate was still ripe for purchase. Borland acquired not only the dBASE product line, but more importantly, the dBASE customer list, which will serve Borland well in the 1990s.

Office Software

Overall, 1990 was a good year for office software. Dataquest expects this healthy trend to continue. The total worldwide office software market will grow to $2.9 billion in 1995 from $1.4 billion in 1990, representing a CAGR of 15.6 percent (see Table 4).

However, manufacturer-based office software is on the decline. Still lagging behind the PC independent software vendors (ISVs) in terms of features of productivity tools—specifically, the standalone variety—the systems vendors dominating this market have relied on their expertise in integration and enterprise-solution orientation to remain competitive. Although this may prove to be the case in the longer term, current trends indicate that neither end users nor vendors believe that systems vendors have the monopoly on enterprise solutions.

Although UNIX experienced high growth in 1990, the UNIX-based segment ultimately remains vulnerable to the fact that UNIX does not equate to open systems. Although this segment is expected to continue its healthy growth, vendors operating in this segment need to provide substantial added value, at least equal to that provided by vendors in the other segments, in order to continue to entice users to the UNIX platform. Business-solution orientation and increased penetration of large accounts would be among the highest imperatives, ensuring continued strength.

As for PC LAN-based office software, this segment remains the dark horse. Although this segment must be a critical component of all office software vendors' strategies, the segment is awaiting impetus from the PC ISVs' entry. Ultimately, office software will be dominated by connected LANs.

Document Imaging Systems

In 1990, the document imaging industry experienced a good year; the overall value of the worldwide document imaging market was $1.8 billion. Revenue for sales of document imaging systems into business and commercial markets grew by nearly 29 percent, and technical document imaging systems revenue increased 45.6 percent.

Dataquest defines document image management systems (DIMS) as computer systems that convert paper documents into digital (bit-map/raster) images that can be viewed at a workstation, stored on random-access media, transmitted across networks, and printed.

Dataquest's overall forecast for the worldwide document imaging industry is growth to $7 billion by 1995 (see Table 5). We expect business document imaging systems to account for roughly 76 percent of the market and technical systems to make up the remaining 24 percent.

Table 4
Worldwide Office Software Forecast by Region
(If-Sold License Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
United States	808	892	1,587	14.5
Europe	491	586	1,066	16.8
ROW	108	130	245	17.8
Total Worldwide	1,407	1,608	2,899	15.6

Source: Dataquest (July 1991)

Table 5
Worldwide Document Imaging Systems Forecast by Region
(Factory Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
United States	1,007	1,441	3,467	28
Europe	406	517	1,350	27.1
ROW	173	230	506	23.9
Total Worldwide	1,586	2,188	5,323	27.4

Source: Dataquest (July 1991)

Factors driving growth in this market include the following:

- The entry of almost all U.S. computer systems companies into the market has legitimized it, driven development forward, and raised user awareness of the technology's potential.
- The growing use of industry-standard PCs as desktop imaging platforms will bring the power of document imaging to more users throughout the decade.
- The focus of providing software solutions to paper storage and retrieval problems will make systems continually more useful.
- The increasingly popular client/server computing model is an ideal architecture for department-size imaging systems, the fastest-growing segment.
- Advances in enabling technologies, such as LAN, compression/decompression, work flow software, optical storage, optical character recognition, full-text retrieval, bar coding, and hand-print character recognition will move document imaging forward.
- Strategic alliances between business and technical document imaging vendors will produce systems capable of managing both small- and wide-format documents and drawings from a common database. The rise of multimedia computing will blend images as a common data element into all of the work that people do on computers by the end of the decade.

CAD/CAM/CAE

The worldwide CAD/CAM/CAE market will maintain consistent, steady growth over the next five years at a CAGR of 12.9 percent. Please refer to Table 6 for further information.

The market will be driven by the following factors:

- CAD/CAM/CAE systems will continue to give buyers a competitive edge. As time-to-market requirements shrink, demand for design automation tools will also increase.
- Market demand will be limited by vendors' inability to fully meet the demand for integrated systems; no vendor will completely solve the systems integration puzzle. Successful vendors will need to invest in systems integration, ensuring that hardware and software work together.
- Incremental progress in delivering open systems and standards to this market will also constrain market demand. When more open systems arrive on the market, the value of CAD tools to many users will become more pronounced. Standards will fuel growth in this market and also encourage third-party software suppliers to enter the market.
- The "late majority" for CAD/CAM/CAE will be coming to the market over the next five years, driving additional growth. However, conservative buyers will favor market leaders. These conservative buyers are the late majority buyers who do not buy until the weight of the majority seems to legitimize the product. Therefore, for vendors, the value of having high market share as well as financial clout will increase.

Computer Storage

Worldwide computer storage factory revenue grew to $21.1 billion during 1990, representing an increase of nearly 18 percent. The market grew more than expected, primarily as a result of increased demand for 3.5-inch rigid disk drives. Rigid disk drive revenue grew to 80 percent of total computer storage revenue during 1990. Within the rigid disk drive market, 3.5-inch drives dominated last year and are expected to continue to do so throughout the forecast period.

New technologies being developed in the computer storage industry will enable the computer equipment manufacturers to incorporate four to five times the storage capacity in their 1995 models, compared with their 1990 models. Dataquest expects this increased storage capacity to be available at nearly the same cost as in 1990.

Dataquest's forecast for the computer storage market is for a 5.6 percent CAGR through 1995 (see Table 7). Rigid disk drive revenue grew to 80 percent of total computer storage revenue during 1990 and is expected to remain at that level. The flexible disk drive and tape drive portions of the market are expected to decline slowly in the years ahead as the optical disk drive portion increases.

Display Terminals

Worldwide display terminal unit shipments grew by 3.3 percent in 1990. However, a sharp decrease in shipments of the relatively expensive IBM 3270-compatible terminals, coupled with the declining prices in the ASCII/ANSI/PC segment, resulted in a 10.5 percent decrease in factory revenue for the display terminal market.

During 1990, growth in the microprocessor-based UNIX and DOS multiuser systems and

Table 6
CAD/CAM/CAE Market Forecast by Region (Factory Revenue in Millions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	5,003	5,378	8,276	10.6
Europe	4,893	5,616	9,199	13.5
Japan	3,573	4,240	6,681	13.9
Asia/Pacific-ROW	563	709	1,535	23.7
Total Worldwide	14,031	15,943	25,692	12.9

Source: Dataquest (July 1991)

Table 7
Computer Storage Market Forecast by Region (Factory Revenue in Billions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	11.0	11.4	12.4	2.6
Europe	4.8	5.4	6.7	6.9
Japan	3.5	4.1	5.8	10.3
Asia/Pacific-ROW	1.8	2.1	2.9	9.6
Total Worldwide	21.1	23.0	27.8	5.6

Source: Dataquest (July 1991)

data communications networks markets created an 8.0 percent increase in demand for ASCII/ANSI/PC display terminals. Expansion of the IBM AS/400 market resulted in a 17 percent increase in IBM 5250-compatible display terminal unit shipments.

Dataquest forecasts the worldwide display terminal market to grow at a CAGR of 0.3 percent, remaining at its steady $4.6 billion level (see Table 8). However, there will be significant changes within the display terminal market. It is expected that ASCII/ANSI/PC terminals will dominate the market by 1995, while IBM 5250-compatible display terminals are expected to maintain their current portion of the market at the expense of the IBM 3270-compatible and asynchronous/synchronous markets.

Electronic Printers

During 1990, North American factory revenue grew by less than 1 percent for the electronic printer market. Unit shipments were less than Dataquest had expected, especially in the higher-value (price per unit) page and line printer segments. Fewer than anticipated unit shipments and accelerated price decreases contributed to the slow revenue growth.

Unit shipments grew by 8.5 percent during 1990. Serial printer unit shipments were up only slightly from 1989, and line printer shipments actually decreased nearly 20 percent. Page printers continued to be dominant components of the printer market, with unit shipment growth of nearly 70 percent during 1990.

Dataquest's forecast for the North American electronic printer market is a 5.6 percent CAGR through 1995 (see Table 9). Page printers currently represent about 25 percent of the market in both unit shipments and revenue. By 1995, the page printer portion is expected to grow to nearly 40 and 60 percent, respectively, of the total unit and revenue market.

The use of color is gaining market acceptance. Printing speeds and quality continue to increase, and more and more businesses are using electronic printers and desktop publishing. Growth rates of total printing capabilities will be in double digits during the forecast period.

In the past, the standalone PC dominated the electronic printer growth path. Now, the electronic printer market profile is changing. In the years ahead, work group clusters, LANs, and file servers/networks will enable rapid growth in printing capabilities, utilizing high-end specialty printers. In addition, there will be increased demand for personal slower-speed (1- to 4-ppm) printers. In total, these networks will increase the overall ratio of PCs to electronic printers, thus contributing to slower market growth rates than what was experienced in the last half of the 1980s.

Table 8
Worldwide Display Terminal Market Forecast (Factory Revenue in Billions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
Total Worldwide	4.6	4.5	4.6	0.3

Source: Dataquest (July 1991)

Table 9
North American Electronic Printer Market Forecast (Factory Revenue in Billions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
North America	6.2	6.8	8.2	5.6

Source: Dataquest (July 1991)

Table 10
U.S. Plain Paper Copier Market Forecast
(End-User, Service, and Rental Revenue in Billions of Dollars)

	1990	1991	1995	CAGR (%) 1990-1995
United States	14.6	15.1	15.2	0.8

Source: Dataquest (July 1991)

Plain Paper Copiers

During 1990, revenue increased by 6.2 percent, while placements (new and rental units) grew by 3.3 percent. Rental revenue grew by more than 10 percent, which pushed total revenue slightly above our previous projections.

Competition in this market remains intense, as manufacturers try to maintain or improve their market share. Dataquest forecasts a number of dramatic changes to this mature market. At the very high end of the copier spectrum, light lens copiers are being supplanted by machines with digital front ends, which eventually will be networked as output devices for demand publishing operations. At the lower end of the copier market, we expect a continuing healthy personal copier market as distribution through nontraditional copier channels improves.

Dataquest forecasts the U.S. plain paper copier market to grow at a CAGR of 0.8 percent (see Table 10). Dataquest believes that the percentage of total pages printed is gradually being shifted away from the traditional copier market into that of the desktop laser printers. This trend is expected to continue and will contribute to many new changes in the copier marketplace as manufacturers try to differentiate their products' performance and reliability.

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 9 **July 22, 1991**

0010955

Regional Pricing Update

DQ Monday Report Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.20	0.16	NA	0.13	0.18	0.13
74AC138	0.34	0.31	NA	0.18	0.37	0.21
74AC244	0.50	0.42	NA	0.25	0.58	0.34
74AC74	0.26	0.23	NA	0.13	0.24	0.17
Lead Time (Weeks)	2	3	NA	4	5	5
74F00	0.11	0.11	NA	0.09	0.10	0.10
74F138	0.17	0.17	NA	0.15	0.21	0.14
74F244	0.24	0.25	NA	0.22	0.36	0.23
74F74	0.12	0.12	NA	0.10	0.13	0.11
Lead Time (Weeks)	2	3	NA	6	5	5
7805-TO92	0.13	0.18	0.11	0.15	0.14	0.10
CODEC/Filter 1	1.68	NA	NA	NA	2.15	1.35
CODEC/Filter 2	NA	NA	NA	NA	NA	NA
Lead Time (Weeks)						
DRAM 1Mbx1-8	4.30	4.15	4.40	4.63	5.05	4.20
DRAM 1Mbx9-8	41.00	49.36	39.00	43.00	49.00	42.00
DRAM 256Kx1-8	1.80	1.65	1.75	1.30	1.55	1.20
DRAM 256Kx4-8	4.33	4.26	4.40	5.00	5.05	4.20
DRAM 4Mbx1-8	16.75	17.71	17.60	19.75	21.00	17.00
EPROM 1Mb, 170ns	3.98	4.65	4.10	5.50	4.00	3.80
EPROM 2Mb, 170ns	8.30	9.66	9.00	NA	7.75	NA
SRAM 1Mb, 128Kx8	16.13	16.10	14.00	NA	18.50	NA
SRAM 256K, 32Kx8	4.18	4.04	4.00	NA	5.50	3.30
SRAM 64K, 8Kx8	1.83	1.51	1.65	NA	1.50	1.20
Lead Time (Weeks)	4	4	4	4	7	3
68020-16	36.50	46.14	NA	44.50	49.50	NA
80286-16	13.50	13.95	15.00	8.90	12.80	13.80
80386DX-25	159.00	171.67	170.00	NA	NA	NA
0386SX-16	54.00	63.30	55.00	64.00	64.00	56.05
R3000-25	130.00	146.64	NA	NA	NA	NA
Lead Time (Weeks)	4	6	NA	NA	NA	NA

NA = Not available
Source: Dataquest (July 1991)

Market Analysis

July Market Watch: Summer Is Here and the Market Is Sleepy

The *Market Watch* is a monthly Dataquest report that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

The Book-to-Bill Slips Again . . . But 1.01 Fits the Seasonal Norm

The decline of the June book-to-bill ratio from 1.04 to 1.01 reflects the shipment of increased orders placed in April combined with the quarter-end shipment scenario (see Figure 1). June billings are up 11.2 percent over May but are down 0.3 percent from the last quarter-ending month, March. The three-month moving average booking activity in June was an even 2 percent below May 1991, and 2 percent above June 1990's level. On the quarterly billings front, the second quarter of 1991 was 3.3 percent above the first quarter of 1991 and 7.3 percent above the second-quarter 1990

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

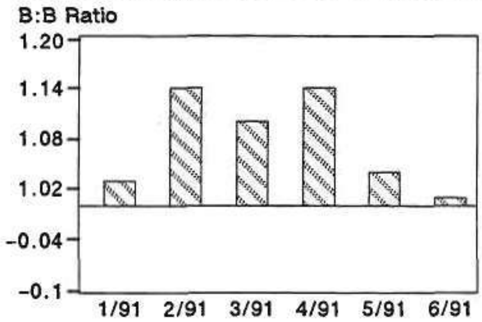


Figure 2
DOC Computer Demand

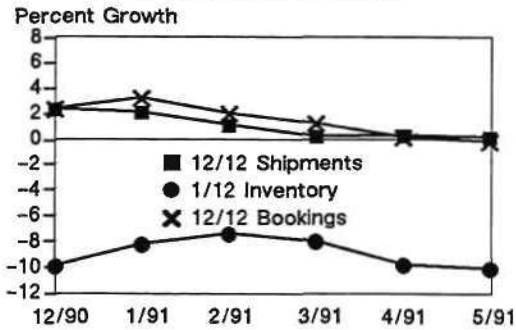


Figure 3
Semiconductor Inventory Level

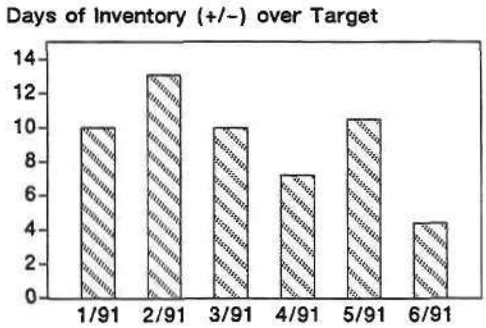
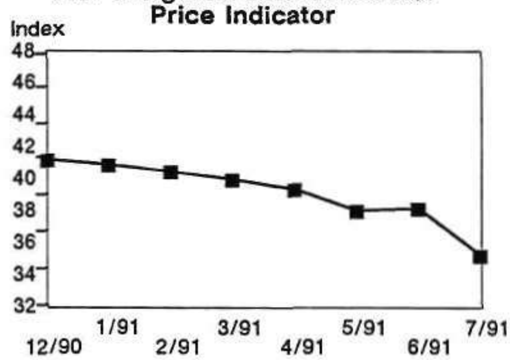


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (July 1991) figure. Billings as of June this year are 7.3 percent above the respective level seen last year. The billings bulge that began two months ago appears to be working its way on through the shipment pipe, and it should trail off by July. Because of good inventory control and slowly declining prices, orders for semiconductors should equate with system shipment rates, which, for the near term, are expected to be flat.

Computer Shipments, Bookings, and Inventory Rates All as Flat as the Market

Figure 2 illustrates how the rates of change of Department of Commerce (DOC) computer shipments and new orders for May are relatively unchanged from April. The May 1/12 inventory rate remains in the negative mode relative to last year, which continues to confirm that inventory control at the system level as well as at the semiconductor level is low and under control. Price pressure at the system level is keeping the dollar-based DOC statistics flatter than actual business activity warrants, as system unit shipments are only growing at slow growth rates. In the absence of any large-volume, high-growth electronic product to pull demand in the near term, Dataquest expects the current situation to continue.

Semiconductor Inventory Levels Plummet, Targets Remain the Same

According to this month's procurement survey respondents, the overall average actual-target inventory difference was reduced to under five (4.4) days. The overall actual inventory level fell to 24 days from the historical mean average of 30 days last month. Figure 3 highlights the trend of the overall reduction of target to actual semiconductor inventory levels over the past six months. This time frame roughly correlates when system pricing became a prominent tool in maintaining market share. System price reductions such as these highlight the continued need for cost control/reductions to preserve margins. Dataquest believes that the level of good inventory control seen over the past 18 months will further improve due to the increased visibility caused by market conditions.

After Brief Hiatus, Semiconductor Pricing Resumes Its Slide

The price index fell 7.5 percent relative to last month's unchanged aggregate level, primarily because of continued DRAM price reductions combined with EPROM, some SRAM, and microprocessor price cuts. The overall demand level for semiconductors is beginning to accurately reflect system sales levels, which currently range from flat to slightly positive in units. Flat unit sales, in conjunction with lower prices, continue to squeeze profits for semiconductor and systems companies alike. The absence of FMVs beginning in August will probably accelerate some price declines (i.e., 4Mb DRAM) at a faster rate than in the past. Dataquest continues to forecast gradual semiconductor price declines for the rest of the year with excellent availability as suppliers vie for supplemental business in the current market.

Dataquest Perspective

The current electronics market (read: no/slow growth) continues to dog the semiconductor industry that is more than able to deliver at increased levels. The resulting short lead times and low prices are being complemented by sagacious semiconductor suppliers that are providing above-par customer service and technical support. Slow markets tend to gloss over the importance of forecast accuracy. There is some concern of possible product shortages *if* demand *quickly* picks up because of low inventory levels. As mentioned many times before, because of the low inventory pad, change in system demand will abruptly translate into corresponding semiconductor demand. The probability of preventing future delivery problems hinges on forecasting accuracy and communicating significant shifts in demand in a timely manner. ■

By Mark Giudici

Procurement Roundtable Overview: Technology, Quality, and Supply Base Are Key Management Issues

Summary

Dataquest held its first Procurement Roundtable on May 30, 1991, at San Jose headquarters. The purpose of the meeting was to provide a candid exchange of ideas and updates on issues currently impacting semiconductor procurement. Procurement managers/professionals from Hewlett-Packard, Octel Communications, Quantum, and Wyse Technology provided an excellent consensus of what the current issues are and how they are expected to change over time. Concisely put, issues involving leading-edge technology and quality were the prerequisites that purchasing managers used in supply base management decisions. After those two needs were met, availability, on-time delivery, and price (in that order) were the key challenges now being faced. This article reviews how companies of different sizes are handling current market conditions and how other companies can benefit from their experiences.

Format

The agenda of the Roundtable was as follows:

- Update the 1991 issues facing procurement managers as seen in November 1990 with a current assessment
- Focus on topical challenges
- Discuss the implications of supply base management

1991 Procurement Issue Update

The top 10 issues expected to concern procurement managers in 1991, according to our annual procurement survey taken last November, are listed as follows:

- Pricing
- Availability
- Cost control
- JIT/inventory control
- Quality/reliability
- On-time delivery
- New products/obsolescence
- Government regulation
- Petroleum-based pricing issues
- Reducing vendor base

Have the issues changed or shifted? As can be seen, the focus of the top six issues was total cost control and methods to achieve it. Based on our recent discussion, the top requirement overriding all others was to have the latest proven technology available. Next in the ranking came quality and product availability, followed by price and on-time delivery. This reshuffling of top issues correlates with the current market and regional demands of the Roundtable participants. Although inventory control was not explicitly mentioned as a key issue, Dataquest's monthly survey noting historically low semiconductor inventory levels attests that this critical area is important.

Inventory control and on-time delivery remain critical issues and ones that companies will continue to improve.

It was interesting to note that the emphasis on issues differed by the size and age of company involved. The younger companies were more concerned with issues surrounding vendor selection and how supplier technology would directly affect their business. The older companies' emphasis was on the quality of product and how a supplier's technology edge, besides improving the end product, could be used to better negotiate with competing suppliers. It was generally agreed that no matter how good the technology or quality was, if the product was not available, all other issues were moot. Along those lines, the issue of price (number one in November 1990) was not as highly ranked by this small sample, primarily because of the current favorable price environment.

Near-Term Issues

Among the current issues facing the Roundtable participants, the overriding near-term problem was cost reduction and the means to achieve it. Some of the approaches taken tie in with the ranking of key overall issues, while some were company-specific. The main way that most of the companies are addressing cost reduction is to view cost as a pie made up of varying pieces such as quality, price, on-time delivery, inventory control, and forecasting. For example, the definition of on-time delivery ranged from +5 days to 0 days to schedule, to +3, 0 days, with many companies reaching for a +1, 0-day goal in 1992. By understanding that total cost is made up of more than one or two variables and that the individual parts of cost often impact each other, these companies are better dealing with market fluctuations and are prioritizing as necessary what piece of the pie requires more or less attention. As mentioned previously, technology and quality are currently taking priority as availability and inventory control are adequately being managed.

Supply Base Management

Supply base management, or the concept of reducing a company's vendor base via strategic alliances and/or suppliers adhering to proscribed procurement specifications, had as many variations as Roundtable participants. There was a consensus goal of having a select group of key suppliers that consistently met the procuring companies' needs. Depending on the user company's size and volume of business done with various suppliers, managing a supply base could involve balancing product mix with the total cost concept comparing the results with a corporate measurement/rating system of suppliers. Some of the participants were carefully managing their existing supplier list and not changing their number of suppliers, while others were consciously paring their list down according to a scale of exceeding, meeting, or not meeting publicly proscribed needs. Number 1 and 2 ranked suppliers are always being graded, while the third-category companies are removed from the supplier list. Companies with offshore manufacturing try to balance their supply base, being sensitive to regional issues as well as spreading risk. It is apparent that the goal of reducing one's supply base is laudable, but the method of doing so is dependent on where a company started with supplier relations and the size of the user company.

Dataquest Perspective

The shifting of issue priorities accurately reflects the current market conditions where differentiation via technology and quality are now being used increasingly in marketing products. Availability and price remain key issues, yet most participants have these areas under control. Inventory control and on-time delivery remain critical issues and ones that companies will continue to improve. In the current sluggish market, the flexibility of suppliers to meet the changing needs of semiconductor users by whatever yardstick the customer requires will greatly aid in future business when activity picks up. The representative Procurement Roundtable held at Dataquest highlights some of these shifted priorities and notes how suppliers can better serve the market. ■

By Mark Giudici

Product Analysis

System Price Cuts Augur a Midyear 1991 Downward Shift in IC Prices

Executive Summary

A recent wave of price reductions by PC, workstation, and other systems manufacturers is exerting downward pressure on IC prices in North America. For example, the results of Dataquest's second-quarter 1991 North American bookings price survey show clear signs of pricing pressure in the microprocessor arena (see Table 1). Another example shows that spot market pricing for 1Mb DRAM on *some* orders recently fell below the $4 level. With major users now crossing over to 4Mb DRAM, the semiconductor marketplace could be on the verge of another period of aggressive pricing.

This article focuses on prices for CISC/RISC microprocessors and DRAMs. A key goal is to examine the assumptions behind these price forecasts so that users can better understand and use Dataquest's price information.

Please note that the price analysis presented here correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement service (SPS) clients on June 13, 1991. The survey information was collected by Dataquest's Research Operations (Primary Research) team. For SPS clients that use the SPS on-line service, the prices presented here correlate with the quarterly and long-range price tables dated June 1991 in the SPS on-line service. The price tables are available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: Third Quarter 1991." For additional product coverage and more detailed product specifications, please refer to those sources.

Microprocessor Trends

As an indication of current system design trends, many Dataquest clients have inquired recently about the price outlook for yet-to-be-introduced RISC devices such as the R4000. Users can expect samples of the 50-MHz R4000 during the second half of 1991 in the price range of $660 to $725. The key point: RISC

Table 1
Estimated Semiconductor Price and Lead-Time Trends
(North American Bookings, Volume Orders)

	1991 Price Trend (Dollars)			
Part	Estimated Second-Quarter Price Range	Forecast for Third Quarter	Estimated Fourth-Quarter Price Range	Lead Times
AM386—40-MHz CPGA	231.00	218.00	203.00	3 weeks
80486—25-MHz CPGA	585.00 to 588.00	445.00*	408.00 to 429.00	6 to 8 weeks
68030—16-MHz PQFP	NA	100.00	90.00	5 to 9 weeks
1Mbx1 DRAM 80ns, DIP/SOJ	4.27 to 4.80	4.49	4.24 to 4.60	1 to 20 weeks
4Mbx1 DRAM 80ns, SOJ 300 mil	17.05 to 20.00	16.00	14.00 to 17.25	2 to 12 weeks

NA = Not available
*Just after publication of the SPS forecast dated June 1991, Intel announced a third-quarter 1991 price of $445 for this device and also the 33-MHz 80486 in 1,000-unit volumes.
Source: Dataquest (July 1991)

processors represent a viable long-term alternative to CISC MPUs sole-sourced by Intel and Motorola.

Intel and Motorola are not standing still. For example, as of the writing of this article, Intel had announced a third quarter 1991 price of $445 for the 25-MHz 80486 MPU in 1,000-unit volumes. Figure 1 shows that the North American bookings price for 25-MHz 80486 in volumes of less than 5,000 pieces should decline to a price of $425 or lower for the fourth quarter of 1991. Users can expect a similar price movement for 33-MHz 80486. Lead times for these 80486 devices remain manageable in the range of 6 to 8 weeks.

Assumptions Behind the 80486 Price Forecast

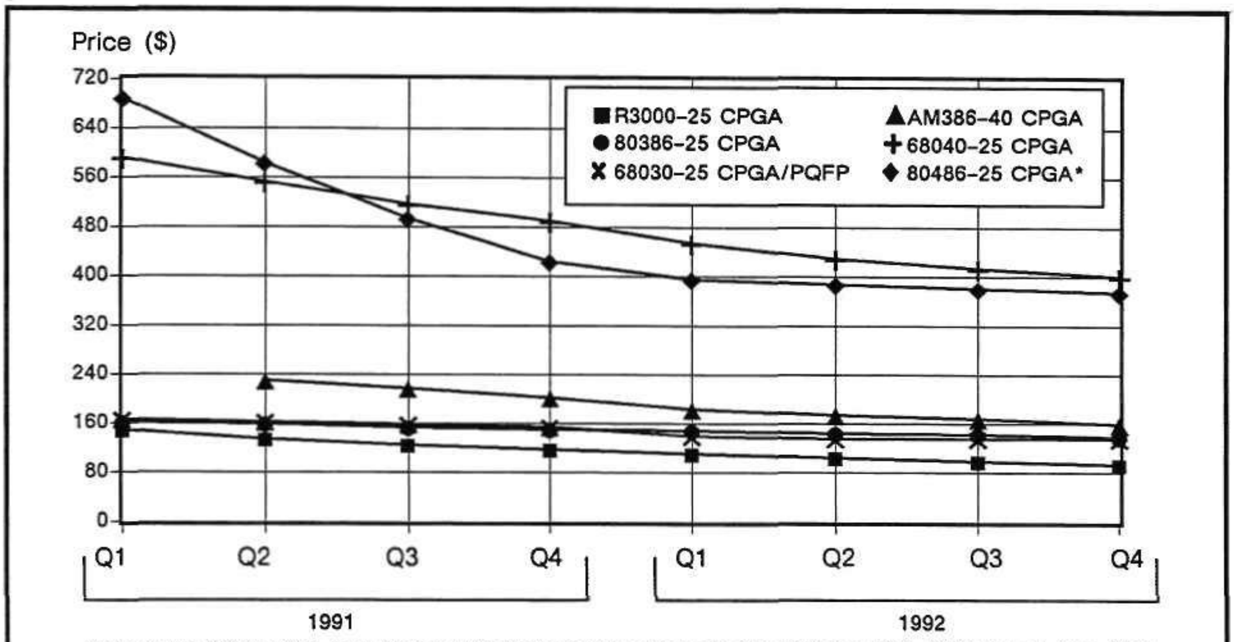
A multiple set of assumptions guide Dataquest's 1991 to 1995 price forecast for Intel MPUs such as the 80486 (see SUIS Research Newsletter 1991-07, entitled "Users' Long-Range Price Outlook—80X86s versus AMX86s versus 680X0s versus RISC Processors"). Users should note that these assumptions are interconnected. In some cases, the assumptions appear inconsistent—which signals a challenge for Intel in terms of achieving its product pricing objectives and for users that must forecast demand and pricing.

Assumption 1: Best to Be Synchronized with Intel Product Migration Plans

A central assumption behind all Intel MPU price forecasts continues to be that Intel will most favorably support users that coordinate system life cycles in line with Intel's product migration schedule. The other side of this truism is procurement headaches for users that are not synchronized with Intel's plans.

In the the newsletter cited previously, Dataquest predicted that "during the second half of 1991 and over the long term, users that shift from the 25-MHz 80386 MPU to higher-performance devices such as the 33-MHz 80386 or the 80486 can expect sharper declines in pricing for these higher-priced ICs." Subsequently, Intel declared 1992 to be the "year of the 80486"—a clear signal that users should migrate during the second half of 1991 to 80486 devices. The current break in pricing for 25-MHz 80486 and 33-MHz 80486, in part, reflects Intel's current effort to migrate users to the 80486.

Figure 1
Microprocessor Price Trends
(North American Bookings; Volume 1,000-5,000)



Note: This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
*Just after publication of the SPS forecast dated June 1991, Intel announced a third-quarter 1991 price of $445 for this device and also 33-MHz 80486 in 1,000-unit volumes.

Source: Dataquest (July 1991)

Assumption 2: New and Shifting Rules of the MPU Game

Dataquest is not stating that life will become easier for users of Intel MPUs. In fact, a second assumption behind the price forecast for the 80486 means a more challenging future for users. As noted in the newsletter cited previously, Dataquest has assumed and continues to assume that Intel, which holds monopoly power, will set new and shifting rules as users move to the 80486 and its likely successor, the 80586. Intel's product/pricing strategy will no longer be based on straightforward premium charges for higher-speed versions of any given MPU. Instead, as shown by Intel's recent introduction of the 20-MHz 80486SX IC, which to date is really the 80486 part with the FPU disabled, Intel plans to vary its MPU architectural mix to tailor it to users' needs regarding MPU price/performance trade-off.

Assumption 3: Impervious to Pricing Competition?

A third assumption behind the 80486 price forecast could change and perhaps is changing at midyear 1991. As stated in the newsletter cited previously, Dataquest has assumed that Intel—through its monopoly on supply of the 80486s—would become *more* impervious to external price competition (e.g., 68040, AM386) than had been the case with prior MPUs such as the 80286 and 80386SX. Dataquest still anticipates that over the long term, Intel will fiercely ignore, to the best of its ability, competitors' pricing for similar products. Current developments such as the nascent investigation by the U.S. Federal Trade Commission (FTC), however, *might* cause Intel to retreat from this strategy, which would mean a sharper long-term downward trend in prices for 80486 MPU users.

Assumption 4: No Intel Price War against the AM386

The third assumption is linked directly to this assumption. As noted previously, Dataquest assumed that there would be little effect during the first half of 1991 from AMD's 40-MHz AM386 device on prices for Intel's 80386 or 80486 devices. The AM386, in part, motivated Intel to rush its 20-MHz 80486SX and 80487 devices to market. As shown in Table 1, AMD intends to lower prices on the 40-MHz AM386 at a sharp rate in order to draw Intel into an AM386/80386-80486 pricing battle as in the earlier 80286/80386SX war.

Dataquest still does *not* assume that Intel will engage in a price war with AMD. Nevertheless, the AM386 device, along with other market factors, has had *some* impact on Intel's MPU product/pricing strategy. In the earlier newsletter, Dataquest predicted that Intel would respond to the AM386 by accelerating the shift of users from the 80386 family to the 80486 family or RISC processors. One result? Violà! Intel's pell-mell introduction of the 80486SX and 80487SX ICs! Intel's recent declaration of 1992 as the year of the 80486 and the associated current break in prices for the 25-MHz 80486 and 33-MHz 80486 devices also reflect, in part, a response to the AM386.

A Fear of RISC IC Competition?

In terms of the current or long-term downward trend in prices for the 80486 devices, another factor—increased competition from RISC ICs—is likely to outweigh Intel's more widely publicized concern about AM386 devices. For example, during the first half of 1991, Intel announced lower prices for some versions of its 80860 RISC processor. This device has not yet won a stellar foothold for Intel in the RISC arena.

By contrast, as shown in Figure 1, the MIPS R3000 architecture has firmly established itself as a viable and price-competitive RISC architecture, which is available from multiple sources, creating significant market excitement about the next-generation R4000 product and for the Advanced Computing Environment initiative. Dataquest's price forecast on the 80486 products does not yet assume that Intel will aggressively compete on price against multisourced RISC ICs, but the growing market penetration of RISC could eventually force Intel into a more aggressive *long-term* pricing strategy for the 80486 (e.g., 50-MHz 80486) or the 80586 lines of products.

The 80386/80386SX Spot Market

At the time that this article was written, Dataquest received some reports of aggressive spot market prices for 80386 and 80386SX MPUs. Intel increased production of these parts over the first half of 1991 but found slower demand than anticipated. In terms of short-term purchasing tactics, users that play on this spot market should realize that Intel is likely to decrease output during the second half of this year, which could cause an upward rebound in prices.

Regarding medium-term strategy (as noted above), users that try to buck Intel's migration path to the 80486 are likely to experience constrained supply/rising prices during 1992 for most 80386 and 80386SX MPUs. Again, Intel will do everything within its corporate power to avoid being drawn into a price war with AMD.

Motorola Not Standing Still

Hidden on Table 1 is a sign that Motorola will continue to evolve with the marketplace. The price forecast for Motorola's 16-MHz 68030 device now specifies a plastic quad flat pack (PQFP) that aims for personal computer applications. Prior forecasts specified a more costly ceramic pin grid array (CPGA) that targeted the workstation market. Motorola also continues to emphasize its newer line of lower-priced 68020/68030 processors designed for embedded control applications. (For the assumptions behind pricing for Motorola devices such as the 68020, 68030, and 68040, see the SUIS newsletter cited previously.)

Memory Trends

All is not quiet on the memory front—especially the ever-volatile DRAM arena. In a related memory market, under guidance from Japan's Ministry of International Trade and Industry (MITI), Japan-based suppliers of slow SRAM in densities of 256K and below and fast SRAM in densities of 64K and below have become resistant to future declines in price. Prices for 1Mb slow SRAM and 256K/1Mb fast SRAM—which are moving through the growth stage of the life cycle—continue to decline at a sharp rate in line with prior expectations.

SRAM lead times now stretch widely—from 2 weeks to 18 weeks or allocation. Lead times for most other memory products remain manageable with several long-side extensions for some users of 1Mb DRAM, 1Mb VRAM, 2Mb EPROM, and 2Mb Flash memory (12 volts).

Megabit-Density DRAM

Figure 2 graphically shows that the North American market crossed over to 4Mb DRAM during the second quarter crossover (4:1 unit/price ratio). Some suppliers of 4Mb DRAM are disgruntled so far with slow market demand for this device. User demand remains cautious given the current North American environment of economic uncertainty.

As shown in Table 1 and Figure 2, large-volume contract buyers in North America can expect a slight decline in prices for 1Mbx1 DRAM 80ns (DIP/SOJ) during the third quarter of 1991. In North America, the large-volume bookings price for the 1Mb DRAM should reach the average level of $4.45 to $4.50 during the third quarter of 1991 versus a price of $4.60 for the second quarter. For the fourth quarter, Dataquest foresees a price of $4.39 *or lower.*

Lead times for 1Mb DRAM range from 1 to 20 weeks with the extended lead times stemming from first-tier 4Mb DRAM suppliers that are moving away from production of the 1Mb part. As shown by the wide range of lead times, the 1Mb DRAM business remains volatile, with spot market pricing activity sending some signals of more aggressive 1Mb DRAM prices than currently projected.

Table 1 and Figure 2 both indicate that the large-volume price for 4Mb DRAM 80ns SOJ (300 mil) should decrease from $17.51 during the second quarter of 1991 to $16.00 for the third quarter. Looking to the fourth quarter of this year, Dataquest expects a price of just under $15.00.

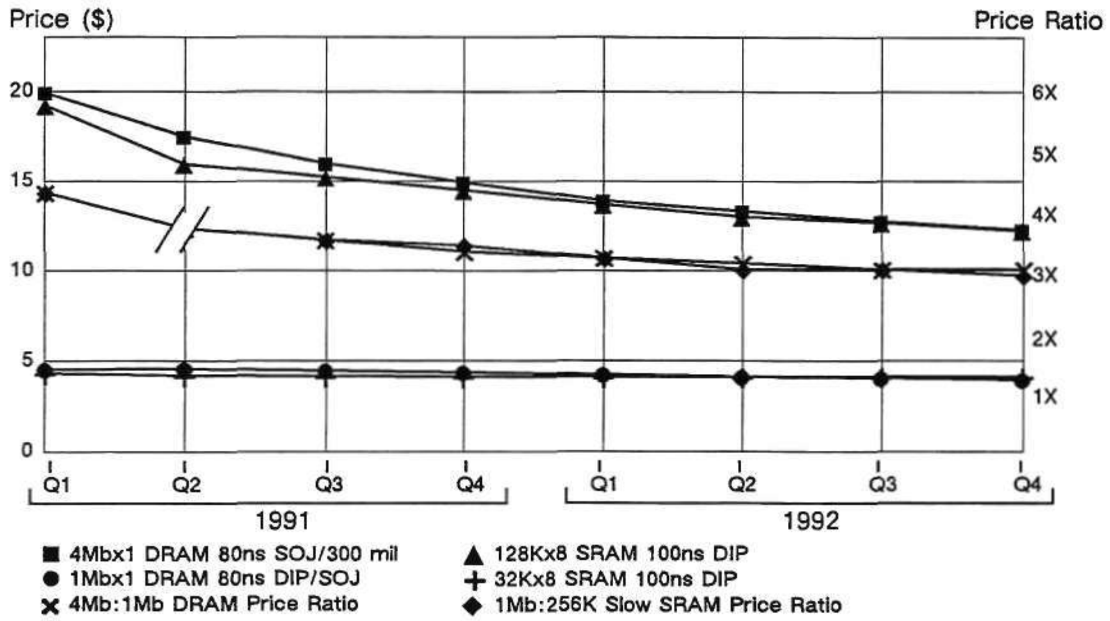
The Range of DRAM Prices

Although survey confidentiality limits disclosure of exact price points, the ranges of pricing from the May to June survey shown in Table 1 reflect the dynamics behind Dataquest's forecast. For example, Dataquest, in part, bases the second-quarter 1991 price of $4.60 for the 1Mbx1 DRAM on actual second-quarter 1991 North American bookings prices that ranged from $4.27 to $4.80. Users should note that price quotes of $5 or higher for 1Mb DRAM no longer appear, but reports of sub-$4 pricing do. Regarding 4Mbx1 DRAM, the second-quarter 1991 price estimate of $17.51 is based on actual prices during the second quarter that ranged from $17.05 to $20.00.

A Third-Quarter Break in 1Mb DRAM Prices?

Dataquest asked this question last quarter, and recent spot market price activity—with prices for 1Mb DRAM temporarily falling below $4 for

Figure 2
4Mb DRAM and Slow DRAM Crossovers
(North American Bookings; Contract Volume*)



Note: Line break shows 4X crossover point. This information coordinates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
*Contract volume = at least 100,000 per order for DRAM, 50,000 per order for slow SRAM

Source: Dataquest (July 1991)

some orders before rebounding upward—indicates that the issue remains unresolved. For Dataquest to achieve one of its most difficult objectives—calling a market break before it occurs—it is best to assess the assumptions behind the megabit-density DRAM price forecast. This process will provide insight on the factors that could lead to what appears to be a "sudden" price break.

The Four Assumptions behind the Megabit-Density DRAM Price Forecasts

As with the 80486 price forecast, a multiple set of interconnected assumptions guide Dataquest's 1991 to 1995 price forecast for 1Mb DRAMs and 4Mb DRAMS (see SUIS *Research Newsletter* 1991-09, entitled "North American Megabit-Density DRAM Price Outlook: Today (1991), Tomorrow (1993), and The Distant Future (1995)"). As noted in this newsletter, the following critical assumptions guide the SPS megabit-density DRAM price forecast for North America.

Assumption 1: More than Adequate DRAM Capacity

Dataquest has assumed that global DRAM capacity exceeds and will continue to exceed market DRAM demand during the first half of this decade. For analysis supporting this assumption, see the Semiconductor Procurement *Dataquest Perspective* Volume 1, Number 1, article entitled "Merchant DRAM Suppliers: Another Shakeout Coming?"). In that article, it was ". . .emphasized that this large DRAM capacity has to be utilized for oversupply to occur. In the short term, DRAM producers could very well choose not to use their full-production capacity. This happened in fall 1990 when Japanese producers announced cutbacks in production of 1Mb DRAMs."

As noted regarding 20-week lead times for some 1Mb DRAM users, Japanese producers continue to throttle back 1Mb DRAM production. Nevertheless, Dataquest stands by the assumption of more-than-adequate 1Mb DRAM capacity now and in the future. The role of non-Japanese suppliers becomes critical in the 1Mb DRAM scenario.

Assumption 2: The Demise of FMVs by Now

In the North American DRAM price outlook newsletter, Dataquest stated its assumption that the foreign market value (FMV) system of pricing will either terminate during mid-1991 or be replaced by a pricing system that ensures low-priced DRAM for North American users. The FMVs—as projected by Dataquest—recently died.

Assumption 3: Continued DRAM Cost-Based Price Reductions

In the same DRAM pricing newsletter, Dataquest assumed—and continues to assume—that cost-based price reductions will ensure lower prices for 4Mb DRAM and also competitive prices for 1Mb devices. For example, a 1Mb DRAM cost model developed by SPS and SEMMS analysts reveals that suppliers will be able to profitably manufacture this device at prices as low as $3.40 in 1993 and $3.20 in 1995. Micron Technology has announced a 1Mb DRAM die-shrink that has translated into cost-based price reductions for some 1Mb DRAM users. Dataquest stands by the original assumption.

Assumption 4: Non-Japanese Suppliers Will Go for 1Mb DRAM Market Share

The fourth assumption is the most critical, especially the *timing* for it to occur. In line with history, Dataquest assumes that non-Japanese suppliers will continue to lower megabit-density DRAM prices to take market share as leading-edge Japan-based suppliers migrate to next-generation products. At the end of 1990, Dataquest made this assumption, which was controverted at the beginning of 1991 when these non-Japanese suppliers went for 1Mb DRAM profits and not market share. We stand by this assumption. Conservatively, we expect the trend to occur after 1991, but pent-up market forces indicate that some suppliers already are on the verge of accepting narrower 1Mb DRAM profit margins in exchange for added revenue.

Market Conditions for the Second Half of 1991

As indicated, DRAM market conditions are changing at midyear 1991, becoming more of a buyer's market and less of a seller's market. For first-tier Japanese suppliers, the ramp to 4Mb DRAM this year is occurring but at a somewhat slower rate than preferred. Suppliers from the newly industrializing countries must do something with their 1Mb DRAM capacity during 1991. Although other non-Japanese 1Mb DRAM suppliers have not broken the supplier "rank" in terms of more aggressive pricing, some suppliers have recently unloaded 1Mb DRAM at sub-$4 prices on the spot market. The likelihood that 1Mb DRAM prices will take a step-function down in the third or fourth quarter of 1991 is *greater* now than last quarter.

The 4Mb DRAM bookings price forecast presented in Table 1 and Figure 2—which shows the second quarter 1991 price of $17.51 declining to $14.95 by the fourth quarter—is a bit higher but otherwise consistent with our original expectations. Lead times, which still run 2 to 10 weeks, reinforce this outlook.

Dataquest Perspective

The results of Dataquest's most recent quarterly survey of semiconductor users and suppliers, along with recent market events, signal an opportunity for users in North America to demand more aggressive pricing. The current market outlook remains uncertain; however, systems manufacturers have been forced to sharply cut prices on PCs, workstations, and other products. Under this condition, procurement teams will be under great pressure to contain and cut costs during the second half of 1991. Continuing soft demand for MPUs and megabit-density DRAM mean an opportunity for users to negotiate lower IC prices.

The assumptions behind Dataquest's booking price forecast for 80486 MPUs and 1Mb/4Mb DRAM indicate why IC prices could take a sharp turn downward at midyear 1991. Users that migrate in synchronization with Intel's product migration plan, which declares 1991 as the year of the 80486, will be rewarded through sharper declines in prices and manageable lead times. Users that buck Intel's plans will experience the painful allocation/high pricing scenario. Users of the 80386/80386SX ICs might enjoy a buyer's market for the next several months; however, Intel is quite likely to quickly adjust worldwide production schedules. Constrained supply of 80386/80386SXs later this year is not unlikely.

The assumptions behind the North American price forecast for megabit-density DRAM also signal the reasons why 1Mb DRAM prices might take a step-function downward this quarter. Soft demand for 1Mb DRAM, in face of more than adequate capacity, declining manufacturing costs, a wide supplier base, and a freer North American pricing environment, set the stage for suppliers to break rank by cutting prices in order to preserve the customer/revenue base.

Dataquest Recommendation

Dataquest's recommendation is succinct: with systems manufacturers under tremendous price pressure, users must aggressively negotiate in order to convert some of the recent IC sellers' markets into buyers' markets during the second half of this year. ■

By Ronald Bohn

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective*:

- August *Procurement Pulse*
- European procurement issues update
- Semiconductor market forecast update

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 8 **July 11, 1991**

Regional Pricing Upate

DQ Monday Report Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.11	0.11	0.09	0.13
74HC138	0.14	0.15	0.15	0.17	0.15	0.21
74HC244	0.21	0.30	0.22	0.23	0.21	0.34
74HC74	0.12	0.12	0.13	0.11	0.10	0.17
Lead Time (Weeks)	4	3	4	5	5	5
339-Com	0.13	0.15	0.12	0.13	0.11	0.13
741-Op Amp	0.13	0.23	0.11	0.13	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.09	0.08	0.07	0.10
74LS138	0.15	0.12	0.15	0.13	0.12	0.14
74LS244	0.21	0.24	0.22	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.10	0.10	0.11
Lead Time (Weeks)	4	3	6	4	5	5
DRAM 1Mbx1-10	4.40	4.32	4.70	4.50	4.60	5.00
DRAM 256Kx1-10	1.60	1.61	1.80	1.30	1.40	1.45
DRAM 256Kx4-10	4.43	4.42	4.70	5.00	4.60	5.00
DRAM 4Mbx1-8	17.83	18.19	19.30	19.75	20.60	NA
DRAM 64Kx4-10	1.65	1.64	2.00	1.70	1.50	1.45
EPROM 1Mb, 200ns	4.58	5.07	4.50	5.50	5.20	4.20
EPROM 256K, 200ns	1.88	1.96	1.80	1.75	1.65	1.55
SRAM 1Mb, 128Kx8	16.50	16.05	14.00	NA	NA	NA
SRAM 256K, 32Kx8	4.20	4.03	4.00	4.95	4.90	4.55
SRAM 64K, 8Kx8	1.70	1.50	1.65	1.23	1.40	1.45
Lead Time (Weeks)	6	4	4	2	7	3
68000 12 MHz	5.10	4.46	5.30	4.15	3.10	4.00
68HC11	8.40	6.78	8.00	8.75	8.60	NA
80286 12 MHz	6.50	13.20	7.25	9.00	9.70	6.80
80386SX-16	56.00	53.50	53.00	64.50	65.00	57.00
8051	1.65	1.98	1.80	2.50	1.80	1.80
Lead Time (Weeks)	6	4	4	3	4	6

NA = Not available
Source: Dataquest (July 1991)

Market Analysis

July Procurement Pulse: Inventories Under Control While Orders, Lead Times Inch Up

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Expectations for Semiconductor Orders and System Sales Rise

Figure 1 illustrates that the general order level of semiconductors for this month's respondents has increased slightly (positive 11.1 percent) over last month, indicating a continuation of the slow growth trend of semiconductor sales. The respondent's overall six-month outlook for system sales has risen to 9 percent from 7.6 percent, again confirming the gradual positive trend of the electronics industry. The computer subset of this month's sample expects to see a more aggressive 10 percent six-month growth rate, which is up from last month's adjusted 9.2 percent positive forecast. From a revenue standpoint, most of our respondents expect to meet or approximate target levels. The challenge for most companies is to meet profit goals in an increasingly price-sensitive market.

Figure 1
Averaged Monthly Semiconductor Orders

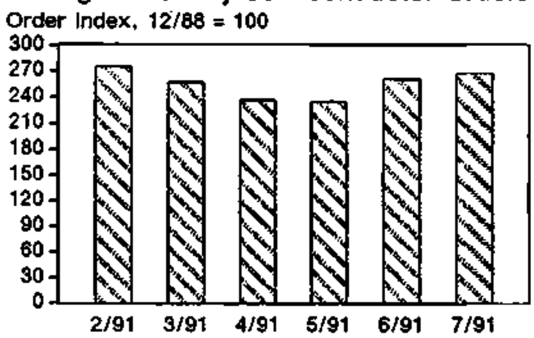


Figure 2
Averaged Semiconductor Lead Times

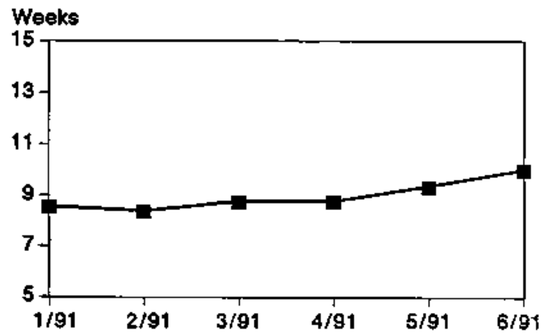


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

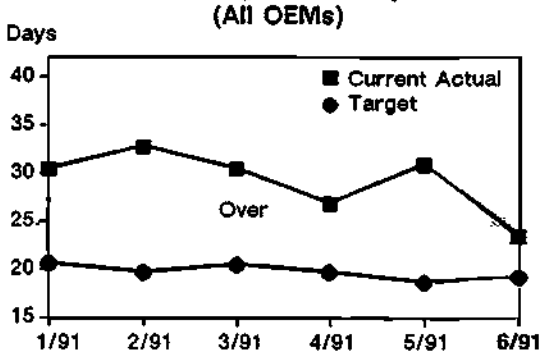
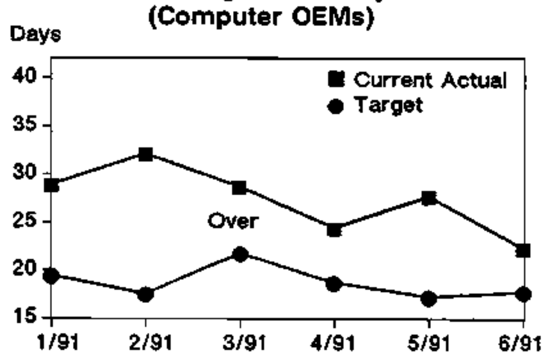


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (July 1991)

Dataquest expects semiconductor price competition to continue at a slightly faster rate than our respondents' current negative 2.1 percent for the rest of the year as FMVs disappear and end-use demand remains flat.

Average Lead Times Rise Less Than a Week—Not a Big Deal

The overall average lead time for semiconductor delivery rose to 10.1 weeks from last month's corrected lead time of 9.4 weeks and continues to remain at the midpoint of the 8- to 12-week range of reported lead times. Figure 2 illustrates that this incremental rise is not significant but reiterates the current balance of overall semiconductor supply with demand. As expected, there have been very few reports of delivery problems for SMT standard logic since last month's report due to the adjusted increase in supply. End-of-life buys and quality remain noted issues for this month's respondents. These issues continue to require good communication for resolution. Coplanarity of high-lead-count plastic quad flat pak (PQFP) packaging is another concern that came up in the survey as well as from an independent inquiry this month. Continual improvements in communication, be it in forecasting, specification correlation, or procedural updates is the common thread of timely problem resolution. Proactive supplier support is becoming more of a differentiator in the current market environment.

Semiconductor Inventories Corrected Again

As seen in Figures 3 and 4, the semiconductor inventory seesaw has dipped again. The reduction in overall actual inventory levels dropped from the adjusted 30 days seen last month to a current 23.6 days, while the target inventory levels stayed at a relatively flat 19.5 and 19.3 days, respectively. The computer company respondents' actual inventories declined from 28.1 to 22.4 days, while the targeted levels also slipped to a respective 18.4 to 17.8 days. Inventory control and availability remain excellent and no foreseen externality is expected to change this trend in the near term. Dataquest expects to see continued scrutiny put upon inventory levels, and, related with inventories, on-time delivery requirements also will be tightened.

Dataquest Perspective

Inventory control and semiconductor availability continue to be well managed. The issues relating to quality and the phasing out of obsolete components still remain with some users. The overall trend for slow system sales and moderate semiconductor orders combined with a focus on cost control paints a fairly bright picture for the near term. As the overall economy improves and demand increases, the need for accurate and timely forecasts and revisions will become paramount. Dataquest expects to see this trend continue for the rest of the year with capacity now in place (and planned for future production) keeping system companies well supplied for the foreseeable future.

By Mark Giudici

U.S. Merchant Semiconductor Capital Spending Highlights: 1990-1991

Dataquest recently completed its survey of U.S. merchant semiconductor manufacturers' capital expenditures and plans for 1990 and 1991. This article highlights the major features of those plans and expenditures.

The U.S. merchant semiconductor companies responding to this survey represent 78 percent of U.S. semiconductor merchant revenue. Their plans indicate that U.S. merchant, company-funded, semiconductor capital spending will increase 3 percent in 1991 over 1990 (see Table 1). However, when Texas Instruments' (TI's) joint-venture expenditures (TI/Acer, TI/Kobe, and TI/Singapore) are added, total (company funded and TI's joint ventures) U.S. merchant semiconductor capital spending will increase by 15 percent in 1991 over 1990.

U.S. Merchant Semiconductor Capital Spending: 1990-1991

Advanced Micro Devices (AMD) is planning to spend approximately $150 million in 1991, down from $275 million in 1990. The company's Submicron Development Center (SDC) fab was completed in Santa Clara, California, in 1990. The SDC is both a production fab and development fab and is one of the most advanced fabs in the world. AMD's 1991 spending will be down because of the completion of this major project. The company's efforts in 1991 will be directed toward ramping up capacity for its 80386 microprocessor in Austin,

Table 1
U.S. Merchant Semiconductor Capital Spending
(Millions of Dollars)

Company	1989	1990	1991	Percent Change 1990-1991
AMD	159	275	150	-4
Analog Devices	44	38	53	41
AT&T	150	100	170	70
Cypress	40	36	60	67
General Instrument	20	NA	NA	
Harris	68	74	70	-5
IDT	57	48	34	-29
Intel	380	550	900	64
LSI Logic	115	71	100	41
Micron Technology	230	107	100	-7
Motorola	540	550	640	16
National Semiconductor	200	146	140	-4
TI	641	707	460	-35
Vitelic	36	35	20	-43
VLSI Technology	50	55	55	0
Western Digital		106	40	-62
Others	416	330	326	-1
Company-Funded Total	3,145	3,228	3,318	3
Percent Change	15	3	3	
TI Joint Ventures		150	550	267
Percent Change		NA	267	
Total	3,145	3,378	3,868	15
Percent Change	15	7	15	

NA = Not available
Source: Dataquest (July 1991)

Texas. It is possible that AMD will build a new fab in two years.

Analog Devices recently acquired Precison Monolithics and is in the process of consolidating its manufacturing operations. As part of its consolidation process, the company recently closed its Greensboro, North Carolina, fab.

AT&T's capital budget has been low in recent years as the company struggled with reorganization. Its Orlando, Florida, fab originally was underutilized, but in the last two years it has been the site of significant foundry activity for AT&T. It has been rumored that the Orlando facility has been short of capacity and late on some semiconductor deliveries recently. We expect AT&T to continue to ramp production at its fab in Spain and add new capacity at its Allentown, Pennsylvania, and Orlando fabs.

Cypress Semiconductor recently acquired Control Data Corporation's fab in Bloomington, Minnesota, for $13.7 million. This fab is one of the few fabs in the world that is fully equipped with standard mechanical interface (SMIF) technology. In addition to its Minnesota fab and its fab in San Jose, California, Cypress also has a fab in Roundrock, Texas, that it shares with Altera Semiconductor. Under this agreement, Altera paid Cypress $7.4 million and manufacturing rights for Altera's Multiple Array matriX (MAX); in return, Altera gains access to a certain portion of the fab's capacity.

Harris is reorganizing its semiconductor operations. It has announced that it is delaying plans to construct a new fab and assembly and test facility in Plymouth, England.

IDT is ramping up its new Technology Development Center fab in San Jose. This fab is a 26,000-square-foot Class 1 facility that is both a development and production fab. It currently has a capacity of 5,000 6-inch wafers per month.

In a year of general and nagging economic recession and uncertainty, the expansion of U.S. merchant capital spending and capacity is significant.

Intel has the most aggressive capital spending plan ($900 million) of any company in the semiconductor industry. Its *increase* alone of $350 million in 1991 capital spending exceeds the 1991 capital budgets of all U.S. merchant companies except Motorola and Texas Instruments.

Intel is upgrading its D2 development line in Santa Clara from 6- to 8-inch wafers. The company is building a new 8-inch fab MPU development line in Aloha, Oregon, and is also building its first European fab (also an 8-inch fab) in Leixlip, Ireland. The company plans to begin production at fab 9.2 in Albuquerque, New Mexico, by mid-1991 and is continuing to add equipment to fab 9.1 in Albuquerque and to its fab in Israel.

LSI Logic has transferred high-volume ASIC production from its facility near London to its fabs in Tsukuba, Japan, and San Jose. LSI plans to manufacture low-volume analog/digital devices at its fab near London in the United Kingdom. LSI is currently spending $150 million to build an additional fab in Tsukuba. This fab is planned to be ready for equipment by this October.

In the first quarter of 1991, Micron Technology completed the conversion of Fab I/II from 5- to 6-inch wafers. Micron has no major plans for expansion this year. It continues to add capacity through shrinking its die size. For example, by shrinking the die for its 1Mb DRAM, Micron claims to have increased its 1Mb capacity by 100 percent.

Motorola completed MOS 11 at its new facility in Oak Hill, Texas, in 1990 and will run first silicon in May. This 8-inch fab is the industry's first for non-DRAM products. Motorola is also adding capacity for 1Mb DRAMs at its East Kilbride, Scotland, facility and building a new bipolar developmental and production line in Chandler, Arizona.

National Semiconductor recently sold Matsushita the Puyallup, Washington, BiCMOS fab that it acquired when it bought Fairchild Semiconductor. National is transferring processes that were formerly run at its Puyallup fab to its Santa Clara fab. The company plans no significant capacity additions in 1991.

TI's company-funded capital spending plans are down significantly in 1991 because the company recently completed adding significant new capacity to its Avezzano, Italy, facility and its joint-venture facility (TI/Acer) in Hsin-chu, Taiwan. However, the company continues to vigorously upgrade its existing facilities and add capacity through noncompany-funded joint ventures such as KTI, the joint venture between Kobe Steel and TI in Japan.

TI recently announced that it will build a $330 million joint-venture DRAM fab in Singapore with the Singapore Development Agency (SDA), Canon, and Hewlett-Packard (HP). TI and SDA will each own 26 percent of the new company, and Canon and HP will each own 24 percent. Construction of the new fab will begin by this summer, and production is expected by the middle of 1993.

By adding capacity now, U.S. merchant semiconductor manufacturers are moving beyond the tactical and are looking forward to the next expansion.

Vitelic broke ground for a new fab in Hsin-chu in late 1989, but stopped construction in late 1990 because of weak demand for its products. It is currently discussing a merger with Hualon Semiconductor, a Taiwanese company. Our estimate for Vitelic's 1991 spending level is based on the assumption that these discussions will result in a merger. Vitelic also bought a fab in Hong Kong from El Cap in 1989 to use as a pilot line and as a means to penetrate the People's Republic of China.

VLSI expanded and upgraded its San Jose fab in 1990 and plans to continue to facilitize its new San Antonio, Texas, fab in 1991.

Western Digital produced first silicon at its new submicron fab in Irvine, California, in March 1991. Manufacturing at this facility will be primarily for the production of engineering prototypes and production volumes aimed at facilitizing early market penetration. Total cost of the facility and equipment was just under $120 million.

Dataquest Perspective

In a year of general and nagging economic recession and uncertainty, the expansion of U.S. merchant capital spending and capacity is significant. AT&T, Cypress, Intel, LSI Logic, and Motorola are increasing their spending plans and adding significant capacity now. Of the eight U.S. merchant semiconductor manufacturers that reported a decline in capital spending, five have recently completed significant state-of-the-art capacity additions. One of these companies, TI, is still adding significant new capacity through its noncompany-funded joint ventures.

With all the new capacity currently being added and recently having been added by U.S. merchant semiconductor manufacturers, the claim can no longer be made that U.S. merchant capital spending is cut back during a downturn or a period of business uncertainty. With the inclusion of TI's noncompany-funded joint ventures, total U.S. merchant semiconductor capital spending will increase 15 percent in 1991.

By adding capacity now, U.S. merchant semiconductor manufacturers are moving beyond the tactical and are looking forward to the next expansion. U.S. merchant capital spending is strategic in nature, at least for this business cycle. ■

By George Burns

(This article is reprinted with the permission of Dataquest's Semiconductor Equipment, Manufacturing, and Materials industry service.)

Technology Analysis

TAB: Serious at Last

Introduction

At recent technical conferences highlighting packaging issues—notably, the Third International TAB Symposium (ITAB) and NEPCON West '91—findings indicate that tape automated bonding (TAB) use is increasing in many applications. For example, in 1990, approximately 40 percent of all worldwide TAB was used in liquid crystal display applications, with another 20 percent found in smart and memory cards. Thus, it is no surprise to find that Japan is the TAB leader, with approximately 70 percent of the world's use. Sharp is the largest volume user of TAB, followed by Matsushita, Casio, and Hitachi.

Europe is second in TAB use, with TAB used primarily for smart cards and watches and secondarily for automotive and telecommunications applications. The United States lags behind. Hewlett-Packard (HP) is the largest U.S. user of TAB in calculators and printheads. Other users include Digital Equipment Corporation and IBM for computers and Motorola and Texas Instruments for application-specific integrated circuits.

TAB Issues and Developments

In addition to the increasing use of TAB, other developments involve TAB technology, materials, and equipment.

Key TAB issues include the following:

- Die design versus tape availability
- Bonding method versus equipment
- Bump formation versus bondability
- Testability versus repairability

Increasing TAB Use

Analysts have been saying for many years that TAB was about to explode as the next technology in interconnects. But always it was just around the corner. Well, the "corner" is finally here, but not for the reasons originally predicted. TAB is not the low-cost solution for all integrated circuit packaging. It is, we are finding out, becoming the preferred solution for the high-lead-count, bond-pad limited die—especially those found in multichip modules (MCMs). Today and in the near future, it will be used in MCMs because of TAB's inherent handling and performance benefits.

Connecting a die to TAB tape allows testing and burn-in characteristics that might be impossible with traditional packaging technologies such as wire-bonding, molded packages, and chip-on-board. Placing a large number of bare, untested die on an MCM substrate (such as would be the case with wire bonding) worries many an engineer. One questionable or bad die can result in a giant headache of rework and expense. However, pretested TAB chips minimize rework and increase yields.

In addition, the nature of the TAB interconnect allows elimination of one level of interconnect. The shorter connection routes increase signal-transmission speed resulting from the lower inductance, capacitance, and resistance. TAB then becomes a beneficial interconnect method for high-speed applications such as those required by multichip modules.

MCMs require higher I/Os on finer pitch. TAB has the ability to connect closely spaced bond pads. Analysts at MCC in Austin, Texas, have concluded that if the cost of additional silicon area needed for wire bonding is factored in the total cost of an MCM, the cost per I/O could favor TAB at higher pin counts. Advanced Packaging Systems (APS) of San Jose, California, has found that module costs can vary depending on the number of chips per module. This can be seen in Table 1. A 4-chip MCM is less costly using wire bonding, while a 12-chip MCM is less expensive using TAB.

Although the number of suppliers seems to have leveled at the moment, the technological innovations have not.

The number of manufacturers of TAB tape has reached a plateau. Japan leads the way with the most companies producing tape, outdistancing the European and U.S. suppliers (see Table 2).

Although the number of suppliers seems to have leveled at the moment, the technological innovations have not. Recent advances have been made in TAB tape. Nippon Mining has developed a new rolled-copper process for three-layer tape. The copper is modified with 300 ppm of indium, which gives improved strength and heat resistance and limits anisotropic conditions normally found in conventional rolled-copper tape (tensile strength versus elongation problems). This rolled-copper tape also results in better electrical characteristics and higher resolution compared to electrodeposited (ED) copper. Tape dimensions as small as 60µ pitch with 25µ lines have been made.

The use of specialized multimetal tape continues to increase.

Shifting focus from small to large, Casio has developed a low-cost TAB process for manufacturing calculators. Based on 158mm (yes, about 6 inches wide!) tape, chips are simultaneously processed using multiple placement heads. One could almost liken this to pseudo reel-to-reel flex circuit material.

The use of specialized multimetal tape continues to increase. 3M, Olin, Rogers, Shindo, and Sumitomo Metal are among those offering two-metal layer TAB tape with a ground plane for controlling impedance and reducing cross-talk. Additionally, Rogers has developed three-metal layer tape, with this third layer used as a power plane. This arrangement limits noise associated with simultaneous switching because the power-supply inductance can be reduced.

Materials

In recent times, tape materials have been dominated by the use of high-performance Upilex polyimide. However, Du Pont Company has developed two new polyimide films, Kapton E and K, to compete with the Upilex. In addition, Casio has developed tape based upon polyester (PET) for low-cost applications. Micro connectors, also from Casio, use anisotropic conductive particles (hollow plastic spheres plated with nickel and gold, mixed with smaller, insulative particles) that conduct only when pressure is applied, breaking the insulation and forming electrical contact.

Table 1
MCM Pricing: TAB versus Wirebond

	4-Chip/Wirebond	4-Chip/TAB	12-Chip/Wirebond	12-Chip/TAB
Number of ICs	4	4	12	12
IC yield (%)	95	-	85	-
IC yield after TAB/test (%)	NA	99	NA	99
1st pass yield (%)	81	96	14	89
Rework 1 site (%)	16	4	32	11
Rework 2 sites (%)	2	-	27	-
Rework 3 sites (%)	-	-	16	-
Rework 4 sites (%)	-	-	7	-
Rework 5 sites (%)	-	-	3	-
Rework scrap rate	10	10	10	10
IC cost ($)	600	640	885	975
HDI substrate cost ($)	55	55	125	125
Assembly cost ($)	30	30	77	77
Rework mat. cost/site ($)	150	160	74	81
Rework cost/site ($)	165	175	93	100
Rework cost/module ($)	33	7	164	11
Rework cost, scrap ($)	16	4	107	15
Tooling cost, assembly ($)	-	80,000	-	120,000
Product life (years)	3	3	4	4
Annual volume	1,500	1,500	100,000	100,000
Module cost, unyielded ($)	685	725	1,087	1,177
Module cost, yielded ($)	733	735	1,358	1,202
Module cost, yielded, w/tooling ($)	733	753	1,358	1,203

NA = Not available
Note: Module pricing does not include the connector, discrete components, encapsulation, or a lid. These would be the same for the wirebond and the TAB cases, so this will not change the relative results. Electrical test costs were also not considered.
Assumptions:

- 4-chip = 2 @ 300 pins; 2 @ 70 pins = 740 wires
- 12-chip = 3 @ 300 pins, 9 @ 70 pins = 1,530 wires
- Connector used to attach HDI substrate to PWB
- WB/TAB assembly cost = $0.04/wire for 4-chip module and $0.05/wire for 12-chip case
- Tooling: 4-chip assumes 2 different TAB footprints with 2 custom trim/form tools and thermodes; 12-chip assumes 2 different TAB footprints with 3 sets of custom tooling

Source: APS/NEPCON West '91

Table 2
Worldwide Tape Manufacturers

Japan	Europe	United States
Shindo Denshi	MCTS	Olin/MOSA*
JIS	Cicorel	Cicorel USA
Nippon Mining	EM	Rogers
Casio		Dyna-Craft
Fuji Micro		Semiconductor Connection
Hitachi		Gould-Microbond
Ibiden		
Mitsui Mining		
Shinko		
Sumitomo Metal		
Nitto Denko		

*Up for sale as of June 1991
Source: Dataquest (July 1991)

Equipment

One of the biggest changes within the last year is in TAB equipment. Many companies have announced available production equipment for TAB (see Table 3). Laser bonding equipment is now a reality for both inner and outer lead bonding, with ESI (in conjunction with MCC), Hughes, SMH/Farco, and Panasonic leading the way. Single-point bonding equipment, previously dominated by U.S. manufacturers, is now available from the Japanese (Shinkawa and Kaijo Denki).

Table 3
TAB Equipment Manufacturers

Company	Location
Anorad	United States
Automated Tooling Systems	Canada
Disco	United States
ESI	United States
Hughes	United States
Cicorel USA, IMI	United States
Kaijo Denki	Japan
K & S	United States
Matsushita/Panasonic	Japan
Micro Robotic Systems	United States
Shibuya	Japan
Shinkawa	Japan
SMH/Farco	Switzerland
Toray	Japan
Universal Instruments	United States

Source: Dataquest (July 1991)

Technology

Many new technologies are in the R&D stage for TAB. Researchers at the University of Berlin have developed a process for bonding 20μ pitch bumps. HP has developed a "bumpless" bonding process. Toshiba has developed a microbump process (pseudo flip-chip) on 10μ pitch. Matsushita continues to promote its TB-TAB (transfer bump) process, in which bumps are plated on a conductive glass substrate and then transferred to planar TAB tape. This forms "bumped tape" via thermocompression bonding.

TAB use continues to expand in the United States, specifically with the advent of multichip modules.

Laser bonding is becoming more visible, due to its many advantages over traditional thermocompression gang-bonding and single-point thermosonic processes. Bond pad layout and pitch are not limited by tool size or pressure, only by laser-beam size. Changing from one die size to another is not hardware limited but software driven. Damage to the chip is minimized because the bond force is only a few grams. Reliability is increased because the die is subjected to minimal heat. Laser bonding provides the speed of gang bonding (65 bonds/sec.) coupled with the reliability of single-point bonding.

Repair

Repair is where TAB has a benefit over wire bonding, specifically due to MCMs. Because MCMs are too valuable to scrap, they must be reworked. In these high-density interconnect modules, bond pads and chips are very close together. For TAB devices that have been die-attached and soldered, MCC has developed a method to rework them without damaging the substrate or the die. Also, the flip-TAB method of attachment has become increasingly used because of its ease of repair and replacement.

Dataquest Perspective

The TAB infrastructure is finally in place. TAB use continues to expand in the United States, specifically with the advent of multichip modules. Dataquest believes that LCD applications for TAB will continue to dominate volume use until they are replaced by less expensive methods such as conductive adhesives (chip-on-glass). We expect laser bonding to become more prevalent as lead counts increase and pad pitches decrease. By 1991, TAB will be used in approximately 8 percent of all interconnects. Even contract assembly manufacturers must get into TAB as TAB's chip-on-board benefits continue to drive low-cost systems. ■

By Jim Walker

News and Views

IBM/Siemens Sign 16Mb DRAM Agreement

International Business Machines (IBM) and Siemens AG of Berlin and Munich have signed an agreement to manufacture 16Mb dynamic random access memory (DRAM) chips at IBM's Corbeil-Essonnes, France, facility. The companies expect to have samples by the end of 1991 and full production in the second half of 1992. The DRAMs will be manufactured on the latest, state-of-the-art manufacturing equipment operating on 200m (8-inch) wafers, and production will be based on the semiconductor process technology operating at Corbeil-Essonnes. The planned production volume is 600 wafer starts per day. The facility will be jointly staffed by IBM and Siemens specialists.

Dataquest Perspective

The new IBM/Siemens agreement makes strategic sense for these two large companies. IBM and Siemens share a history of working together on ROM products, a future in the agreement to design and development a 64Mb DRAM, and now, under this new agreement, a current relationship. Either company could do this on its own, and both have 16Mb designs and have been producing samples. IBM has long been in Europe, but it needs a strategic presence there--and what better way to accomplish this than with design at the component level? Siemens is the only major European DRAM producer. As risks and costs continually climb, Siemens needed to start looking for some company to share those risks and costs. Nor will IBM compete with Siemens on DRAM sales in the merchant market. Also, it is vital to the survival of the European semiconductor community to have a European DRAM producer, and this partnership guarantees that a DRAM producer will survive.

Under this new agreement, IBM is putting up the physical facility, the process technology, and initially the design. Siemens is putting up money and technology. The estimated financial investment is $500 million for equipment and R&D. As with the 4Mb DRAM that IBM licensed to Micron, it is not likely that the IBM design will enter the merchant market. The IBM design is more applicable to large mainframe computers. So, during production ramp-up, Siemens will be fitting its design to the IBM process.

IBM will use its share of the 16Mb DRAMs internally and will probably take all of those manufactured during the ramp-up period. By the second half of 1992, the Siemens design will be in place, and Siemens will offer its share of these DRAMs in the merchant marketplace. Dataquest believes that the 16Mb implementation is strategic to the success of these companies' 4Mb products. It is likely that the companies will use the 16Mb technology to drive improvements in the 4Mb products so that when the crossover occurs, it will be nearly transparent.

This agreement is much more than a capacity-sharing agreement. It is technology sharing, design sharing, and cooperative manufacturing. This is the trend that Dataquest identified more than two years ago as being necessary to manage the huge expense required to continually develop DRAM technology. ■

By Marc Elliot

In Future Issues

The following topics will be featured in future issues of Semiconductor Procurement *Dataquest Perspective:*

- Third Quarter 1991 Semiconductor Update
- Procurement Managers' Roundtable Highlights
- July *Market Watch*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 7 June 21, 1991

Regional Pricing Update

Market Analysis

Product Analysis

News and Views

Regional Pricing Update

DQ Monday Report Volume Mean Pricing

Table 1
DQ Monday Report
Volume Mean Prices

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.11	0.11	0.09	0.13
74HC138	0.14	0.15	0.15	0.17	0.15	0.21
74HC244	0.21	0.30	0.22	0.23	0.21	0.34
74HC74	0.12	0.12	0.13	0.11	0.10	0.17
Lead Time (Weeks)	4	3	4	5	5	5
339-Com	0.14	0.15	0.12	0.13	0.11	0.13
741-Op Amp	0.13	0.23	0.11	0.13	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.09	0.08	0.07	0.10
74LS138	0.15	0.12	0.15	0.13	0.12	0.14
74LS244	0.21	0.24	0.22	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.10	0.10	0.11
Lead Time (Weeks)	4	2	6	4	5	5
DRAM 1Mbx1-10	4.40	4.45	4.70	4.50	4.60	5.00
DRAM 256Kx1-10	1.60	1.62	1.80	1.30	1.40	1.45
DRAM 256Kx4-10	4.45	4.56	4.70	5.00	4.60	5.00
DRAM 4Mbx1-8	18.13	19.01	19.50	19.75	20.60	NA
DRAM 64Kx4-10	1.60	1.65	2.00	1.70	1.50	1.45
EPROM 1Mb, 200ns	4.68	5.09	4.50	5.50	5.20	4.20
EPROM 256K, 200ns	1.83	1.98	1.70	1.75	1.65	1.55
SRAM 1Mb, 128Kx8	17.25	17.58	14.00	NA	NA	NA
SRAM 256K, 32Kx8	4.25	4.06	4.00	4.95	4.90	4.55
SRAM 64K, 8Kx8	1.65	1.51	1.65	1.23	1.40	1.45
Lead Time (Weeks)	6	4	4	2	7	3
68000 12 MHz	4.95	4.49	5.30	4.15	3.10	4.00
68HC11	8.40	7.36	8.00	8.75	8.60	NA
80286 12 MHz	6.50	13.99	7.30	9.00	9.70	6.80
80386SX-16	56.00	53.80	53.00	64.50	65.00	57.00
8051	1.65	2.01	1.80	2.50	1.80	1.80
Lead Time (Weeks)	6	4	4	3	4	6

NA = Not available
Source: Dataquest (June 1991)

Market Analysis

June Market Watch: Overall Business Flattens; Midterm Outlook Remains Positive

The *Market Watch* is a monthly Dataquest report that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Skidding to 1.04, the Book-to-Bill Ratio Reflects Flat Electronics Sales

The actual numbers supporting the decline of May's book-to-bill ratio of 1.04 from April's 1.15 (see Figure 1) mirror a static market that is very conscious of cost (read: inventory) control. In the aftermath of post-victory optimism, many buyers again are facing the balancing act of semiconductor inventories against a slow-growth electronics market. Any uptick in orders not

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

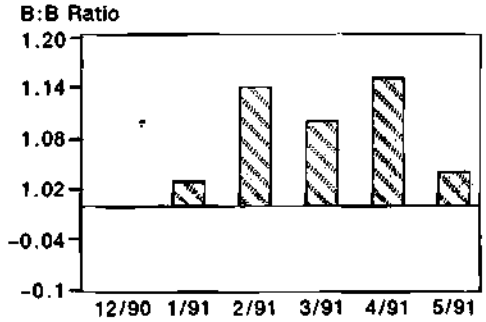


Figure 2
DOC Computer Demand

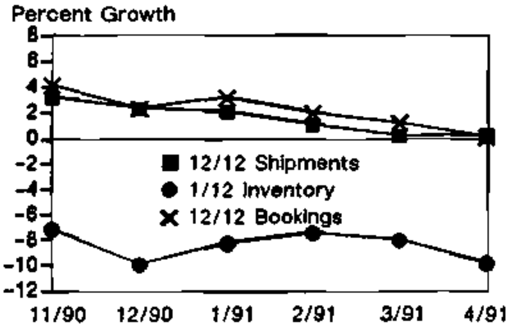


Figure 3
Semiconductor Inventory Level

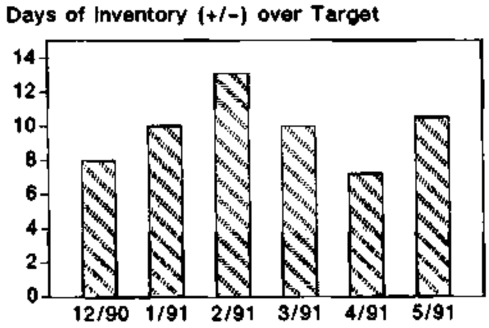
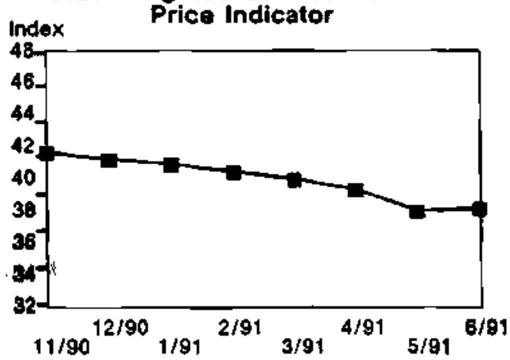


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (June 1991)

Source:

immediately tied to system sales has been quickly corrected through inventory control measures, and the record semiconductor bookings and billings seen in April are not an exception.

The flat/slow growth electronics market that we have been seeing for the past six months is now being reflected in the market statistics.

The question raised in last month's *Market Watch*, "How will the increase in orders (April) be absorbed by a flat systems market?" is being answered by managing inventory levels and curtailing orders where required. The May three-month moving-average bookings level was 6.9 percent less than April's corresponding level, while the May billings level was 8.2 percent higher than those seen in April. The higher billings level is primarily a function of previous orders making their way through the system, while order levels are back in sync with system demand. Once this order "bulge" works its way on through shipment, semiconductor order levels should equate to system shipment rates.

Computer Inventories Fall in Response to Flat Shipment and Order Rates

Figure 2 illustrates that both the shipment and order 12/12 rates of change have declined and are effectively flat with respective levels seen a year ago. Correspondingly, the inventory rate has declined, keeping inventory levels on par with business activity. The fact that the Department of Commerce data are listed in dollars masks what is shaping up to be a pricing war in the computer market. System unit shipments are generally growing at a moderate rate, while price pressure is forcing slower growth in revenue. This somewhat somber business picture is not without some positive attributes; semiconductor supplies are more than adequate to meet increases in demand, and low inventory levels (both system and semiconductor) will quickly translate into order activity when demand picks up.

Semiconductor Inventories Rise to Historical (Still Low) Levels

Our latest survey of procurement managers reflects a rise in semiconductor inventories to target goals, but the rise from a very low 27 days to 30 days still highlights good inventory control. Dataquest views this three-day average increase as a normal reaction to large order levels being delivered in a slow-to-flat electronics market. The May target/actual inventory delta of 10.5 days is up from April's 7.2 difference but is back to the 10-day overage seen in March. Average on-hand inventory levels of one month still reflect healthy business activity and, as mentioned before, consistent inventory control. Dataquest continues to expect inventory control to be a major factor in any turnaround in system and corresponding semiconductor growth.

Overall Prices Stay Flat; Availability Remains Excellent

The overall price index for this month reflects very little movement because of flat demand combined with a relatively balanced supply of parts. The DRAM area is where price pressure is most noticeable, but only among non-Japanese suppliers. The current low volume of aggressive DRAM pricing is not enough to move the overall index.

In the upcoming months, the absence of the FMV system will allow all suppliers to price according to market demand levels, which may influence overall pricing. Aside from DRAMs, prices for logic, microprocessor, and nonvolatile memory products remain very steady and in fine tune with current demand levels. For the near and midterm, Dataquest expects some slow price declines, while availability remains a nonissue.

Dataquest Perspective

The flat/slow growth electronics market that we have been seeing for the past six months is now being reflected in the market statistics. All of the indicators (except inventory days) are listed in dollars, which hides the fact that unit shipments are still chugging along, although at reduced prices. The outlook for a new, high-volume product(s) pulling demand upward is not on the foreseeable horizon, so current demand levels, combined with supply, will not pose an availability constraint. The accuracy of the forecast function combined with cost control measures is sustaining and will continue to sustain companies in the current environment.

By Mark Giudici

Five-Year Capital Spending Forecast: It's a Good World in Spite of 1991's Uncertainty

Summary

The year 1991 will be a year of uncertainty. Dataquest's forecast for worldwide spending on semiconductor property, plant, and equipment (PPE) calls for 11 percent growth (see Table 1). Barring a sustained worldwide recession, investment plans currently under way or about to be implemented will almost certainly be pushed back.

Although the passage through the first year of our five-year forecast contains hazards such as war and recession, we are optimistic about the five-year period as a whole. Demand for devices will continue to grow as clever engineers from around the world find new applications for ever more complex and sophisticated devices. Historically, semiconductor capital spending has doubled every five years. We believe that this doubling will continue. Capital spending will grow at a compound annual growth rate (CAGR) of 15 percent over the period from 1990 to 1995. We expect worldwide capital spending for PPE to reach $25 billion by 1995.

The regions of Europe and Asia/Pacific will continue to be the fastest-growing markets for capital spending, although Japan and the United States will continue to be the two largest markets for capital expenditure.

Although we are optimistic about the upcoming five-year period, we note that there is currently an excess of DRAM capacity and if recently announced DRAM capacity additions take place as planned, then an excess capacity situation will extend throughout our forecast period. This excess is a negative factor in the forecast and could both change individual companies' plans and slow down the growth rate of capital spending.

Regional Markets

The discussion that follows is about regional markets. Spending in these regions is defined to include spending by both domestic and foreign-based companies taking place within that region. Spending by domestic companies that takes place offshore is included within the region where it takes place. For example, spending by a U.S. company in Japan would be counted as spending within the Japanese

Table 1
Regional Capital Spending Forecast (Millions of Dollars)

	1989	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Capital Spending								
Japan	5,348	5,381	6,045	7,270	8,651	9,169	10,178	14
Percent Change	16	1	12	20	19	6	11	
United States	3,846	3,949	4,265	5,223	6,267	6,831	7,515	14
Percent Change	12	3	8	22	20	9	10	
Asia/Pacific	1,961	1,736	1,875	2,581	3,665	4,214	4,425	21
Percent Change	16	(11)	8	38	42	15	5	
Europe	1,141	1,313	1,575	1,989	2,466	2,811	3,233	20
Percent Change	22	15	20	26	24	14	15	
Worldwide	12,296	12,379	13,760	17,062	21,049	23,026	25,352	15
Percent Change	22	1	11	24	23	9	10	

Source: Dataquest (June 1991)

regional market and not as spending within the U.S. regional market.

Japan

Japan is the largest market for capital spending in the world. Total spending in Japan for PPE in 1990 was $5.4 billion, up 1 percent from 1989's level of $5.3 billion. Measured in dollars, these are record levels of spending. However, it should be pointed out that spending in the peak years of 1984 and 1985, measured in yen (¥924 billion and ¥794 billion, respectively), was higher than in 1989 and 1990 (¥754 billion and ¥767 billion, respectively).

Growth in spending in Japan will be fueled mainly by Japanese company spending, in both the near term and long term. This spending will be to maintain market share, as well as technological parity and technological leadership in device technology and manufacturing. In addition to defending their leadership position in commodity DRAMs, Japanese companies will continue to invest in ASIC and noncommodity DRAM markets such as application-specific DRAMs.

In evaluating the strength of the Japanese regional market, it is important to note that a growing percentage of Japanese company spending will take place outside of Japan, in the United States and Europe. As evidence of this, we note that in 1985 there was only one Japanese fab line operating outside of Japan. However, in 1990, we count 13 such fab lines, and we expect that there will be 27 fab lines operating outside of Japan by 1992.

This trend of Japanese companies building fabs outside of the Japanese region will slow down the long-term growth rate of spending in Japan. We expect capital spending in Japan to almost double by 1995 to $10.1 billion. The CAGR for the 1990 through 1995 period is expected to be 14 percent, which is less than the growth rate expected for the European and Asia/Pacific regions.

United States

The United States is the second largest regional market for capital spending in the world. Total spending in the United States for PPE in 1989 was $3.8 billion. In 1990, the market in the United States increased 3 percent to $3.9 billion. This spending increase was led by capital spending increases by major U.S. merchants and by the increasing presence of Japanese manufacturers in the United States. We estimate that spending by Japanese companies in the United States increased from more than $400 million in 1989 to more than $600 million in 1990.

Overall spending in the United States as a region was influenced negatively by the fact that a substantial portion of spending by companies such as IBM, LSI Logic, Motorola, National Semiconductor, and Texas Instruments was done outside of the United States. Cutbacks in spending by many of the second- and third-tier U.S. companies also brought down the 1990 growth rate for the U.S. region.

We expect capital spending in the United States to almost double by 1995 to $7.5 billion. The CAGR for the 1990 to 1995 period is expected to be 14 percent. One of the major reasons for this low growth rate is that U.S. companies will continue to spend a substantial portion of their capital expenditure offshore.

Asia/Pacific

Asia/Pacific includes the Pacific Rim countries, excluding Japan. The size of capital spending in Asia/Pacific exceeds that of capital spending in Europe. Capital spending in the Asia/Pacific region declined 11 percent from $1.9 billion in 1989 to $1.7 billion in 1990. This decline was due to cutbacks in spending by South Korean companies. Part of this decline was made up by an increase in spending in Taiwan. However, because South Korea is the largest market for capital investment in the Asia/Pacific region, the overall trend in 1990 will be down.

Dataquest expects fairly robust growth in spending in South Korea in 1991, spurred by additions of DRAM capacity and also by the recent commitment of South Korean companies to become major players in the ASIC markets.

Spending in Taiwan could be flat in 1991. This could be due to a rapid decline in the Taiwanese stock market (about NT$11,000 in the first quarter of 1990 to about NT$3,000 in the third quarter of 1990). Partly as a result of this crash, and also because of a general uncertainty about business conditions, Taiwanese semiconductor manufacturers are now delaying orders by a quarter or two.

We expect capital spending in the Asia/Pacific region to grow over the five-year forecast period at a CAGR of 21 percent and to reach $4.4 billion by 1995.

Europe

Spending in Europe by all companies increased by approximately 15 percent in 1990. This spending increase in Europe was fueled primarily by offshore companies from the United States and Japan building new fabs in Europe. We expect that capital spending will increase 20 percent in Europe in 1991, again primarily because of the increased activity of offshore manufacturers. Japanese companies will approximately double their spending in Europe in 1991 to about $800 million. Fujitsu, Hitachi, NEC, Mitsubishi, and perhaps Toshiba will have fabs or be building fabs in Europe by the end of 1991.

We expect capital spending to reach $3.2 billion by 1995 and to grow at a CAGR of 20 percent from 1990 to 1995. This growth will be fueled by the general economic growth that will be the result of the integration of the EC and the desire of major non-European manufacturers to have a fab line close to their customers and also adjacent to Eastern Europe.

Dataquest Perspective

In a year in which war and recession are the major topics of conversation, forecasters and businesses necessarily concentrate on the short run. The year 1991 could be one of moderate growth in capital spending, or it could be a year in which, because of war and recession, there is no growth. In the short run, semiconductor companies are planning to go ahead with their expansion plans as there was no major adverse effect from the Persian Gulf war. However, orders can be canceled and implementation of plans can be delayed. Our forecast for 1991 is for capital spending to increase by a modest 11 percent. This forecast is fringed with uncertainty.

In the long term, however, we do not see a future clouded with any more uncertainty than is usual. We expect semiconductor capital spending to continue to increase at healthy rates for the five-year period to 1995. This increase will be fueled by semiconductor companies buying equipment and building fab lines for half-micron fabs; by new entrants into the industry, such as the Taiwanese and South Koreans; and by the need for all large manufacturers to have a manufacturing presence in every region of the world.

(This article was reprinted with the permission of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service.)

By George Burns

Product Analysis

Semiconductor Technology Risks Threaten Systems Manufacturers

Executive Summary

From the halls of Motorola's new gallium arsenide (GaAs) IC fab in Austin, Texas, to the doors of government patent offices around the globe, trends in semiconductor technology—whether newly minted or recently obsolete—*must* be managed by systems manufacturers that plan to survive and prosper during the 1990s. This article provides the users' view on semiconductor technology life cycles as of June 1991 including BiCMOS, gallium arsenide, and Flash memory *and* techniques for managing IC technology risks.

Overview

This *Dataquest Perspective* article, the fourth in a series, provides procurement teams, component engineers, and other semiconductor users with practical and strategic information for choosing which product technologies to use and for which time period. This article focuses on the semiconductor technology life cycles and the cycle for microcontrollers, ROMs, EEPROMs, and Flash memory. (The report replaces the "Product Overview" section of the *Industry Trends* binder of the former Semiconductor User Information Service.) To date, *Dataquest Perspective* reports have been written during 1991 on microprocessors (Vol. 1, No. 3), EPROMS (Vol. 1, No. 4), and ASICs (Vol. 1, No. 5).

The life cycle of a device and of the equipment into which it is being designed should always be compared.

Along with the prior articles on semiconductor life cycle analysis, the information in this article enables users to develop a sound strategy for satisfying demand for semiconductors on a consistent, cost-conscious basis over the long term despite shifts in the market or among suppliers.

Future articles in this series will examine the life cycle/supplier base for key products such as DRAMs and SRAMs.

Typical Semiconductor Product Life Cycle

Figure 1 illustrates a typical IC life cycle. Semiconductors follow the traditional life cycle of manufactured products including electronic systems: development, introduction, growth, maturity, market saturation, decline, and phaseout.

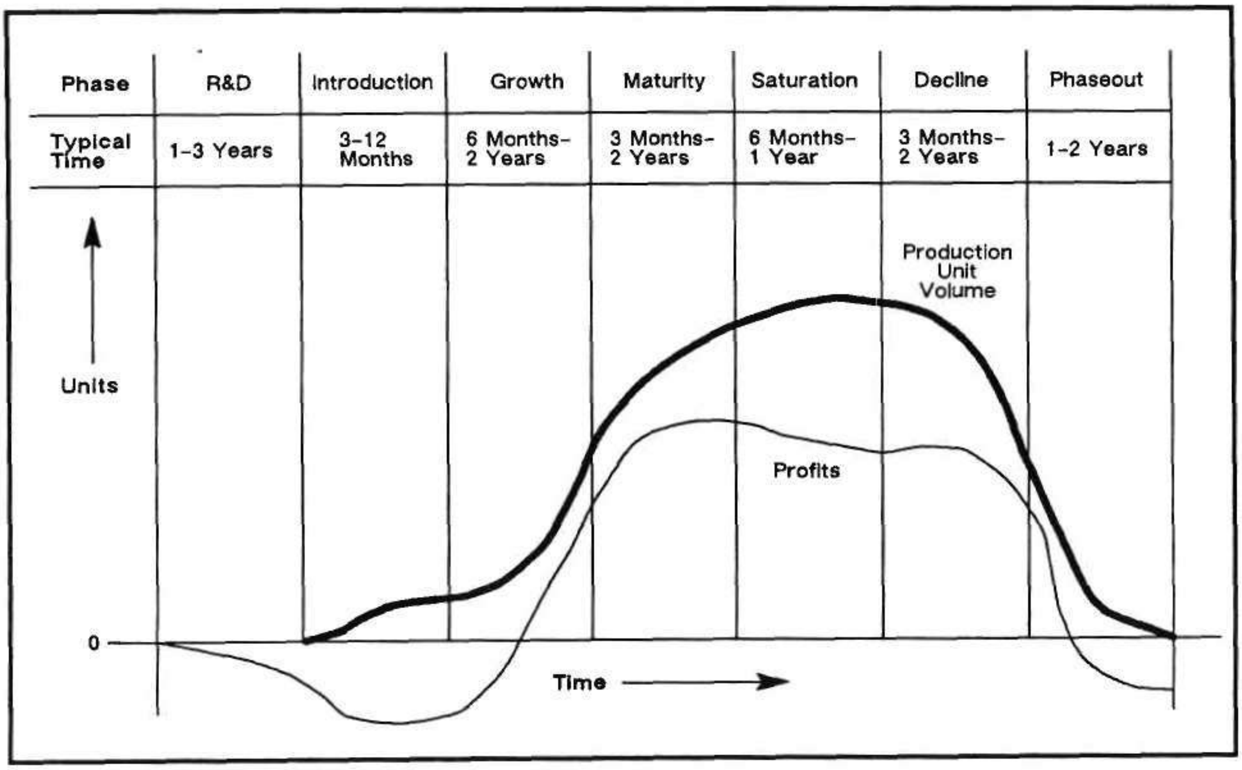
Suppliers Resist Forward Pricing

Because of the high cost of development, a semiconductor manufacturer in the past typically did not begin to realize profits from a device until well into the growth phase of the product's life. Manufacturers of leading-edge electronic equipment usually adopt the product in this phase of its life cycle. The pattern of low profitability during the early stages of the IC life cycle (see Figure 1) is known as "life cycle pricing" or "forward pricing." Given the high cost of constructing fabs, IC suppliers now tend to resist the forward-pricing practice.

Comparing Systems and Semiconductor Life Cycles

The life cycle of a device and of the equipment into which it is being designed should always be compared. Continued use of a device that is in the decline phase of its life cycle may eventually force the equipment manufacturer to pay a premium price for an obsolete

Figure 1
Typical Integrated Circuit Life Cycle



Source: Dataquest (June 1991)

product or make an expensive lifetime buy of that part. At the other end of the life cycle, the risks of designing in an untried product technology must be weighed against the ostensible technical advantages of the new device.

For example, some IC products become obsolete in only a few years, especially products such as semiconductor memory. This accelerated life cycle can adversely affect the market position of the semiconductor user's end product. The best protection against this risk is for the user to work with the supplier base to anticipate the next one or two generations of product evolution. This approach allows the next generation of semiconductor devices to be incorporated into the final product with minimal engineering changes. Succinctly, system life cycles, which can range from as short as one-half year in the case of consumer electronics, to as long as 50 years for certain industrial equipment, must be coordinated as closely as possible with semiconductor product life cycles. Some of the major factors that affect semiconductor life cycle length and timing are as follows:

- Technology changes
  - Device and circuit innovations, e.g., Flash memory, chip sets
  - Process evolution/decline, e.g., silicon gate CMOS, bipolar ECL
  - Innovative processes, e.g., BiCMOS, gallium arsenide (GaAs)
- Economic factors
  - Extreme pricing pressure on suppliers, e.g., 1Mb DRAM in 1990
  - Exchange rates, volatility of dollar against yen/deutsche mark
- Political and legal factors
  - U.S.-Japan Semiconductor Trade Arrangement revision during 1991
  - Deregulation in Europe
  - Reference prices in Europe
  - Legal action surrounding microprocessors, DRAM patents
- Manufacturing constraints
  - Phaseover to new production equipment, e.g., from 6- to 8-inch wafers
  - Advances or delays in availability of new test or production methods

Technology Life Cycles

Figure 2 depicts semiconductor technology life cycles.

For the various technologies, Figure 2 breaks each stage of the cycle into specific time intervals. As shown in Figure 2, Dataquest fully expects long life cycles for two technologies, CMOS silicon gate and bipolar ECL, which now are moving through the peak maturity/saturation stages of the cycle.

BiCMOS versus GaAs Technology

Analysis should focus on the opposite extremes of the curve—the introduction/growth stages and the decline/phaseout stages—because these stages typically generate greatest concern for supply base managers. Supply base managers should compare their long-term system migration path with this technology curve to guard against system-semiconductor technology mismatches over time.

> *Semiconductor technology has been and should continue to be a key factor in the long-term success—or failure—of global systems manufacturers.*

Figure 2 shows that the BiCMOS process technology now moves through the growth stage of the life cycle on its way to becoming one of the mainstream technologies of the 1990s. Users can design BiCMOS SRAMs, ASICs, and other ICs into systems with a firm expectation of solid support over the long term from a dependable supplier base.

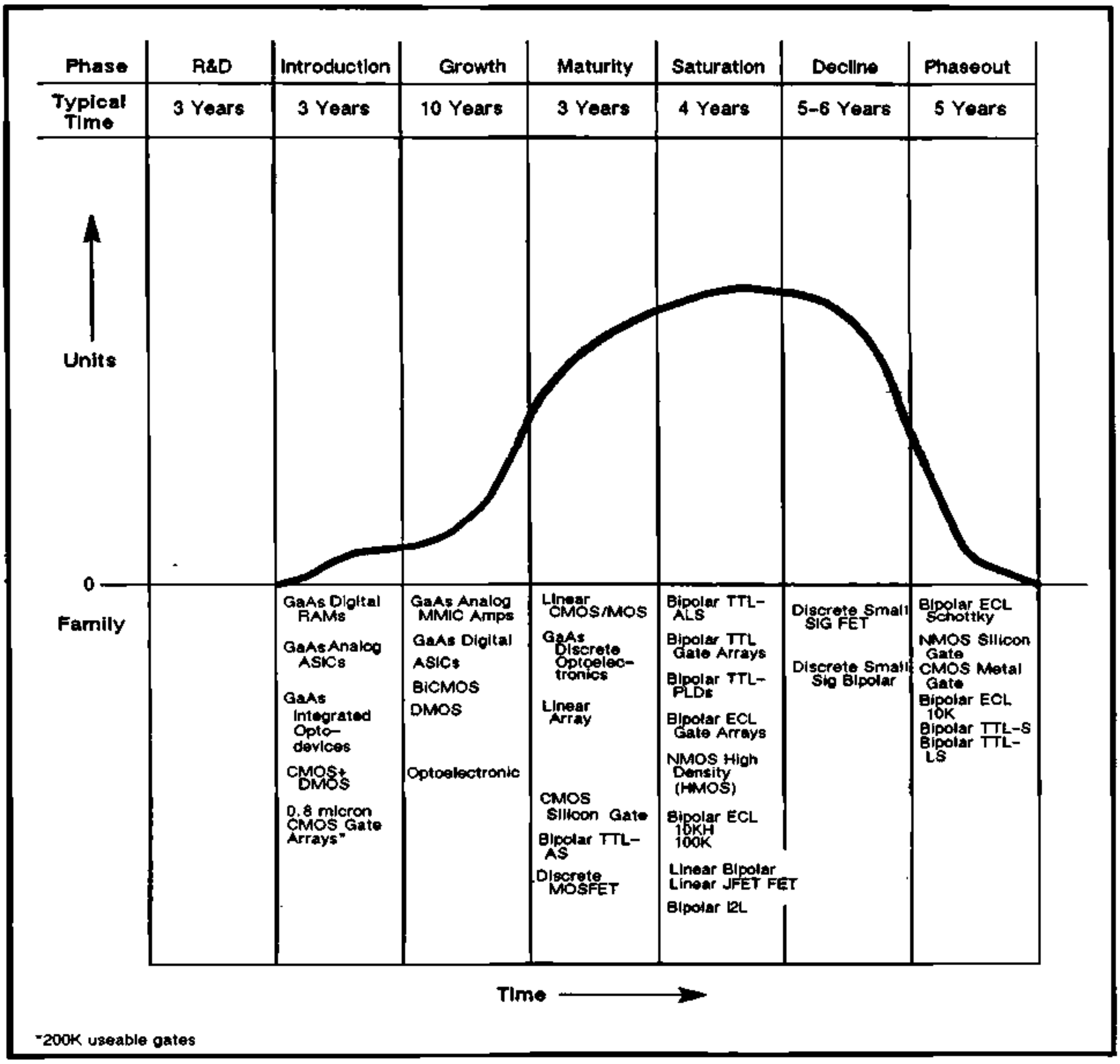
The outlook remains less certain regarding another very high speed, low-power technology, gallium arsenide (GaAs). Figure 2 positions the GaAs technology at either the introduction or growth stage of the life cycle, depending on the specific product. The GaAs technology remains relatively unproven; however, Motorola's dedication of a GaAs fab during 1991 puts the manufacturing weight of an industry giant behind the GaAs process. Along with Motorola, Fujitsu, Texas Instruments, TriQuint, and Vitesse aim for success in the GaAs marketplace.

Dataquest continues to recommend that users carefully explore their systems' needs and the strength of the supplier base in weighing whether or not to design GaAs products into systems.

Impending Obsolescence

At the other end of the spectrum, Figure 2 shows that a host of product technologies (for

Figure 2
Semiconductor Technology Life Cycle As of June 1991



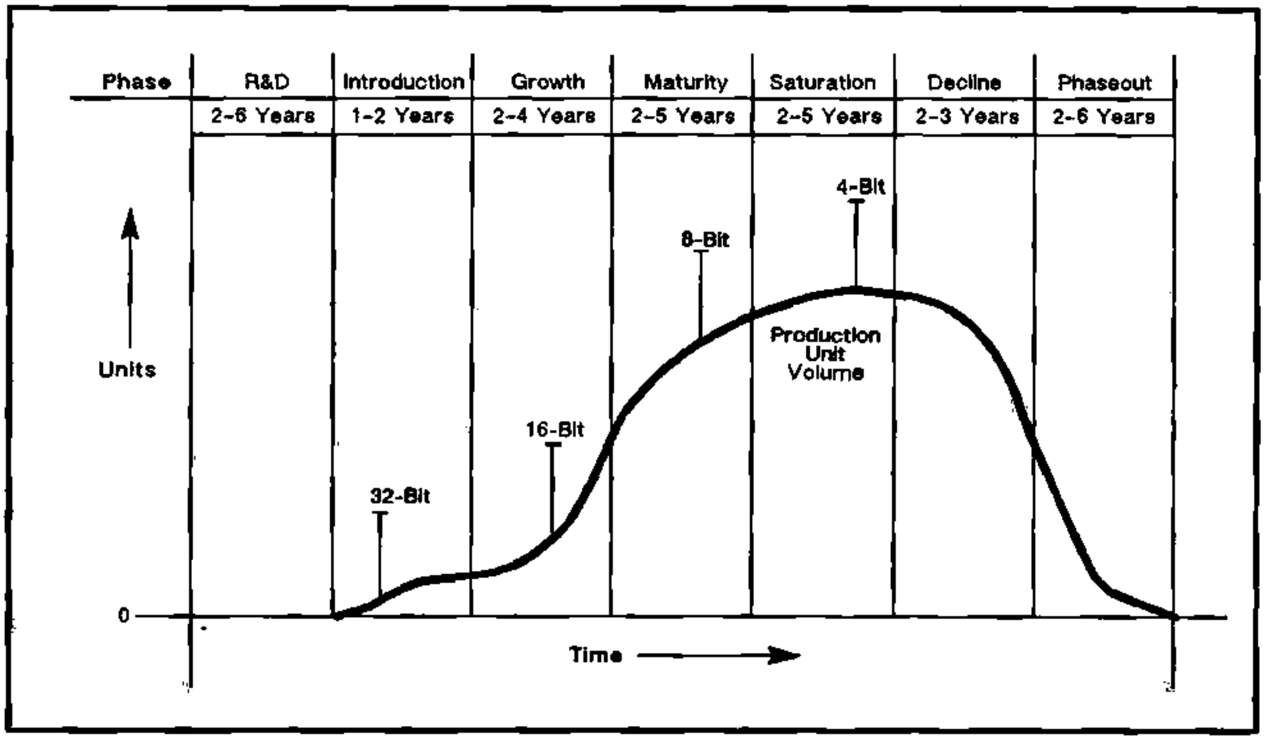
Source: Dataquest (June 1991)

example, CMOS metal gate, NMOS silicon gate, bipolar TTL, and 3.0-micron gate arrays) have hit the late decline or phaseout stage. Users whose systems incorporate these semiconductor technologies must develop plans to safeguard against the related problems of semiconductor technology phaseout and premature system obsolescence.

The Life Cycle Length of MOS Microcontrollers

Dataquest defines a microcontroller (MCU) as a single-chip component that contains on-board program memory in the form of ROM, EPROM, or EEPROM; some input/output capability; a general-purpose read/write memory; the CPU

Figure 3
Microcontroller Product Life Cycle as of June 1991



Source: Dataquest (June 1991)

function; and possibly other functions such as timers or digital/analog conversion. The MCU market is quite large—worldwide shipments totaled 1.36 billion during 1990.

Figure 3 shows the product life cycles of typical MCUs. These devices usually have much longer life cycles than other integrated circuits.

As shown in Figure 3, MCU life cycles are expected to run for 30 years and in some cases for half a century. MCUs are widely used in systems that also have long life cycles. Such systems frequently require 6 to 18 months from product concept to initial production, so there is often a relatively long development period between early samples of MCUs and volume ramp up.

Figure 3 reveals that the 4-bit MCU devices stand at the saturation (or peak) stage of their life cycle and should remain in that stage for the next several years. Figure 3 also shows that 8-bit MCUs are now moving toward the peak of their product life cycle. The 16-bit MCUs are on the growth path, while 32-bit MCUs stand in the introduction stage of the cycle.

Trends in MCU Technology

The MCU product trend continues to be a move away from general-purpose MCUs to devices differentiated on the basis of application. For example, designs are making use of the more advanced technologies and architectures available at the 8- and 16-bit levels. On-chip EPROM or on-chip EEPROM have been successful features for small-volume applications. Another trend is the increased integration of application-specific features.

Nevertheless, for users of MCUs, instruction-set compatibility is a major factor, as any major rewrite of MCU code tends to be costly. Users also tend to match the MCU to the needs of the application, advancing to a more costly MCU (e.g., from 8- to 16-bit) only when absolutely necessary. This reality translates into lengthy life cycles for MCUs.

Trend Toward Higher-Speed MOS ROMs

Read only memories (ROMs) are nonvolatile devices that are programmed during the manufacturing process. The programming is usually achieved by customizing the design of one or more layers of the ROM IC. Worldwide shipments of ROMs totaled 361 million units during 1990.

Figure 4 shows the life cycle curve for MOS ROMs.

High-volume/slower-speed applications such as disk drives, laptop computers, and video games typically have driven ROM product technology trends. During the 1980s, these slower-speed applications translated into a large supply of ROMs that operate at speeds of 200ns or slower. In line with user demand for higher-speed devices, the predominant speeds for ROM should range from 150 to 250ns at megabit-density levels, which still does not satisfy all user system requirements.

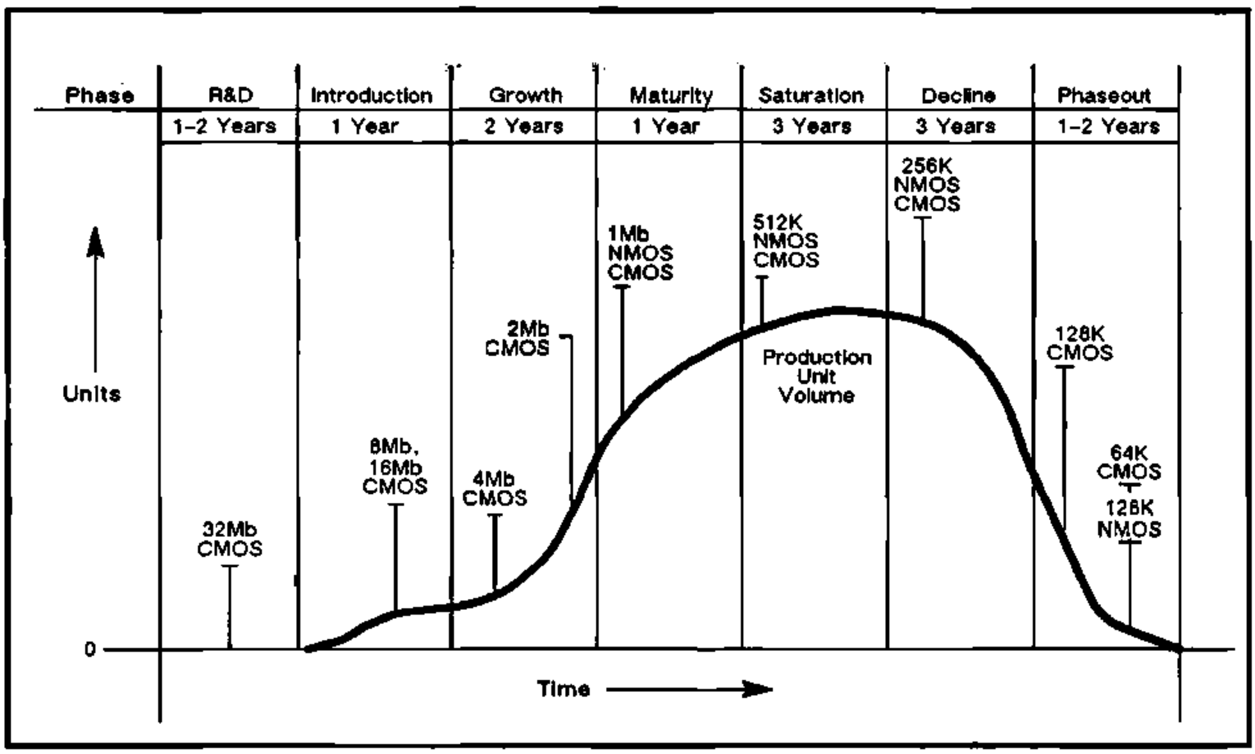
As shown in Figure 4, 1Mb ROMs stand at the peak stage of the life cycle. The 4Mb ROM devices advance through the growth stage of the cycle in the path of the 1Mb product. The outlook is less certain for the intermediate 2Mb product because of fewer design wins and lower demand. The 8Mb and 16Mb ROMs are moving through the introduction stage of the cycle. Users should plan for the introduction of 32Mb ROM devices during 1992.

Uncertain Outlook for the EEPROM Technology

Electrically erasable programmable ROM (EEPROM) technology has been in development since 1973. Full-featured EEPROMS, which means the device offers the programming/on-chip functions required for in-system programming, first appeared in the early 1980s.

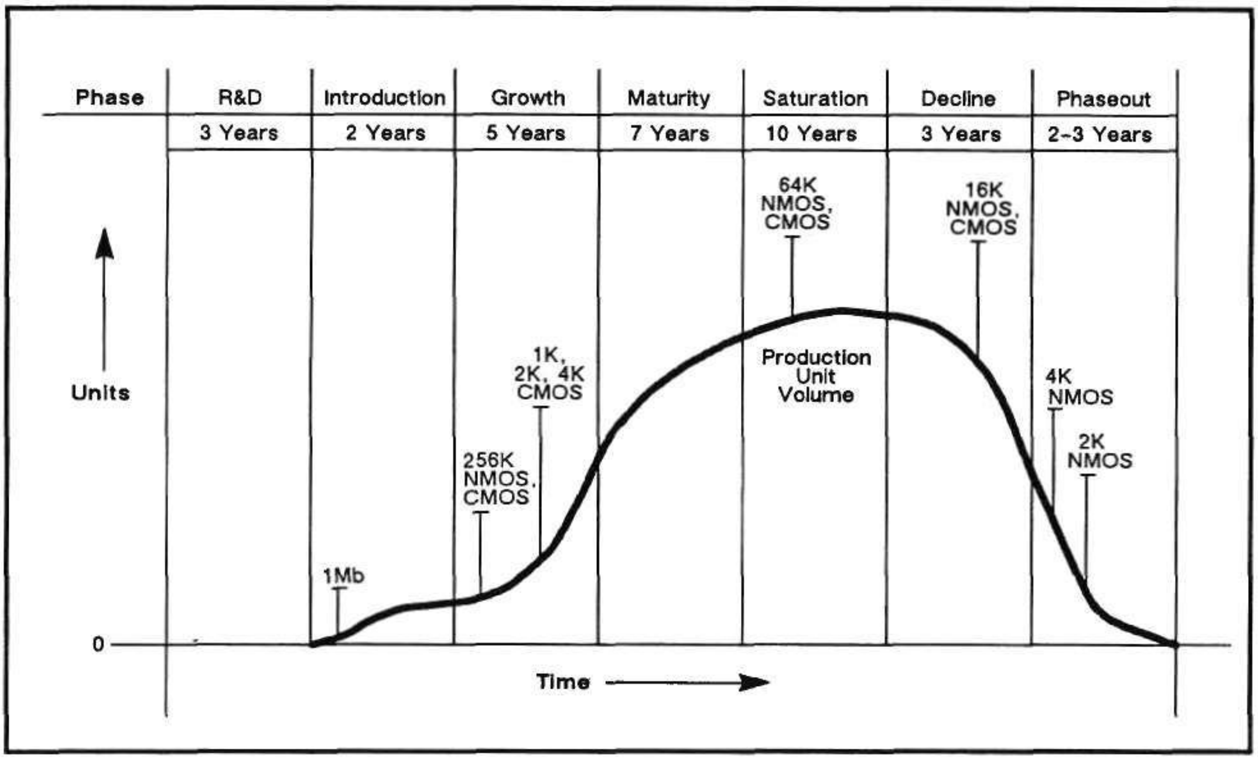
Shipments of EEPROMs totaled 127 million units during 1990. EEPROMs offer the advantages of in-circuit and remote reprogramming vis-à-vis other memory product choices (e.g., EPROM). Because of the small size of the EEPROM supplier base and high unit costs, however, the EEPROM product solution continues as a niche market that could be challenged by less costly nonvolatile alternatives such as EPROMs, battery-backed SRAMs, and possibly Flash memory.

Figure 4
MOS ROM Product Life Cycle as of June 1991



Source: Dataquest (June 1991)

Figure 5
EEPROM Product Life Cycle as of June 1991



Source: Dataquest(June 1991)

Figure 5 shows the life cycle outlook for EEPROMs.

Figure 5 shows that the 16K EEPROM continues to move down the decline stage of the cycle. The 64K part is in the mature stage, which should be long due to the product's design in military systems with lengthy life cycles. The 256K EEPROM is now moving through the growth stage with the 1Mb EEPROM in the introduction stage.

Bright Future for Flash Memory?

Depending on system needs, a newer memory technology recommended by Dataquest for evaluation is Flash memory. Dataquest defines Flash memory as a nonvolatile product designated as Flash EPROM/EEPROM that incorporates either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/chip erase.

Figure 6 shows the life cycle outlook for Flash memory.

Dataquest believes that Flash memory has the potential of keeping pace with other nonvolatile devices (e.g., EPROMs, EEPROMs) in systems applications. Worldwide shipments—which totaled less than 3 million units during 1990—should approach 250 million units for 1995. Global giants like Intel, Texas Instruments, and Toshiba are dedicated to success in this marketplace.

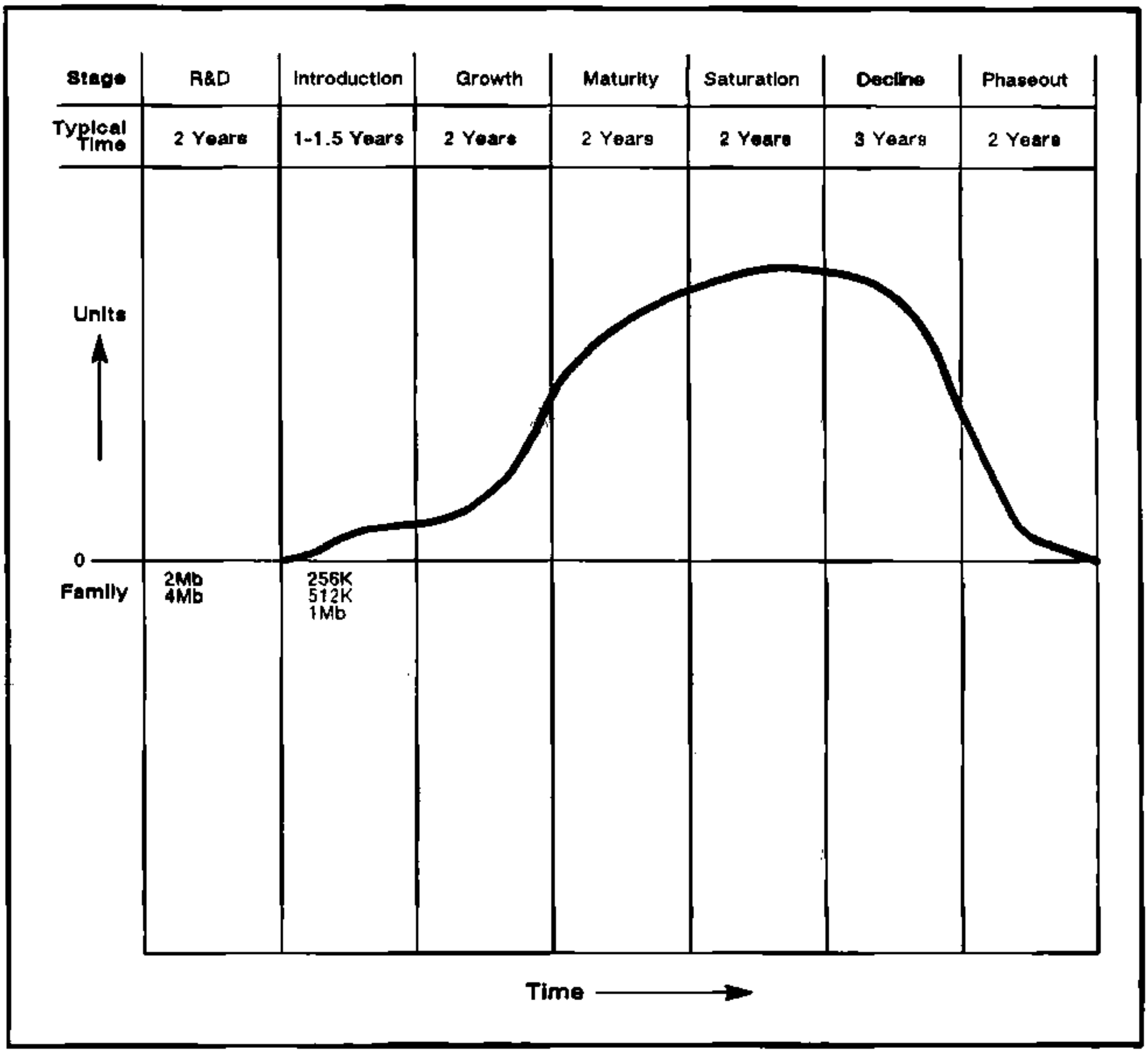
Even a conservative approach—avoiding risk by staying with proven mainstream component technologies—can result in unexciting and noncompetitive systems that lag technology leaders.

Dataquest expects Flash memory to win its place in higher-density nonvolatile applications.

Dataquest Perspective

Semiconductor technology has been and should continue to be a key factor in the long-term success—or failure—of global systems

Figure 6
Flash Memory Product Life Cycle as of June 1991



Source: Dataquest (June 1991)

manufacturers. Component engineers must work with systems designers and procurement teams in order to effectively manage the technology flows during the 1990s—*or else.*

For users, the key issue will be qualification of the supplier base including second sources—and pricing.

Semiconductor technology evolution—as reflected in Figure 2—demands careful evaluation by prospective users. Competitive systems manufacturers must also be wary of the eventual implications for them of the possible use by their *competitors* of newer IC technologies such as BiCMOS or GaAs.

Users constantly face a series of technology risks. For example, staying with older IC technologies creates the risk of abrupt IC/system obsolescence. By contrast, the design of newer technologies into systems means the risk of failure of unproven technologies at a critical stage of the system life cycle. Even a conservative approach—avoiding risk by staying with proven mainstream component technologies—can result in unexciting and noncompetitive systems that lag technology leaders. Under these market conditions, Dataquest makes the following recommendations:

- Systems manufacturers must carefully coordinate semiconductor technology life cycles with the planned system migration path. By using the information in Figures 2 to 6—as well as this entire series of life cycle articles—systems manufacturers can work with their supplier base to minimize IC "technology risks" during the 1990s.
- At one end of the technology life cycle curve, users whose systems are based on now-matured semiconductor technologies such as CMOS metal gate, NMOS silicon gate, or 3.0-micron gate arrays must forge contingency plans *now* to guard against the associated risk of IC technology phaseout/ system obsolescence.
- At the other end of the curve, users can design BiCMOS SRAMs, ASICs, and other ICs into systems with a relatively low degree of technology risk. For users, the key issue will be qualification of the supplier base including second sources—and pricing.

Dataquest continues to recommend that users carefully explore their systems' needs and the strength of the supplier base in weighing whether or not to design GaAs products into systems.

By Ronald Bohn

News and Views

DRAM Bookings Price Ranges

The results of Dataquest's second quarter 1991 survey of North American bookings prices for semiconductors are available. Table 1 shows the range of estimated North American bookings DRAM prices gathered during the just-completed April-May 1991 price survey.

Dataquest Perspective

The survey results show a narrower range of 1Mb DRAM prices than earlier this year—reflecting lower volatility in this ever-volatile market. Contract-volume pricing for 1Mb DRAM ranged from a low of $4.27 to a high of $4.80 during the second quarter. Dataquest has received some reports of occasional spot market pricing for 1Mb DRAM of as low as $4; however, that price trend has *not* been consistent. Prices for 4Mbx1 DRAM continue to decline in line with prior expectations.

By Ronald Bohn

Table 1
DRAM Price Ranges—North American Bookings (Contract Volume; Dollars)*

	Second Quarter 1991			Fourth Quarter 1991		
	High	Low	Average	High	Low	Average
1Mbx1 DRAM DIP/SOJ (80ns)	4.80	4.27	4.55	4.60	4.24	4.41
4Mbx1 DRAM SOJ 300 mil (80ns)	20.00	17.05	18.01	17.25	14.00	15.37

*Contract volume is at least 100,000 per order
Note: This information correlates with Dataquest's quarterly forecast for 1991-1992 dated June 1991.
Source: Dataquest (June 1991)

In Future Issues

The following topics will be featured in future issues of *Dataquest Perspective:*

- TAB packing trends and issues
- U.S. semiconductor companies capital spending
- July *Procurement Pulse*

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 6 **June 11, 1991**

Regional Pricing Update

DQ Monday Report Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.11	0.11	0.09	0.13
74HC138	0.14	0.15	0.15	0.17	0.15	0.21
74HC244	0.21	0.30	0.22	0.23	0.21	0.34
74HC74	0.12	0.12	0.13	0.11	0.10	0.17
Lead Time (Weeks)	4	3	4	5	5	5
339-COM	0.14	0.15	0.12	0.13	0.11	0.13
741-OP AMP	0.13	0.23	0.11	0.13	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.09	0.08	0.07	0.10
74LS138	0.15	0.12	0.15	0.13	0.12	0.14
74LS244	0.21	0.24	0.22	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.10	0.10	0.11
Lead Time (Weeks)	4	2	6	4	5	5
DRAM 1Mbx1-10	4.40	4.60	4.70	4.50	4.60	5.10
DRAM 256Kx1-10	1.55	1.62	1.80	1.30	1.40	1.45
DRAM 256Kx4-10	4.45	4.78	4.70	5.00	4.60	5.10
DRAM 4Mbx1-8	18.13	20.82	19.00	20.00	20.60	NA
DRAM 64Kx4-10	1.55	1.65	2.00	1.70	1.50	1.45
EPROM 1Mb, 200ns	4.80	5.50	5.00	5.50	5.20	4.20
EPROM 256K, 200ns	1.83	2.05	2.00	1.75	1.65	1.55
SRAM 1Mb, 128Kx8	17.50	18.67	14.50	NA	NA	NA
SRAM 256K, 32Kx8	4.25	4.16	4.25	4.95	4.90	4.70
SRAM 64K, 8Kx8	1.60	1.54	1.75	1.23	1.40	1.45
Lead Time (Weeks)	6	4	4	2	7	3
68000 12MHz	4.95	4.67	5.30	4.15	3.10	4.00
68HC11	8.40	7.36	8.00	8.75	8.60	NA
80286 12MHz	6.50	14.00	8.00	9.35	9.70	6.80
80386SX-16	54.00	53.84	53.00	64.50	65.00	57.00
8051	1.65	2.01	1.90	2.50	1.80	1.80
Lead Time (Weeks)	4	4	4	3	4	6

NA = Not available
Source: Dataquest (June 1991)

Market Analysis

June Procurement Pulse: Semiconductor Orders, Inventories Inch Upward

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Semiconductor Orders Rise While System Sales Forecast Stabilizes

This month's respondents expect to incrementally increase their semiconductor order activity by 11.3 percent because of expected higher system sales over the next six months (see Figure 1). The overall six-month system sales outlook rose again this month from 6.5 percent to a current 7.6 percent. This barometer of business optimism has nearly doubled over the past two months, going from 3.4 percent in April to 7.6 percent expected in June! The computer segment's response was muted somewhat from last month's aggressive 10 percent, six-month system forecast to a current 8.3 percent in the short term. The overall positive outlook continues to emphasize that although the general economic situation has been better, business is expected to improve at a gradual and manageable pace. In the absence of a large-volume, high-growth product(s) pulling demand, Dataquest believes that it is highly probable that the current spate of electronic system price cutting will continue to maintain and grow revenue streams.

Lead Times Remain Unchanged—Not Unexpected

The stability in semiconductor lead times shown in Figure 2 continues to highlight the supply/demand balance that has existed for

Figure 1

Averaged Monthly Semiconductor Orders

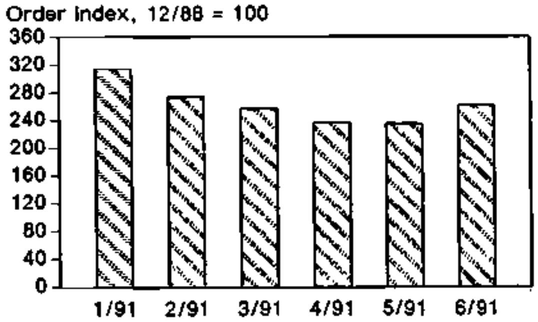


Figure 2

Averaged Semiconductor Lead Times

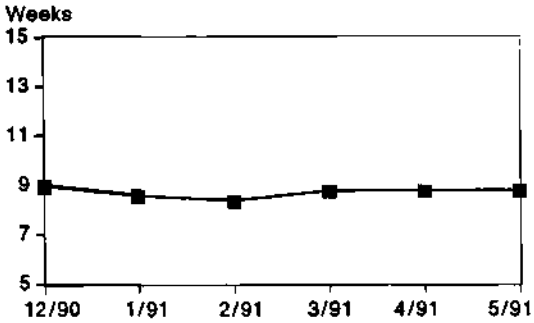


Figure 3

Actual vs. Target Inventory Levels (All OEMs)

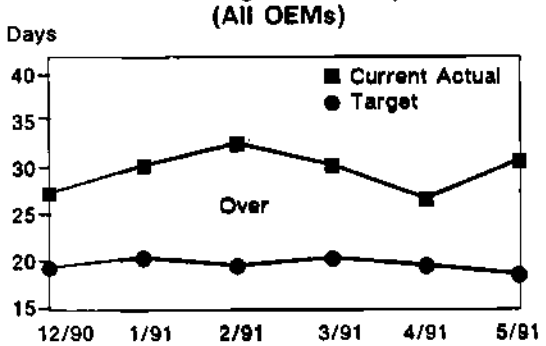
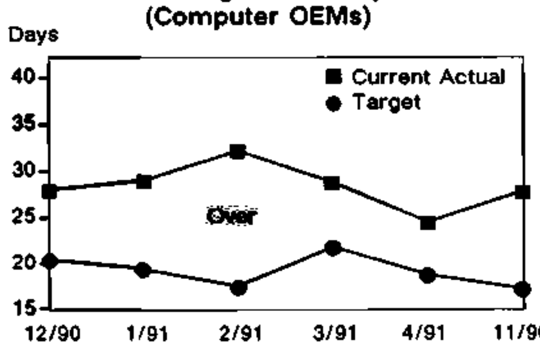


Figure 4

Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (June 1991)

approximately the past year. The current unchanged average lead time of 8.8 weeks is the mean of a 4- to 12-week range. As in the past several months, overall semiconductor availability remains excellent. There are some reports of continued lead time extensions for surface-mount standard logic in the 8- to 12-week range due to an unanticipated aggregate increase in SMT logic demand that started 8+ weeks ago and has kept lead times for these parts on the high end of the scale. As mentioned in earlier *Procurement Pulses*, this blip in extended lead times has been addressed with increased wafer starts and should be corrected in 4 to 6 weeks. On a related topic, respondents noted the availability of obsolete parts as being a continuing issue. The process of designing out of specific mature products and designing in of newer parts requires good communications between users and suppliers to help smooth over potential supply disruptions. As of this writing, it appears almost certain that a continuation of the U.S.-Japan Semiconductor Trade Arrangement will be signed. As mentioned in the May 10 Dataquest Perspective, a direct result of this agreement will be that U.S. semiconductor buyers of memory will no longer have to deal with FMVs and cost-based pricing.

Semiconductor Inventories Rise Again To The (Low) Historical Average

The inventory reductions experienced over the past two months that resulted in sub-30-day overall inventory levels was adjusted upward, as seen in Figures 3 and 4. The current actual overall inventory level now stands at 31.1 days, up from last month's 27-day level, while respective targeted levels dropped to 18.8 from 19.8 days. The computer segment respondents' targeted and actual inventory levels followed a similar pattern, with the targeted level dropping to 17.3 days from 18.8 and respective actual levels increasing to 27.8 days from 24.5 days. Dataquest does not view these inventory increases as indicators of a trend, but more a balancing of near-term order rates with anticipated system demand trends. As noted in past *Procurement Pulses*, average target and actual inventory levels have not strayed far from the golden mean historical respective averages of 20 and 30 days; therefore, it would not be surprising to see a small increase in average target inventory levels in the near future. With inventory management ingrained as a potent cost-control tool, maintenance and long-term reduction of target and actual inventory levels remains a high priority of both semiconductor users and suppliers.

Dataquest Perspective

The overall electronics outlook remains positive, and semiconductor availability and pricing is excellent. Issues surrounding the phase in and phase out of systems and their corresponding component requirements remain an area where improvements in design engineering/procurement/supplier communications are needed. With order rates increasing, system sales forecasts positive, and the overall economic environment improving, the gradual and manageable low-growth scenario Dataquest has been depicting is playing out. Continued focus on communication regarding demand changes and design or quality concerns is being addressed that will reinforce the current growth mode. ■

By Mark Giudici

Final 1990 Semiconductor Market Shares

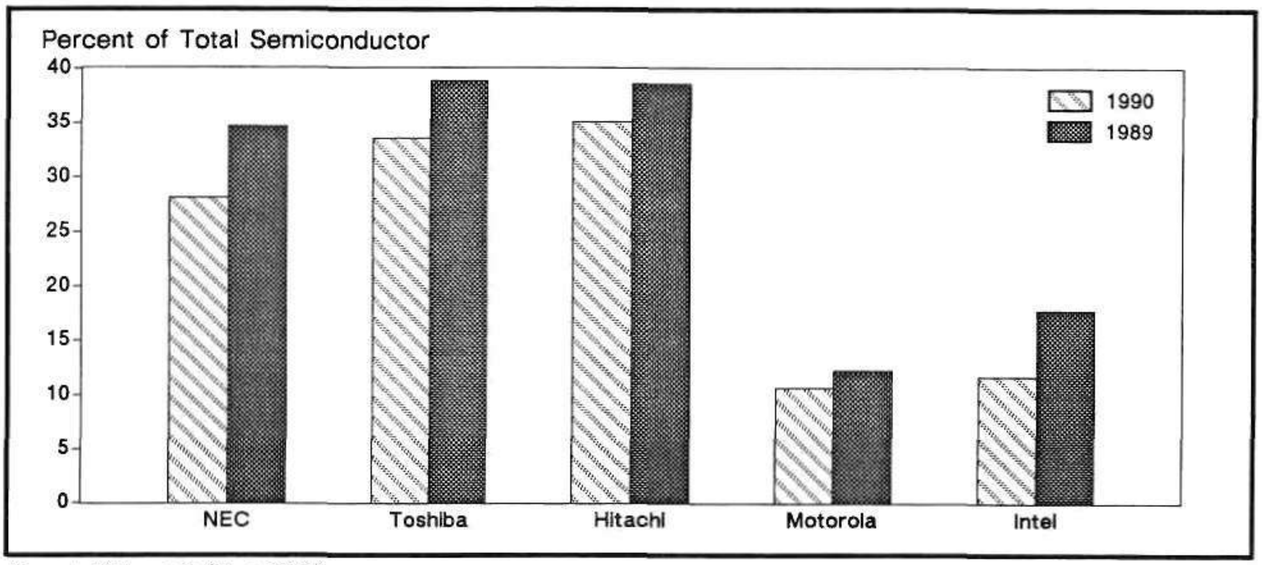
Introduction

The number one rule of the semiconductor game asserted itself forcefully in 1990: What goes up must come down. Companies that derive large portions of their revenue from highly volatile commodity products will eventually see their business decline and their market share decrease as rapidly as they had previously grown. The case in point is MOS memory, which was responsible for much of the semiconductor industry's growth in 1988 and 1989. The market share gains made by memory suppliers in those years fell by the wayside (in most cases) in 1990, allowing other companies to move up in the ranking list.

Microcomponents: The 1990 Market Driver

Although the memory market did not disappear in 1990, steep price declines made it an unpleasant market to be in. The top three semiconductor vendors in 1990—NEC, Toshiba, and Hitachi—each derived 35 percent or more of their 1990 semiconductor revenue from MOS memory products. In 1990, this ratio slipped by 3 to 6 percentage points. Although the same effect can be seen for the fourth and fifth ranked companies—Motorola and Intel—these companies received only 12 and 18 percent, respectively, of their 1989 revenue from MOS memory. Figure 1 compares 1989 and 1990 reliance on MOS memory by these companies. In 1990, these top five companies increased the percentage of total semiconductor revenue from MOS microcomponents. In the case of Intel, which went up in the rankings

Figure 1
Top Five 1990 Semiconductor Suppliers' Reliance on MOS Memory (Percentage of Total Semiconductor)



Source: Dataquest (June 1991)

from number eight to number five, the portion of total semiconductor revenue that came from microcomponents grew from 79 to 86 percent. These comparisons can be seen in Figure 2.

The effect of MOS microcomponents on the industry as a whole can be seen in Figure 3, which shows that were it not for the dramatic growth of microcomponents, the semiconductor industry would have declined by 2 percent in 1990, rather than growing 2 percent.

Differences in Regional Companies

It is very clear that vastly different product strategies are being followed by each regional grouping of companies. The largest portion of North American companies' 1990 revenue—27 percent—came from microcomponents, while the largest portions of Japanese companies' revenue were from MOS memory (28 percent) and the combined grouping of bipolar digital, discrete, and optoelectronics (29 percent). European companies, on the other hand, are heavily dependent on bipolar digital/discrete/opto (36 percent) and analog (30 percent); their revenue from the fastest-growing segments of the semiconductor industry (in the long term)—MOS memory and microcomponents—totaled only 21 percent of their semiconductor revenue. Asia/Pacific companies' revenue was very heavily skewed in favor of memory, with 63 percent of their revenue coming from that product category.

Figure 4 illustrates the product portfolios by regional company base. From this analysis, it appears that the most evenly balanced portfolios belong to the North American and Japanese companies, with percentage point spreads of only 13 and 16 percentage points, respectively, between the largest and smallest categories.

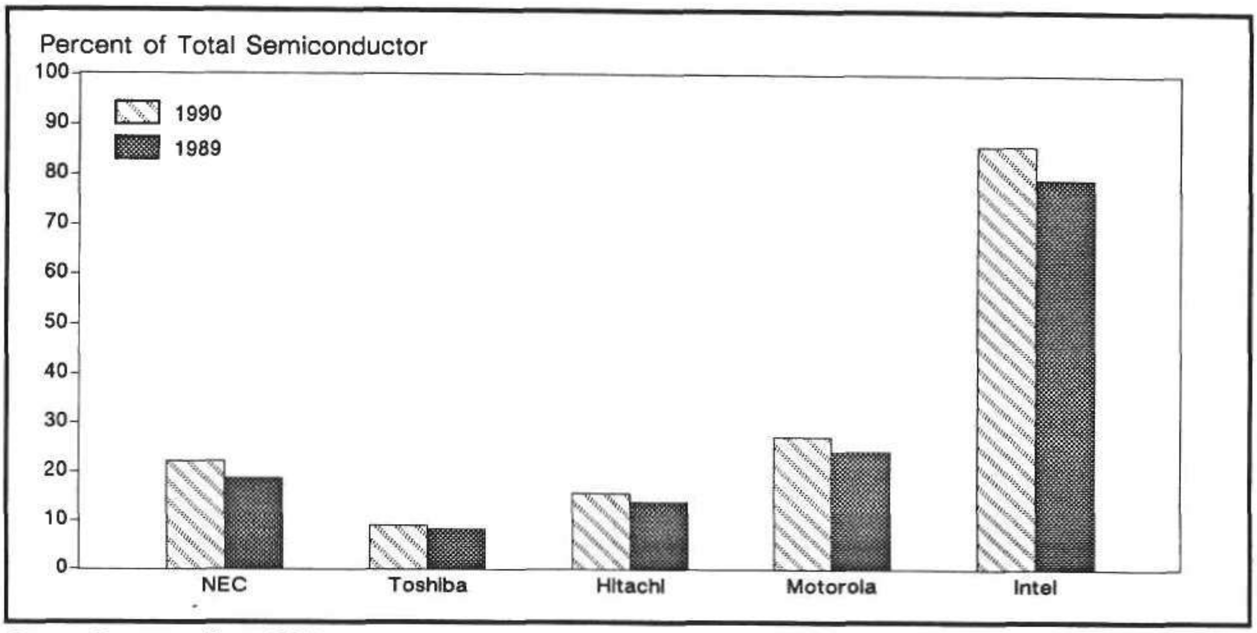
Although it might initially appear that European companies' portfolios are less well balanced, their targeted application markets differ from North American and Japanese companies in that a higher percentage of their output is aimed at the consumer and telecommunications industries, which use large quantities of discrete and analog chips.

The Asia/Pacific company statistics are skewed by Samsung, whose sales account for 62 percent of this group. Because Samsung has become one of the world's largest DRAM suppliers, it is not surprising that MOS memory accounts for 63 percent of Asia/Pacific company semiconductor revenue.

1990 Rankings and Market Share

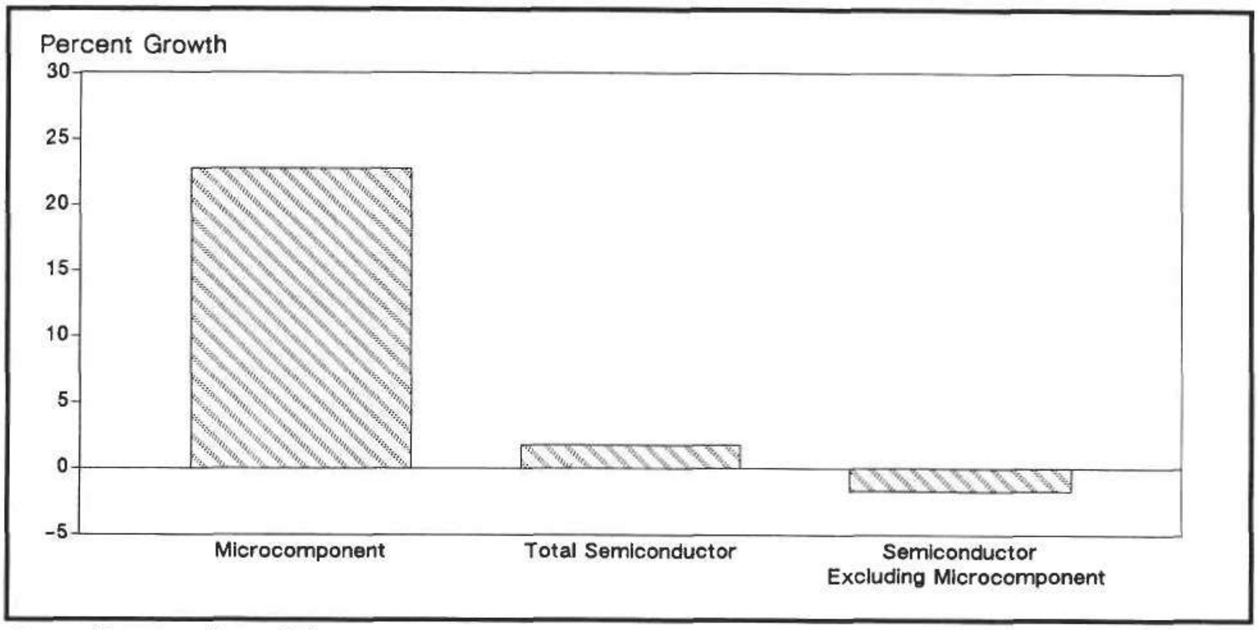
Table 1 is an analysis of the worldwide semiconductor market by regional supplier base and regional consumption market. This table shows that in 1990 North American companies held 37 percent of the worldwide semiconductor market, Japanese companies held 49 percent, European companies held 11 percent, and Asia/Pacific companies held 4 percent.

Figure 2
Top Five Semiconductor Suppliers' Reliance on MOS Microcomponents (Percentage of Total Semiconductor)



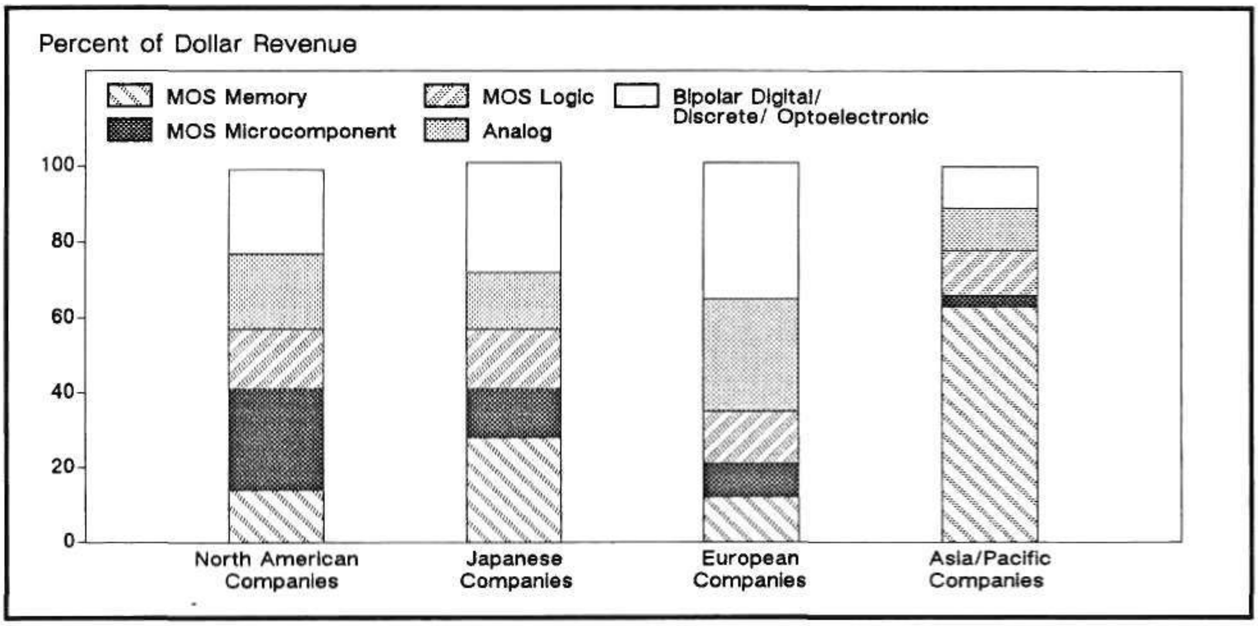
Source: Dataquest (June 1991)

Figure 3
MOS Microcomponents: The Industry Driver (Percent Growth in 1990)



Source: Dataquest (June 1991)

Figure 4
1990 Product Portfolios by Company Base
(Percentage of Dollar Revenue by Product Category)



Source: Dataquest (June 1991)

Table 1
Estimated Final 1990 Semiconductor Market Share Analysis by Regional Market
(Factory Revenue in Millions of U.S. Dollars)

Company:	Each Regional Base	Distribution Channel:	Not meaningful
Product:	Total Semiconductor	Application:	All
Region of Consumption:	Each	Specification:	All

Company Base	North America	Japan	Europe	Asia/Pacific-ROW	World
North America ($M)	11,942	2,402	4,492	2,701	21,537
Percent of Regional Market	69	11	42	35	37
Percent of Company Sales	55	11	21	13	100
Japan ($M)	3,777	19,825	1,814	2,961	28,377
Percent of Regional Market	22	88	17	39	49
Percent of Company Sales	13	70	6	10	100
Europe ($M)	1,074	164	4,117	851	6,206
Percent of Regional Market	6	1	39	11	11
Percent of Company Sales	17	3	66	14	100
Asia/Pacific ($M)	593	117	238	1,157	2,105
Percent of Regional Market	3	1	2	15	4
Percent of Company Sales	28	6	11	55	100
World ($M)	17,386	22,508	10,661	7,670	58,255
Percent of Regional Market	100	100	100	100	100
Percent of Company Sales	30	39	18	13	100

Source: Dataquest (June 1991)

Table 2
Estimated Semiconductor Consumption
(Factory Revenue in Millions of U.S. Dollars)

Company:	All	Distribution Channel:	Not meaningful
Product:	Each	Application:	All
Region of Consumption:	Worldwide	Specification:	All

	1989	1990	Change (%)
Total Semiconductor	57,213	58,225	1.8
Total Integrated Circuit	46,924	47,303	0.8
Bipolar Digital	4,510	4,440	-1.6
Bipolar Memory	540	459	-15.0
Bipolar Logic	3,970	3,981	0.3
MOS Digital	33,024	32,292	-2.2
MOS Memory	16,361	13,091	-20.0
MOS Microcomponent	8,202	10,068	22.8
MOS Logic	8,461	9,133	7.9
Analog	9,390	10,571	12.6
Discrete	7,662	8,235	7.5
Optoelectronic	2,627	2,687	2.3

Source: Dataquest (June 1991)

Table 3
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40	Distribution Channel:	Not meaningful
Product:	Total Semiconductor	Application:	All
Region of Consumption:	Worldwide	Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
1	1	NEC	5,015	4,898	-2	8.4
2	2	Toshiba	4,930	4,843	-2	8.3
3	3	Hitachi	3,974	3,893	-2	6.7
4	4	Motorola	3,319	3,694	11	6.3
5	8	Intel	2,430	3,171	30	5.4
6	5	Fujitsu	2,963	2,880	-3	4.9
7	6	Texas Instruments	2,787	2,574	-8	4.4
8	7	Mitsubishi	2,579	2,319	-10	4.0
9	10	Philips	1,716	2,011	17	3.5
10	9	Matsushita	1,882	1,942	3	3.3
11	11	National Semiconductor	1,618	1,719	6	3.0
12	13	SGS-Thomson	1,301	1,463	12	2.5
13	12	Sanyo	1,365	1,381	1	2.4
14	15	Sharp	1,230	1,325	8	2.3
15	14	Samsung	1,260	1,315	4	2.3
16	16	Siemens	1,194	1,224	3	2.1
17	19	Sony	1,077	1,146	6	2.0
18	17	Oki	1,154	1,074	-7	1.8
19	18	Advanced Micro Devices	1,100	1,053	-4	1.8

(Continued)

Table 3 (Continued)
Estimated Market Share Ranking
(Factory Revenue in Millions of U.S. Dollars)

Company:	Top 40	Distribution Channel:	Not meaningful
Product:	Total Semiconductor	Application:	All
Region of Consumption:	Worldwide	Specification:	All

1990 Rank	1989 Rank		1989 Revenue	1990 Revenue	Percent Change	1990 Market Share (%)
20	20	AT&T	873	861	-1	1.5
21	21	Harris	830	800	-4	1.4
22	22	Rohm	740	774	5	1.3
23	23	LSI Logic	512	598	17	1.0
24	26	Sanken	387	407	5	0.7
25	NM	GEC Plessey	0	390	NM	0.7
26	28	Fuji Electric	362	385	6	0.7
27	29	Analog Devices	357	381	7	0.7
28	25	ITT	390	371	-5	0.6
29	31	VLSI Technology	286	324	13	0.6
30	30	Telefunken Electronic	299	295	-1	0.5
31	24	Micron Technology	395	286	-28	0.5
32	32	Hewlett Packard	269	279	4	0.5
33	35	Chips & Technologies	240	265	10	0.5
34	40	International Rectifier	190	225	18	0.4
35	39	Cypress Semiconductor	196	223	14	0.4
36	42	General Instrument	170	214	26	0.4
37	27	Seiko Epson	368	213	-42	0.4
38	NA	Shindengen Electric	NA	209	NA	0.4
39	33	NMB Semiconductor	247	201	-19	0.3
40	43	Rockwell	165	200	21	0.3
		All Others	7,043	6,399	-9	11.0
		North American Companies	19,978	21,537	8	37.0
		Japanese Companies	29,809	28,377	-5	48.7
		European Companies	5,443	6,206	14	10.7
		Asia/Pacific Companies	1,983	2,105	6	3.6
		Total Market	57,213	58,225	2	100.0

NA = Not available
Source: Dataquest (June 1991)

Table 2 is a breakdown of the semiconductor market by product category for 1989 and 1990. The market grew a total of only 1.8 percent, but as previously alluded to, MOS microcomponents grew by 22.8 percent. Analog ICs, the second fastest-growing market, grew 12.6 percent. (We have included mixed-signal analog/digital ICs in the analog category.)

The top 40 semiconductor companies' worldwide rankings and revenue are shown in Table 3.

Dataquest Perspective

The memory market will recover, and companies with major commitments in this market will have a chance to regain semiconductor market share. However, in 1990 Dataquest saw that a strong marketing strategy in other product areas can pay off handsomely. We continue to believe that companies with balanced product portfolios in conjunction with volatile commodity exposure will gain market share over the long term.

Note: Detailed market share data books have been completed and mailed to binderholders of the Semiconductors *Worldwide*, Semiconductors *Japan*, Semiconductors *Europe*, Semiconductors *Asia*, and North American Semiconductor Markets services. ■

By Patricia S. Cox

Product Analysis

Semiconductor Price/ Performance: A Report from the DRAM Front

Summary

In a recent newsletter entitled "Will Industry Economics Defy Moore's Law?" Dataquest analysts highlighted factors that we believe will lead to a slowdown in the historic rate of price/performance improvements in leading-edge semiconductor devices. This article explores the degree to which those factors apply to the DRAM business and the possible implications for the electronics market as a whole.

Based on Dataquest research and the experiences and projections of a number of leading suppliers, it seems clear that leading-edge DRAMs in the megabit era will no longer be able to continue along the same learning curve observed in previous generations. Put simply, the price per bit of commodity memory will no longer decline as fast as it has in the past. Given the importance of ever-decreasing memory costs to the evolution of the PC industry as well as to other segments of the electronic equipment business, this prediction may seem ominous. However, Dataquest believes that although DRAM manufacturers will continue to deliver their historic 4x improvements in bit density per DRAM generation, life cycles will be longer, and DRAM devices will no longer be as inexpensive on a per-bit basis at the megabit and gigabit densities.

The good news is that the "new world order" in DRAMs will create a more stable environment for producers and consumers alike. This stability, however, will come at the price of further industry consolidation. This article discusses a number of issues pertaining to DRAM price/ performance, including the following:

- Factors affecting DRAM cost per die
- The evolution of wafer size increases
- DRAM market elasticity and future growth
- The implications of the above for semiconductor manufacturers

That Was Then; This Is Now

During Dataquest's 1990 Semiconductor Industry Conference, Fujitsu America Vice President David Sear estimated that, in the past few years, price-per-bit reductions helped drive memory demand at a quarterly compound growth rate of 20 percent. Historically, the cost of semiconductor memory has fallen dramatically since the introduction of the 1K DRAM. Figure 1 shows the historic price experience curve for DRAMs, which, in spite of industry booms, busts, and the occasional political intervention, has maintained a historic slope of 66 percent. This figure also supports a Dataquest model of DRAM price/shipment history over the past five years, which basically illustrates that a doubling of volume on a per-bit basis leads to a 35 percent price reduction.

As the industry makes the transition from megabit to gigabit memories, Mr. Sear and a number of major DRAM suppliers are wondering if price reductions can continue at their past rates. A slide presented at the conference by Dr. Tsugio Makimoto, director and general manager of the Semiconductor Design and Development Center of Hitachi Ltd., illustrates that, although technical limitations pose challenges to DRAM density improvements, the first hurdle the industry will face has to do with "bit-cost saturation"—the flattening of the industry's historic price/performance curve. Dr. Makimoto's slide is recreated in Table 1.

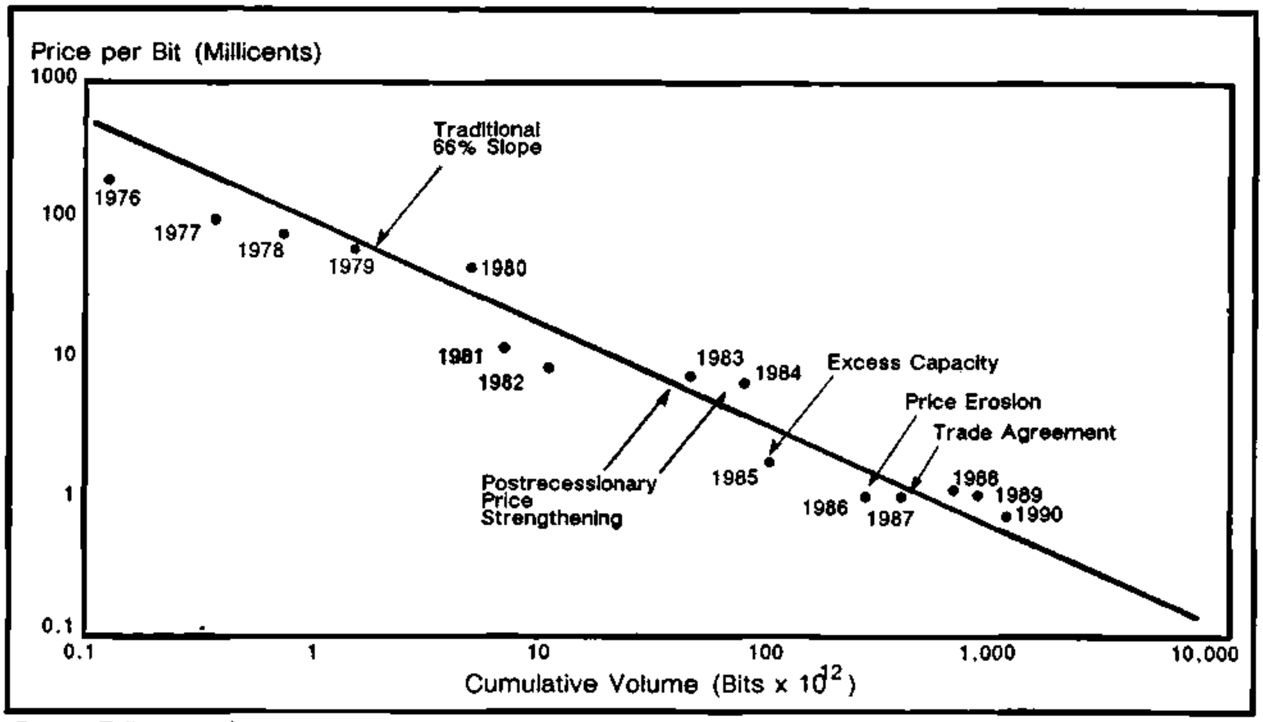
The Cost-Per-Die Battle: Size Versus Density

Based on the observations of major DRAM suppliers, a number of factors emerge that will contribute to Dr. Makimoto's observation of bit-cost saturation. These factors basically have to do with increases in the cost per die of high-density DRAMs. Basically, the industry is experiencing a discontinuity between the pre- and post-megabit era of DRAM densities.

To understand this discontinuity, one should note that during the transition from the 1K to 64K DRAM, die size remained fairly constant at about 25,000 square mils. However, although die size remained constant, density effectively improved by a factor of 64! To begin with, from the 1K to 64K DRAM, processing resolution went from 10 microns down to 5. Density improvements were also propelled by what Dr. Gordon E. Moore has referred to as the "cleverness" factor: the evolution from the 3-transistor cell to the 1-transistor cell, the evolution from double polysilicon to triple poly, the use of stacked capacitors, and so on.

Since the 256K DRAM, however, the combined improvements in device cleverness and reductions in scaling have not been enough to hold

Figure 1
DRAM Price Experience Curve



Source: Fujitsu America

Table 1
Fundamental DRAM Limits

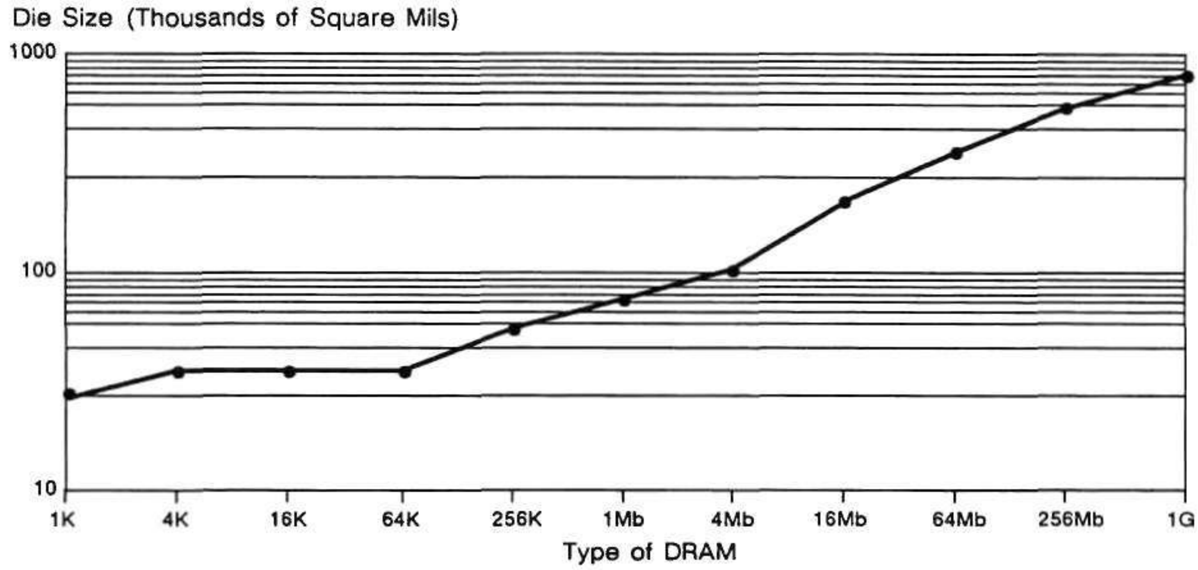
Device Issue	Geometry Limit (Microns)	Limiting Factor
Cost	0.3-0.2	Bit-cost saturation
Performance	0.2	Access time saturation
Reliability	0.1	Breakdown by tunneling effect
Manufacturing		
Yield	0.1	Yield limit by fluctuations
Lithography	0.1	Optical lithography limit
	<0.1	e-beam or x-ray lithography

Source: Hitachi Ltd.

down increases in die sizes, which have been taking place at an ever-expanding rate. In continuing the 4x density improvements per DRAM generation, Dr. Makimoto points out that although finer geometries will contribute two-thirds of the improvements, larger chip area will contribute one-third. Put another way, pattern size will get smaller by a factor of about 60 percent, contributing to a density improvement of 2.8 times per DRAM generation. Chip area, however, will increase 1.4 times per generation. Extrapolating on these observations, Figure 2 illustrates that between the 256K and the 1Gb DRAM, we will see a 4,000 times improvement in density, but it will be accompanied by a 20 times increase in die size.

To further aggravate matters, the experiences of major DRAM suppliers indicate that improvements in defect density are not keeping pace with increases in die size. As a result, the maximum potential die available per wafer will continue to decline per generation of megabit DRAM devices. The combined effects of larger die and slowing improvements in defect density are resulting in fewer die per wafer, further contributing to increased cost per die. In the past, end users have enjoyed ever-decreasing

Figure 2
DRAM Die Size Trends: Actual and Projected Die Sizes of Each DRAM Generation



- During the transition from the 1K to the 64K, the die size has been relatively constant at 25,000 square mils.
- Since the 256K, the die size has been increasing at an ever-expanding rate.

Source: Fujitsu America

costs for successive DRAM generations. This was especially true between the 1K and 64K DRAM generations. Comparing die cost trends since the introduction of the 1K DRAM, Mr. Sear points out that the 64K was 70 percent of the cost of a 1K, even though it had 64 times the number of bits. The ratio with the 256K was not quite as good, being only 83 percent—and from here it continued to climb. At the 1Mb level, die cost compared with the 1K reached 140 percent because the die size grew faster than all the techniques that could be used to control it. The 1Mb DRAM, therefore, clearly marks the transition to a new die cost curve and a slowdown in the rate at which the price per bit will decline.

Wafer Size: The Capital Equipment Trump Card

The trump card that manufacturers can, of course, play in stemming the tide of die cost increases is to shift to larger wafer sizes. The competitive advantages of moving to a larger wafer size is obvious from the following example offered by Mr. Sear: from a 5-inch wafer, which costs about $300, a manufacturer can yield 300 DRAM units given a 40,000-square-mil die. By moving to a 6-inch wafer, however, a manufacturer can get approximately 450 units at a wafer cost increase of only $100. Therefore, although the potential cost of a 40,000-square-mil die produced on a 5-inch wafer is about $1.00, the cost will decline to $0.89 using a 6-inch wafer.

The downside to this cost-reduction strategy is that each wafer size upgrade involves large capital investments to support. Nevertheless, switching from 6- to 8-inch wafers will be a necessity, albeit an expensive one, in improving the number of die per wafer in the 4Mb and 16Mb DRAM generations. Unfortunately, this improvement will once again begin to decline with the advent of the 64Mb device. If the industry is going to keep from being totally outdistanced by die costs, memory suppliers will have to completely switch to 8-inch wafers beyond the 4Mb DRAM generation and switch to 10-inch wafers beyond the 64Mb DRAM. Currently, there is little 8-inch capacity in the world today and no 10-inch capacity. This lack spells a massive capital investment ahead!

Other Imperatives

Cost per die, however, is not the only imperative driving the move to larger wafer sizes. Increased output that can be gained from using larger wafers will be necessary just to outweigh increases in the capital costs associated with them. The current industry trend in the relationship between initial fab costs and capacity (measured in millions of square inches of silicon produced) has been analogous to the situation in die cost trends. Dataquest found that the initial capital cost of a state-of-the-art fab (facility and equipment) between 1970 and 1987 rose from $30 million to $225 million. During this same period, typical fab capacity rose from 70 million square inches of silicon per month to 565 million—a rate of increase slightly exceeding the growth rate of initial fab costs. As a result, the ratio of initial fab cost to monthly square inch capacity decreased from $422 per square inch to $398 per square inch—a decrease of 6 percent. This decrease was accounted for by both a doubling of the number of wafers a fab could produce and a doubling of the wafer size. From 1970 to 1987, wafer size doubled from 3 to 6 inches, and wafer capacity also doubled from 10,000 to 20,000 wafers per month.

Since 1987, however, initial fab costs for 6-inch wafer fabs have continued to rise while capacity has remained constant, resulting in an increase in the ratio of initial fab costs to capacity to $522 per square inch. Along with the concern over cost per die, semiconductor manufacturers will have to continue to increase wafer diameters in order to slow the rise in initial fab cost per square inch of silicon capacity. For 4Mb DRAMs, Dataquest analysts estimate that initial facility and equipment cost per square inch of capacity in a 6-inch wafer fab is over $500 per square inch. Making the switch to 8-inch wafers will lower this cost to under $400 per square inch. In terms of cost per die, the Dataquest DRAM manufacturing cost model supports Mr. Sear's observations by demonstrating that semiconductor manufacturers able to maintain yields and move to larger wafer sizes will have a tremendous cost advantage over those that have stayed with smaller wafers.

For these reasons, Dataquest expects to see 10- or 12-inch pilot lines announced in the mid-1990s, with widespread use of 12-inch wafers occurring around the turn of the century. Because it takes six to seven years to develop a new process, companies that expect to remain competitive must today be looking beyond the 8-inch wafer. The price of this transition will be considerable. According to Dr. Makimoto, the costs of producing 1 million DRAM devices have nearly doubled with each DRAM generation since the 64K: from $18 million with the 64K to $35 million with the 256K, $70 million for the 1Mb, $120 million for the 4Mb, and $210 million estimated for the 16Mb!

Redefining Elasticity. . .Rethinking Growth

In his speech at the 1987 Semiconductor Industry Conference, Dr. Moore acknowledged that "greater density at lower relative cost could not alone spur technological development over the long run because declining device prices would threaten the industry's profitability. Technological progress has also required expanding markets." From Dr. Moore's point of view, only by doubling the amount of electronics in the world each year could the semiconductor industry afford to offer smaller dimensions and higher functionality at lower relative prices. "Essentially," Dr. Moore stated, "economies of scale have allowed us to continue advancing the technology."

As a benefactor of the global electronics business, the characteristic pervasiveness of the semiconductor industry (marked by growth rates that exceed those of the markets it serves) can be attributed to the fact that the industry not only creates markets through invention but expands them through its ability to offer greater performance at lower cost. Based on Dataquest's observations, a 35 percent decrease in price per DRAM bit results in a doubling of unit volume. Clearly, with the introduction of the 1Mb DRAM, the fundamental economics of silicon-based memories have changed. A price reduction/learning curve of 80 to 85 percent might be more likely than the 70 percent seen in the past.

But does it necessarily follow that a fundamental change in DRAM price/performance curve will result in a less elastic market and therefore slower growth? This question depends partly on how one defines growth. Using the bit price model worked out in Dataquest's consulting group, going from a 35 percent decrease in price to a 15 percent decrease would, theoretically, result in a roughly 40 percent increase in unit volume—a far cry from the doubling of unit volume associated with a 35 percent decrease. By charging 85 percent of original cost instead of 65 percent, however, the dollar value of the DRAM market will still grow at a 20 percent rate versus the 30 percent associated with more aggressive price erosion.

The Memory Market: Bigger and More Diversified

Whatever actual change takes place in memory price per bit trends during the next decade, the consensus among major suppliers is clearly that it cannot be business as usual. It is, however, highly unlikely that this new world order of high-density memory will slow memory at the systems level. Although we forecast the worldwide electronic equipment market to grow at a compound annual growth rate of 8 percent during the next five years—a far cry from historic levels—this modest growth rate will result in a worldwide market of $1 trillion in 1995! And this market will continue to be hungry for memory. Dr. Makimoto believes that by the year 2000, worldwide per capita consumption of memory will rise from 160 kilobits (Kb) to 8Mb (based on a population of 6 billion)—about 50 times today's level.

It is likely that we are seeing the tip of the iceberg of memory demand. Regarding the PC, we can certainly identify continued growth in memory requirements being fueled by such advances as high-resolution graphics, digital video technology, and CD-quality sound. More importantly, these performance improvements are driving the evolution of the PC from a terse computer syntax to a user-friendly interface involving increasingly complex software. Quoting Mr. Sear: ". . .software designers—for the last five, possibly eight, years—never thought about the amount of memory the software was going to use. In fact, I believe that they treated memory as though it were infinite in size and zero in cost."

Perhaps as important as the growth in sheer demand for semiconductor memory will be the diversification of that demand and the opportunity it will create for manufacturers to address more value-added applications. The era of gigabit memory will coincide with the era of the 1 giga instruction per second (GIPS) processor. Hitachi's opinion is that this GIPS processor should allow for applications such as real-time language translation machines. Application-specific memory requirements will include PSRAMs (as an SRAM alternate), VRAMs (for graphics), field memory (for TV and graphics), and frame memory (for high-resolution video). All of these types of products, with their various speed grades, organizations, and packaging options, should lengthen the life cycle of each generation of DRAM. In addition, memory density and cost per bit should create a solid-state disk market by the late 1990s.

The extent to which today's DRAM suppliers may be rearranging their product mix and marketing strategies was reflected in a recent presentation to Dataquest analysts by NEC. Based on a figure illustrating the future product mix in the year 2000, NEC showed only one-third of its MOS memory revenue coming from commodity DRAMs—the rest would come from application-specific DRAM products. Hitachi talks of the future "Magic" chip—the combination of high-density DRAM memory and logic on the same piece of silicon.

Dataquest Perspective

However the DRAM market changes during the next 10 years, one aspect that will remain constant is the primary qualification for participation: lots of cash. What *will* change, however, is the legendary volatility of the commodity memory business—and therefore the profitability of participating in it. Reasons for this change are probably apparent from the issues discussed here and are as follows:

- As cash outweighs creativity in the DRAM business, the industry will consolidate further.
- The slowing of price-per-bit erosion will help preserve average selling prices.
- The politics of DRAM trade will make it less likely that the industry will be buffeted by cartel-like behavior or the purchasing of market share through dumping.
- Even as the commodity end of the business continues to be competitive, more diversified memory products will help bolster overall margins for suppliers.
- The integration of logic and memory in DRAMs and the possible lengthening of generation life cycles will extend the useful life of a memory fab and lower the costs of its depreciation.

Another advantage that will accrue to remaining in the DRAM business is the strength it will lend to a company's submicron manufacturing capability—and whether a company produces gate arrays, microprocessors, or DRAMs, it will be doing so at the submicron level if it plans to be at the leading edge. ■

By Michael J. Boss
Len Hills

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European DRAM Market Update—Welcome to the 4Mb

Introduction

Dataquest published its long-term outlook for the European DRAM market in March this year. This article focuses on the short-term issues that will affect the market up to the end of 1992. Our forecast is quarterly, and, where appropriate, updates are made to our March analysis. Special attention is given to the 4Mb DRAM as this product is approaching volume production and DRAM buyers are now considering their options.

Summary

The European DRAM market is in a state of transformation. Our quarterly forecast shows that the European DRAM market will grow in value by 10.9 percent in 1991, assuming a unit growth of 6.6 percent and an average selling price (ASP) growth of 4.0 percent. This is a promising recovery from 1990, which saw a 26.1 percent market decline caused by an ASP decline of 33.8 percent and a unit growth of 11.6 percent.

The European DRAM market is now in recovery following weak unit growth and rapid price erosion in 1990.

Three key changes have occurred in the market since we prepared our long-range European MOS Memory Consumption Forecast booklet. These are as follows:

- Total DRAM sales to the European market for 1990 have been finalized at $1,216 million. This is $76 million greater than the preliminary market size given in the booklet and is believed to include direct shipments of 1Mb devices from Japan.
- Poor first quarter results by major end users of DRAM have led us to revise the expected unit demand for the 1Mb in 1991.
- Market prices for the 1Mb increased substantially at the beginning of the second quarter of 1991. This development is believed to be related to the DRAM reference price agreement between Japanese companies and the European Commission, and it is discussed in detail later.

In summary, key assumptions for 1991 are:

- The 64K is experiencing a sharp decline in demand.
- The 256K shows general slowdown in production, leading to higher prices.
- The 1Mb shows slowdown in Japanese production, leading to higher prices.
- The 4Mb is ramping up in Japanese production, leading to price erosion.
- The 4Mb has reached price-per-bit parity with the 1Mb.
- The European PC market is growing at approximately 10.0 percent.
- No shortages are expected in 1Mb or 4Mb DRAMs.
- DRAM market growth is at 10.9 percent.
- DRAM market growth in 1992 will be at 34.9 percent.

Product Analysis

Price Trends

Japanese companies continue to be a major influence in the European market despite the fact that only two out of the top five suppliers to the European DRAM market in 1990 were Japanese. Those two are Toshiba and NEC, ranked second and fifth, respectively. In fact, the market share results belie the fact that in 1990 Japanese companies collectively served an estimated 47.1 percent of the European DRAM market. At the 4Mb density, this dominance is greatest, and currently stands at around 85.0 percent. Obviously then, any forces affecting the DRAM activities of Japanese companies will affect the marketplace.

The DRAM market of today is driven by application.

In January 1990, the European Commission entered into an agreement with Japanese DRAM manufacturers; it set minimum European price guidelines for Japanese DRAM products based on cost of manufacture. Dataquest believes that 1Mb and 4Mb DRAM reference prices (RPs) applied to Japanese-sourced DRAMs increased in the first quarter of 1991, followed by further growth in the second quarter. The cause was rising manufacturing costs, which are used to determine RPs. Japanese companies have been reducing production of 1Mb DRAMs, which has augmented unit costs, and hence the 1Mb RP.

The 4Mb DRAM RP increases are less easy to understand, but are believed to be caused by the late inclusion of some previously overlooked manufacturing costs by Japanese companies. The RP agreement allows for the correction of previously underestimated costs by adding the shortfall to current cost estimates. The scale of the rise in RP varies depending on the currency used, but the fact remains that these increases have been followed closely by growth in market prices.

Dataquest believes that Japanese companies do not always lose their business to non-Japanese competitors as a result of increases in reference prices. Some Japanese suppliers are believed to offer package deals, which maintain conformance to DRAM reference price levels, but include other products at discount. In this way, competitiveness can be maintained against suppliers not bound by DRAM reference prices. The net effect is that Japanese companies hold on to their DRAM customers, and the market ASPs reflect RP levels.

It is now vitally important to understand what the customer wants in order to ensure that the correct balance of options is made available to the market.

We found it necessary to integrate RP trend assumptions into our forecast, linked to how Japanese DRAM production capacity is utilized and affects the 1Mb and 4Mb:

- 1Mb RPs are expected to continue to rise throughout the forecast period.
- 1Mb market ASPs will follow a similar trend, but will be below 1Mb RPs. RPs will have progressively less effect on market ASPs as Japanese suppliers withdraw from this density.
- 4Mb RPs are expected to decline from the third quarter of 1991 to the end of the forecast period.
- 4Mb market ASPs will closely follow 4Mb RP trends as Japanese suppliers are expected to maintain leadership in this market throughout the forecast period.
- RP trends will show short-term deviations as a result of exchange rate fluctuations, DRAM production changes, and errors and corrections in cost projection.

Product Diversification

The DRAM market of the past was driven by technology, and users needed to design their systems around the product. The DRAM market of today is driven by application. The number of user options available for DRAM has increased with each generation, and currently exceeds 400 at the 4Mb density from some vendors. These options cover speed, configuration, package type, refresh mode, write mode, read mode, power consumption, and special modes. This excludes permutations possible from DRAM module configurations. It is now vitally important to understand what the customer wants in order to ensure that the correct balance of options is made available to the market.

Trends by Product

Dataquest has surveyed major European users of DRAM in order to produce a demand-driven quarterly forecast that has been balanced against production estimates from suppliers.

64K DRAM

From the beginning of the year, this part has experienced a sharp decline in demand. Users have finally chosen to move up to the 256K part, which is only 10 percent more expensive. The 64K and 256K DRAM ASPs are expected to converge and follow a similar upward trend through to the end of 1992. Dataquest believes that the timing of this move was inevitable. The number of suppliers of the 64K is dwindling, and as each one of them withdraws, the volume of supply will be reduced significantly.

The short-term outlook for the 64K market is . . . rapid decline.

Most vendors can effectively support three generations of DRAM, and so the imminent takeoff of the 4Mb market puts the 64K on borrowed time. Typical applications for the 64K include TV teletext buffers, satellite receiver memory, and small system memory upgrades. Even if some of these applications do not require the capacity of a 256K, the lower cost-per-bit and benefit of a more secure supply will prevail. The short-term outlook for the 64K market is therefore rapid decline.

256K DRAM

Demand for the 256K part has been in steady decline since mid-1989 when the price-per-bit of the 1Mb reached parity with it. Current supply of this part in Europe is mainly from non-Japanese vendors such as Samsung, Texas Instruments, and Siemens, and many of these plan to phase out the product by the close of 1991. Major European users of the 256K include telecommunications and computer manufacturers, with key applications being digital exchanges and PCs, respectively. These end users are finding that shortages of the part have led to higher prices.

Leading package options, in order of preference, are dual in-line package (DIP), plastic leaded chip carrier (PLCC), and zigzag in-line package (ZIP). The 1Mb, in 64K×16 and 256K×4 configurations, is a convenient replacement for the 256K in 64K×4 and 256K×1 configurations. The outlook for the 256K market is for continued decline in units coupled with increasing prices. Notices of withdrawal from the 256K market are expected to be announced by vendors throughout the year.

1Mb DRAM

This product has now reached maturity and is expected to peak in unit shipments in the third quarter of this year. Unit demand is expected to decline in the second half of 1991, and coupled with price erosion, will lead to a sharp drop in revenue. After the second quarter of 1992, 1Mb revenue will fall below that of the 4Mb. Key European applications of the 1Mb include most PCs, workstations, memory expansion modules, laser printers, and telecommunications equipment. Leading package options, in order of preference, are small outline J-leaded (SOJ), DIP, ZIP, and thin small-outline package (TSOP) type 2. Configuration options, also in order of preference, are 1Mb×1, 256K×4, and 64K×16. Access speeds vary from 120ns to 53ns, with most demand in the region of 80ns, though the trend is toward 70ns.

Japanese suppliers began cutting back on 1Mb production in the third quarter of 1990 as there was a slump in worldwide demand. This led to increases in 1Mb reference prices from the first quarter of 1991, which took the 1Mb user base by surprise. Many non-Japanese vendors have ramped up production in order to take up the excess business. This has led to Samsung becoming the world's largest producer of 1Mb DRAMs. However, this concerted effort has not prevented the 1Mb from becoming booked out or prices from rising in Europe.

Dataquest is of the opinion that 1Mb DRAM market prices in Europe will begin to diverge from reference price trends in the medium term.

The 1Mb price rise meant that the 4Mb part achieved price-per-bit parity with the 1Mb. We expect non-Japanese suppliers to reduce 1Mb prices again to delay users migrating to the 4Mb. However, there are complications to this effort, as the European Commission is investigating a number of South Korean DRAM suppliers accused of dumping DRAMs in Europe. Dataquest is of the opinion that 1Mb DRAM market prices in Europe will begin to diverge from reference price trends in the medium term.

Welcome to the 4Mb

This part is now at parity on price-per-bit with the 1Mb DRAM. Second-generation devices are becoming available, with package outlines and speeds that are attractive as replacements for the 1Mb. This article pays special attention to the future development of this market.

The growth of the 4Mb market through 1990 was dogged by continued price erosion of the 1Mb DRAM. This kept the price-per-bit of the 4Mb above that of the 1Mb for longer than would normally be expected. Added to this, 4Mb suppliers shot themselves in the foot by promising that the 4Mb would eventually have the same outline as the 1Mb. This would be achieved by releasing a second-generation 4Mb using 0.8µm design rules to replace the initial first-generation 1.0µm offering. This is believed to have given users cause for concern: the first-generation 4Mb in 350-mil SOJ might not last long before being made obsolete by its 300-mil SOJ successor. A wait-and-see attitude thus developed.

The growth of the 4Mb market is now finally under way. Our key 4Mb market assumptions are as follows in configuration options:

- 4Mb×1—Bit-wide organized versions of the 4Mb are required in large systems such as mainframe, mini-computers, and large dedicated systems. These users were some of the early adopters of the 4Mb. This organization currently accounts for 50 percent of the European market. It will represent a smaller share in the future, as strong growth in other applications is expected to demand wider organized 4Mb.
- 1Mb×4—Nibble-wide organized versions of the 4Mb are in demand for 80386/80486- and 68030/68040-based systems for main and expanded memory. This organization has remained popular from the earliest days of the 4Mb, although it lost some ground to the 4Mb×1 over the last two years. The outlook is for increased share of the 4Mb market, as OEMs of the above systems collectively move to the 4Mb from the 1Mb. Memory modules are also an important application for the 1Mb×4. As an example, a 1Mb×9-configured single in-line memory module (SIMM) can have its power consumption reduced by 67 percent and its height reduced by 18 percent when using two 4Mb (1Mb×4) DRAMs and one 1Mb (1Mb×1) DRAM instead of nine 1Mb (1Mb×1) DRAMs on the board.
- 512K×8—Byte-wide organized versions of the 4Mb are required in a number of portable systems such as notebook computers and in high-resolution output devices such as laser printers. Memory modules are also an important application for the 512K×8. As an example, the 512K×36-configured SIMM can have its power consumption reduced by 50 percent by using four 4Mb (512K×8) DRAMs and eight 256K (256K×1) DRAMs instead of sixteen 1Mb (256K×4) DRAMs and eight 256K (256K×1) DRAMs. Samples of this part are now becoming available from leading suppliers, with other vendors following by the end of this year. Versions of the 512K×9 configuration will be released simultaneously for users requiring a parity check facility on-chip. The outlook for this configuration is expected to be a relatively minor share in the medium term.
- 256K×16—Word-organized versions of the 4Mb are already in demand from users currently employing the 1Mb in a 256K×4 configuration. This covers a wide range of equipment, including systems based on 80386 and 68030 microprocessors. High-resolution displays also require this configuration. Samples of this part will become available from major vendors this quarter and from other vendors over the next 12 months. Some vendors have brought forward their release dates in response to strong interest from users. The 256K×18 versions will be released simultaneously for parity checking. The outlook for this part is for a significant share in the medium term.

The 4Mb market has no clear leader yet, though Hitachi and Toshiba are clearly ahead of the rest of the competition.

The 4Mb has a number of packaging options. All dimensions in the following list are based on 4Mb×1 and 1Mb×4 configurations. For 512K×8/9 and 256K×16/18 configurations, add 50 mil and 100 mil, respectively, to give a rough guide. Packaging options for the 4Mb are as follows:

- SOJ—This surface mount package is available in 350 mil from most 4Mb vendors. Second-generation 300-mil versions are now becoming available from leading vendors. This part is suitable for use on motherboards and modules in most systems. The SOJ is estimated to account for 85 percent of all European shipments today. This share is forecast to decline as other packages increase in popularity.
- ZIP—This through-hole package is available in 400 mil from most vendors. Second-generation 300-mil versions are now being test-marketed in through-hole and surface-mount versions. This part is suitable for motherboard mounting in large systems where small footprint and heat dissipation are major issues.
- TSOP type 1—This surface-mount package is now available in 315 mil from leading vendors. Second-generation versions featuring smaller outlines will be available in the second quarter of this year. This part is suitable for high-density mounting on motherboards, modules, and, most importantly, memory cards. The availablity of reverse-pinout versions allows for maximum mounting density when required. However, the fine pin pitch (0.5mm) of this device makes it difficult to mount, and is expected to be used only in

applications where minimum board space is a critical consideration. The future for this package is mainly dependent on the market for memory cards, which is expected to take off strongly in the medium term. Development of memory cards is particularly advanced in Japan.

- TSOP type 2—This surface-mount package is available in 450 mil from most vendors. Second-generation 300-mil versions are now also becoming available from leading vendors. The main benefit of this part is that it has the same height as TSOP type 1 and the same footprint as the second-generation SOJ. However, it is easier to mount than TSOP type 1 because the pin pitch (1.27mm) is greater. Applications will be a cross between those for SOJ and TSOP type 1. The outlook for this part is for significant market share in the medium term.
- Others—This category includes DIP and tape-automated bonding (TAB). DIP is a through-hole part and is believed to be available from only one manufacturer to date. It is suitable for small-volume custom equipment where small outline is not a concern and assembly facilities are primitive. The outlook for this part is as a niche option. TAB is a low-profile surface-mount part and is expected to be used in portable applications such as memory cards and notebook computers. The outlook for this part is mainly dependent on the market for memory cards, which is expected to take off in the medium term, as discussed earlier.
- Modules—This category includes padded SIMMs and pinned single in-line packages (SIPs). Modules currently account for a high proportion of 4Mb DRAM shipments and stood at an estimated 70 percent of all 4Mb shipments in the first quarter of 1991. Modules are suitable for memory expansion and dense motherboard assemblies. They are expected to continue to account for a major part of the market, although TSOP and second-generation ZIP will steal some of this business.

16Mb DRAM

Samples of this product are available now from leading suppliers. It is available in 400-mil SOJ, ZIP, and TSOP type 2. Access speeds range from 60ns to 100ns, with the most popular at 70ns, and a trend is expected toward 60ns. Current configurations are 16Mb×1 and 4Mb×4, with plans for 2Mb×8 and 1Mb×16 by the end of 1992. Internal voltages range between manufacturers but are understood to be 3.3V or 4.0V, as opposed to 5.0V standard for preceding generations. External voltages are 5.0V in all versions, but users may find the internal voltage better to work with, especially if the 16Mb is for use in portable equipment. The outlook for the 16Mb market is for general prototyping demand beginning in the first half of 1992.

Dataquest Perspective

The European DRAM market is now in recovery following weak unit growth and rapid price erosion in 1990. The end of the Gulf war has released a wave of pending orders, reflected in the very high DRAM book-to-bill ratios of leading suppliers in recent months. Some of these orders are likely to have been prompted by the news that DRAM reference prices were to increase again in the second quarter of this year. Orders of this nature tend to be soft. Dataquest believes that these are a minority, and the majority of recent orders are firm. However, the second half of 1991 is expected to be weak in terms of new orders, leading to a mild growth of 10.9 percent in total revenue. The year 1992 should see a stronger market, with 34.9 percent growth in revenue.

Diversification will be the name of the game.

The availability and pricing of the 4Mb now makes it an attractive proposition in Europe. Users are looking hard at their options and are generally believed to be ready to take up the successor to the 1Mb. The 4Mb supplier needs to be ready to supply the options its customer wants. This is a task to be undertaken with forethought, especially for those suppliers with the responsibility of investing in European fabrication facilities. The 4Mb market has no clear leader yet, though Hitachi and Toshiba are clearly ahead of the rest of the competition. Ultimately, the successful players of the 4Mb market will be determined by the customer base that will place orders with those suppliers offering the right product mix. Diversification will be the name of the game. ■

By Byron Harding

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In Future Issues

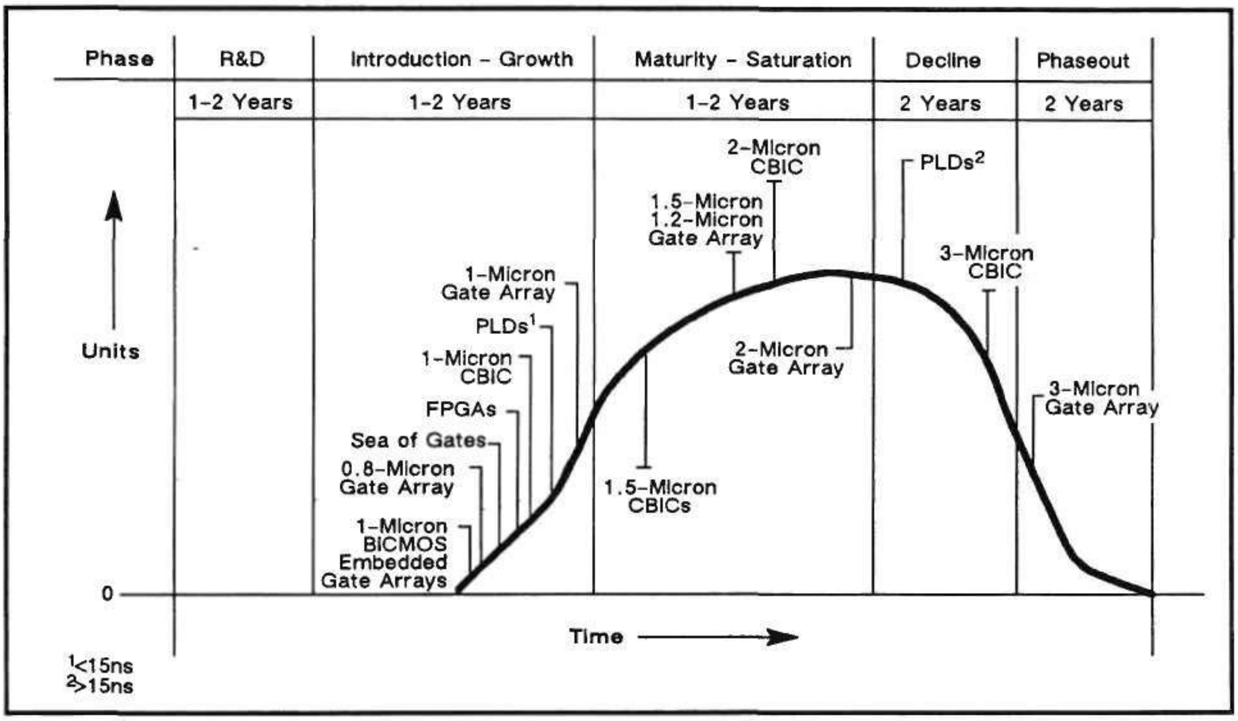
The following topics will be featured in future issues of *Dataquest Perspective:*

- Semiconductor product update
- Semiconductor capital spending update
- TAB package trend/outlook
- June Market Watch

Errata

In the article entitled "A User's Perspective on ASICs—Supplier Base, Technology Cycles, and Product Choices," in Semiconductor Procurement *Dataquest Perspective* Vol. 1, No. 5, Figure 1 was incorrectly depicted. The revised figure correctly shows the decline and phaseout stages of slow PLDs and 3-micron ASIC families, as well as the status of field-programmable gate arrays (FPGAs).

Figure 1
ASIC Product Technology Life Cycles as of May 1991
(Production Unit Volumes)



Source: Dataquest (May 1991)

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 5 **May 28, 1991**

Regional Pricing Update

DQ Monday Report
Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.11	0.11	0.09	0.13
74HC138	0.14	0.15	0.15	0.17	0.15	0.21
74HC244	0.21	0.30	0.22	0.23	0.21	0.34
74HC74	0.12	0.12	0.13	0.11	0.10	0.17
Lead Time (Weeks)	4	3	4	5	5	5
339-COM	0.14	0.15	0.12	0.13	0.11	0.13
741-OP AMP	0.13	0.24	0.11	0.13	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.09	0.08	0.07	0.10
74LS138	0.15	0.12	0.15	0.13	0.12	0.14
74LS244	0.21	0.24	0.22	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.10	0.10	0.12
Lead Time (Weeks)	4	2	6	4	5	5
DRAM 1Mbx1-10	4.63	4.63	5.00	4.50	4.60	5.20
DRAM 256Kx1-10	1.55	1.63	1.80	1.30	1.40	1.50
DRAM 256Kx4-10	4.65	4.81	5.00	5.00	4.60	5.20
DRAM 4Mbx1-8	18.00	21.32	20.00	20.00	19.90	NA
DRAM 64Kx4-10	1.60	1.67	2.00	1.70	1.50	1.50
EPROM 1Mb, 200ns	4.80	5.53	5.00	5.50	5.20	4.20
EPROM 256K, 200ns	1.83	2.06	2.00	1.75	1.65	1.55
SRAM 1MB, 128Kx8	18.00	18.79	14.50	NA	NA	NA
SRAM 256K, 32Kx8	4.25	4.19	4.25	4.95	4.90	4.80
SRAM 64K, 8Kx8	1.65	1.55	1.75	1.23	1.40	1.55
Lead Time (Weeks)	6	4	4	2	7	3
68000 12MHz	4.95	4.70	5.30	4.00	3.10	4.00
68HC11	8.40	7.95	8.00	8.75	8.60	NA
80286 12MHz	6.50	14.09	8.00	9.35	9.70	6.80
80386SX-16	54.00	54.19	53.00	64.50	65.00	57.00
8051	1.65	2.03	1.90	2.50	1.80	1.80
Lead Time (Weeks)	4	4	4	3	4	6

NA = Not available
Source: Dataquest (May 1991)

Market Analysis

May Market Watch: Semiconductor Market Strong While System Shipments Remain Static

The *Market Watch* is a monthly Dataquest article that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

The Book-to-Bill Jumps to 1.15, Billings Normal for April

Figure 1 illustrates the relative strength of the past three months' semiconductor market compared with the prior three month period. April's preliminary book-to-bill ratio of 1.15 is the highest recorded since last May's 1.15 reading. Looking at the actual numbers, billings declined an understandable 16 percent in April from March, primarily due to the shift from March's five-week billing period to April's four-week month. Compared with February (the nearest four-week month), April billings are off 1.6 percent. On the bright side, April 1991 billings are 3.2 percent higher than April 1990. The booking level is what is causing the high rise in the book-to-bill ratio, which raises a valid question: How will this increase in orders be absorbed by a flat systems market? April's three-month

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

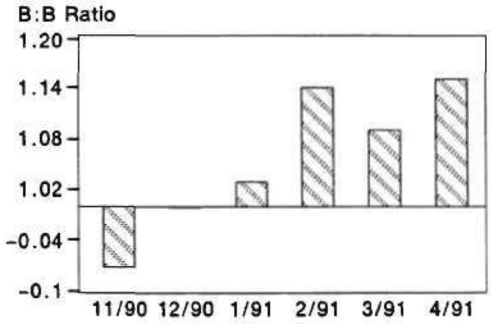


Figure 2
DOC Computer Demand

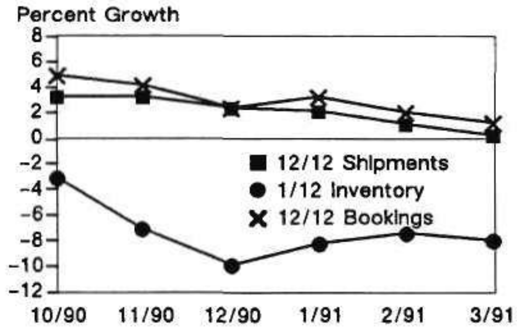


Figure 3
Semiconductor Inventory Level

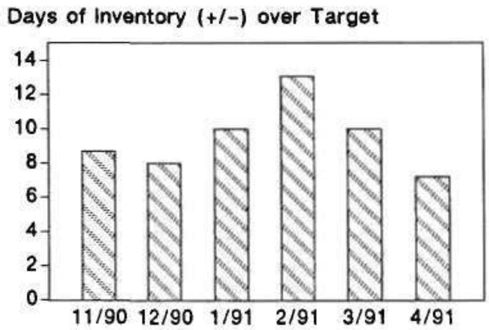
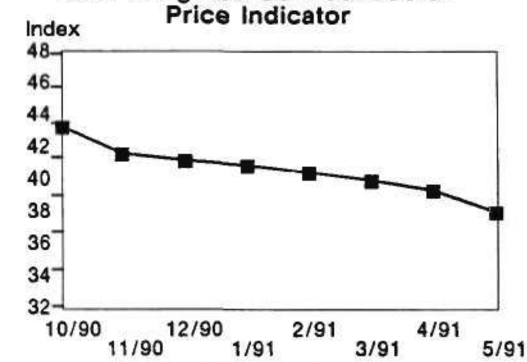


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (May 1991) moving average booking level exceeded March by 6.2 percent while totally surpassing January's (the last quarter beginning month) level by 19.9 percent. The momentum of increased order activity ties in with an improved economic environment (improved consumer confidence, lower interest rates) and the optimistic system sales outlook noted in this May's *Procurement Pulse*.

Computer Bookings, Shipments, and Inventory Rates Stagnate

As seen in Figure 2, the Department of Commerce's data note a slight decline in all three rates of change that we track. Although the 12/12 booking and shipment rates remain positive, a respective positive 1.3 percent and positive 0.3 percent does not reflect moderate growth. These annualized growth rates compare with last month's bookings rate of positive 2.1 percent and a shipment rate of positive 1.2 percent. The 1/12 inventory rate declined slightly from March's negative 7.3 percent to the current negative 7.9 percent, reflecting how inventories of systems are matching the sluggish market. The flatness in the computer market is not being impeded by any product shortages or lead time delays per our procurement surveys. An upturn in demand (as expected by our procurement survey respondents) would be ably handled by the level of semiconductor capacity on hand.

Semiconductor Inventories Controlled Further

Based on our latest procurement survey, overall inventory levels were pared below the 30-day level to an average of 27 days! Both target and actual average levels declined, resulting in a 7.2 day difference compared with last month's delta of 10 days as illustrated in Figure 3. This tight control of inventories reflects the improved levels of communications between semiconductor suppliers and users as well as the ongoing efforts to control costs in a flat market. Low inventory levels of components are a positive sign that reflects efficient operations and flexibility to react to quickly changing demand levels.

Prices S-L-O-W-L-Y Decline, Availability Excellent

Compared with last month, the only difference in pricing occurred in the memory area, causing the overall index to dip by 3.3 percent as seen in Figure 4. The overall market can currently be described as "in balance." Dataquest is beginning to hear of isolated below average pricing for 1Mb DRAMs from non-Japanese suppliers. Although currently the exception, this pattern of pricing was forecast back in February as a probable reaction to 1Mb DRAM production cutbacks by the major Japanese producers. With demand levels being adequately handled by current supplies, Dataquest expects to see more competition in the DRAM market, especially if (as noted in the last *Dataquest Perspective*) the FMV system is abolished. The high-end microprocessor market may be in line for some long-overdue competition *if* Advanced Micro Devices gets a favorable ruling regarding the use of "386 type" microcode. Dataquest is closely following these developments and will report on them as more information becomes available.

Dataquest Perspective

The continued strength of the semiconductor market appears to be a leading indicator of where the electronics industry is heading. The overall economy and electronics market currently are in a no/slow growth phase that is expected to improve over the next two quarters based on the availability of money, anticipated consumer confidence, and increased demand. Gradual improvements in system shipments/demand are not expected to strain the supply line of semiconductors as long as accurate and frequent forecasting occurs and low inventory levels are maintained.

By Mark Giudici

Second Quarter 1991 Semiconductor Industry Outlook: Recovery in a Maturing Industry

Introduction

Following a year in which the worldwide semiconductor industry grew less than 2 percent, an industry recovery is under way that Dataquest believes will result in dollar-based consumption growth of 13.7 percent in 1991. This is equivalent to 9.6 percent growth if constant 1990 exchange rates are used against the dollar. With first quarter results available already for the North American and European markets (which grew at approximately 3 and 11 percent, respectively, from fourth quarter 1990), it is clear that a turnaround has occurred. We expect every quarter this year to have positive growth worldwide; however, this will not be true for every region.

We have lowered our long-term growth rate expectations for the worldwide industry to 12.6 percent from 1990 to 1995. (Our previous expectation was 14 percent.)

Key events and assumptions driving our short- and long-term forecasts are as follows:

- Memories, microcomponents, and MOS logic are leading the industry recovery in 1991.
- Fluctuations of European and Japanese currencies against the U.S. dollar are skewing 1991 dollar growth upward.
- The European and Asian semiconductor markets are the hotbeds of activity for both the near and long term.
- As electronic equipment becomes an ever-larger component of the worldwide economy, semiconductor growth rates are slowing.
- The historical cyclicality of the industry, while still visible, has moderated.

Dataquest Forecast Scorecard

How good have our forecasts been in the past? As shown in the scorecard in Table 1, our forecast accuracy has improved over the last several years. In fact, we called 1989 and 1990 almost right on. But even in our forecasts of 1987 and 1988, we called the direction and general magnitude correctly.

In February, we forecast that first quarter 1991 growth in the North American market would be 1 percent and that the European market would grow by 6 percent. The actuals, per the WSTS flash report, were 3 percent and 11 percent, respectively.

Short-Term Outlook

Currency fluctuations are skewing our dollar-based growth outlook for 1991. As shown in Table 2, growth rates in local currencies are actually rather modest this year. The Japanese market will grow less than 9 percent in yen, but an astounding 17 percent in dollars. The European market will grow less than 10 percent in ECUs, but 15 percent in dollars. The North American and Asia/Pacific-Rest of World (ROW) markets, which we forecast only in dollars, will grow at 7.9 and 15.2 percent, respectively. All of this will yield dollar-based worldwide growth of 13.7 percent this year; using constant exchange rates, the growth will be only 9.6 percent.

Figure 1 shows our quarterly growth expectations worldwide. It is important to note, however, that we expect virtually all North American growth to occur in the first two quarters of the year. We are forecasting no growth in the last two quarters of 1991 in North America. The April WSTS flash report confirms our outlook for the second quarter. In Japan, we believe that the first quarter declined from fourth quarter 1990, and we forecast growth to pick up through the rest of the year. Europe, as mentioned earlier, had 11 percent growth in the first quarter. Even with slow growth in the second quarter and negative growth in the third quarter, Europe will have a good showing on an annualized basis. We forecast negative growth in the first quarter for Asia/Pacific-ROW, with strong growth in the next two quarters.

A pickup in DRAM pricing and a strong PC market are current market drivers. Our contacts tell us that the PC market weakness being experienced in the North American market is not occurring in Europe and Asia. In fact, many companies are experiencing their strongest business from the PC area. For the remainder of this year, we expect the telecom market to carry European semiconductor consumption.

Long-Term Outlook

General Trends

From its beginnings in the mid-1950s, through 1990, the worldwide semiconductor industry grew at a compound annual growth rate

Table 1
Dataquest Forecast Scorecard: Forecast of Worldwide Industry Growth (Percent Growth—Forecast versus Actual*)

Year Being Forecast	Forecast Growth (%)	Actual Growth (%)
1987	18	24
1988	24	33
1989	10	12
1990	2	2
1991	15	??? Current forecast = 13.7

*The actual is determined at the completion of our final market share project in the second quarter of the year following the forecast year.
Note: The forecasts were made in October of the year preceding the forecast year.
Source: Dataquest (May 1991)

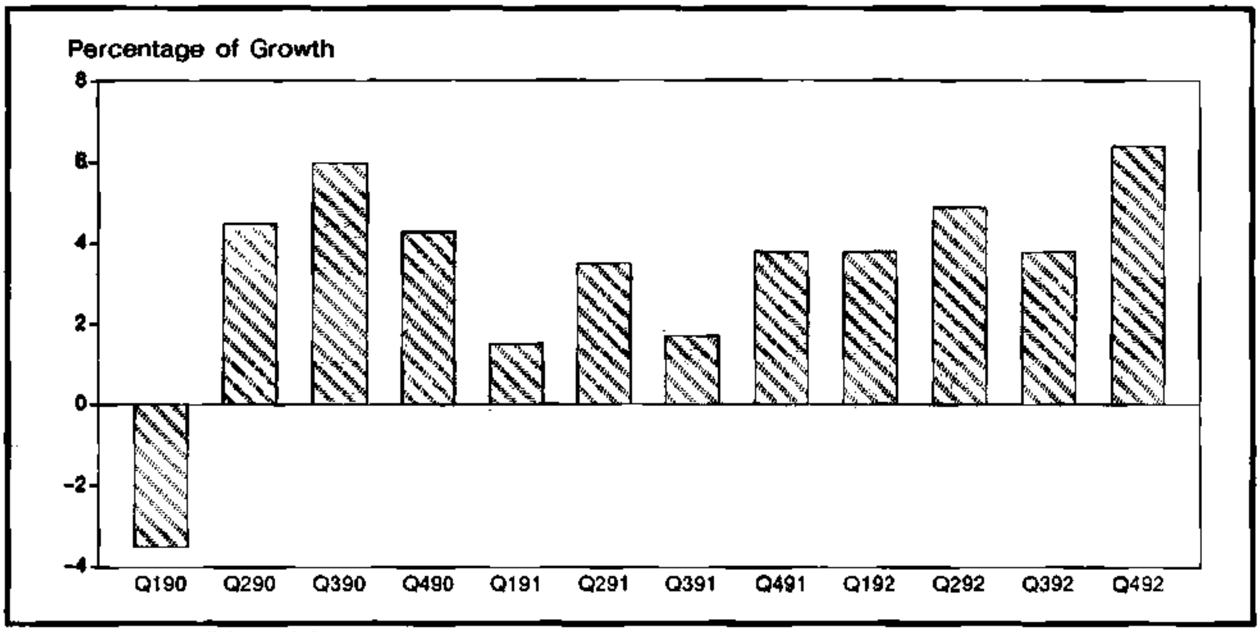
Table 2
Worldwide Semiconductor Consumption by Region
(Factory Revenue in Dollars and Local Currencies)

Company:	All	Distribution Channel:	NM
Product:	Total Semiconductor	Application:	All
Region of Consumption:	Each	Specification:	All

	1990	1991	Percent Change 1990-1991	1995	CAGR (%) 1990-1995
North America ($M)	17,386	18,761	7.9	28,001	10.0
Japan ($M)	22,508	26,354	17.1	40,762	12.6
Japan (¥B)	3,241	3,529	8.9	5,458	11.0
Europe ($M)	10,661	12,274	15.1	20,764	14.3
Europe (EcuM)	8,384	9,206	9.8	15,573	13.2
Asia/Pacific-ROW ($M)	7,670	8,834	15.2	16,004	15.8
Worldwide ($M)	58,225	66,223	13.7	105,531	12.6
Worldwide ($M at Constant Exchange Rate)	58,225	63,818	9.6	101,574	11.8

NM = Not meaningful
Source: Dataquest (May 1991)

Figure 1
Worldwide Semiconductor Consumption Quarterly Growth
(Percent Change in Dollars)



Source: Dataquest (May 1991)

(CAGR) of 18.8 percent. However, the fastest growth occurred between 1970 and 1980. Since 1980, growth has slowed; the 1980-through-1990 CAGR was only 15.2 percent.

Through most of its history, the industry has been cyclical, reaching peaks of growth every four to five years. The magnitude of the peaks and valleys has been very large, reaching peaks of as much as 40 percent growth and valleys of as much as a 15 percent decline.

We believe that the long-term trend toward slower growth will continue. We are forecasting a CAGR of 12.6 percent from 1990 through 1995. In addition, we believe that the cyclicality of the industry, although still in evidence, will abate considerably in magnitude. We do not foresee annual growth approaching even the 25 to 30 percent range in any one year. Figure 2 shows the worldwide industry size in dollars from 1970 through 1995. Figure 3 shows the annual percentage of change for each year.

Reasons for Changes in Trends

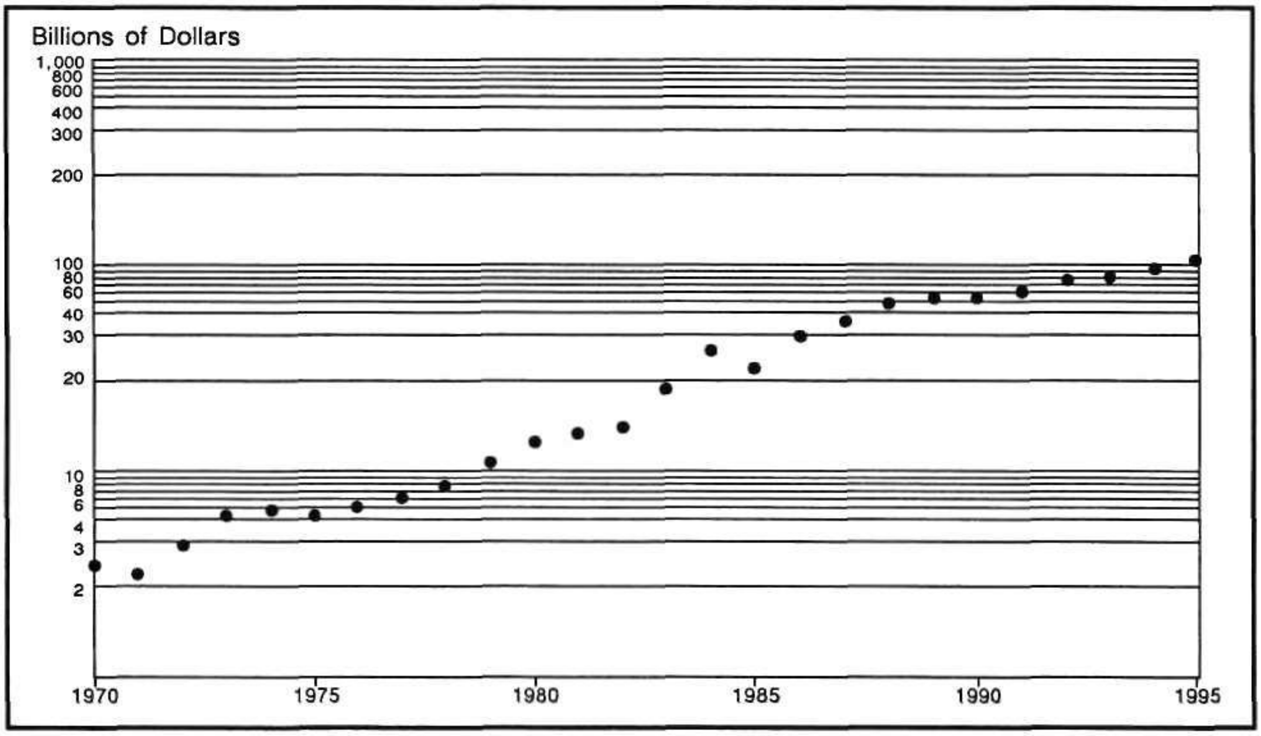
Some reasons for generally slower growth and moderation of the silicon cycle are as follows:

- In the United States, electronic equipment production is approaching 4 percent of GNP. As other industries have reached this rate, they have begun to grow in line with GNP growth rather than at a higher rate. In addition, many U.S. semiconductor and electronic equipment companies are building new manufacturing plants in Europe to capitalize on 1992 and the high growth that is currently being experienced and is expected to continue in that market. We forecast electronic equipment production in North America to grow at a 5.3 percent CAGR from 1990 through 1995.
- In general, most industrialized economies are now growing at a slower rate than in the 1980s. This is particularly true for the United States and Japan, both of which are moving manufacturing operations overseas to Europe and Asia. We forecast Japanese electronic equipment production to grow at a CAGR of 7.3 percent from 1990 through 1995. The biggest areas of activity during this period will be Europe and Asia/Pacific-ROW, with electronic equipment production CAGRs of 9.0 and 12.7 percent, respectively.
- There is no single product visible to us that can fuel the industry in the way that the hand-held calculator and the personal computer did in their early years.
- Improved relationships between semiconductor vendors and users have led to better inventory control by users and better capacity planning by vendors. In the past, poor management of these two variables has led to double and triple ordering and severe overcapacity situations.

The Forecast

Table 3 shows our forecast by region from 1990 through 1995. We expect the next market peak to occur in the 1992-to-1993 time frame, in keeping with historical cyclicality and the

Figure 2
Worldwide Semiconductor Consumption Long-Term Trend
(Factory Revenue in Billions of U.S. Dollars)



Source: Dataquest (May 1991)

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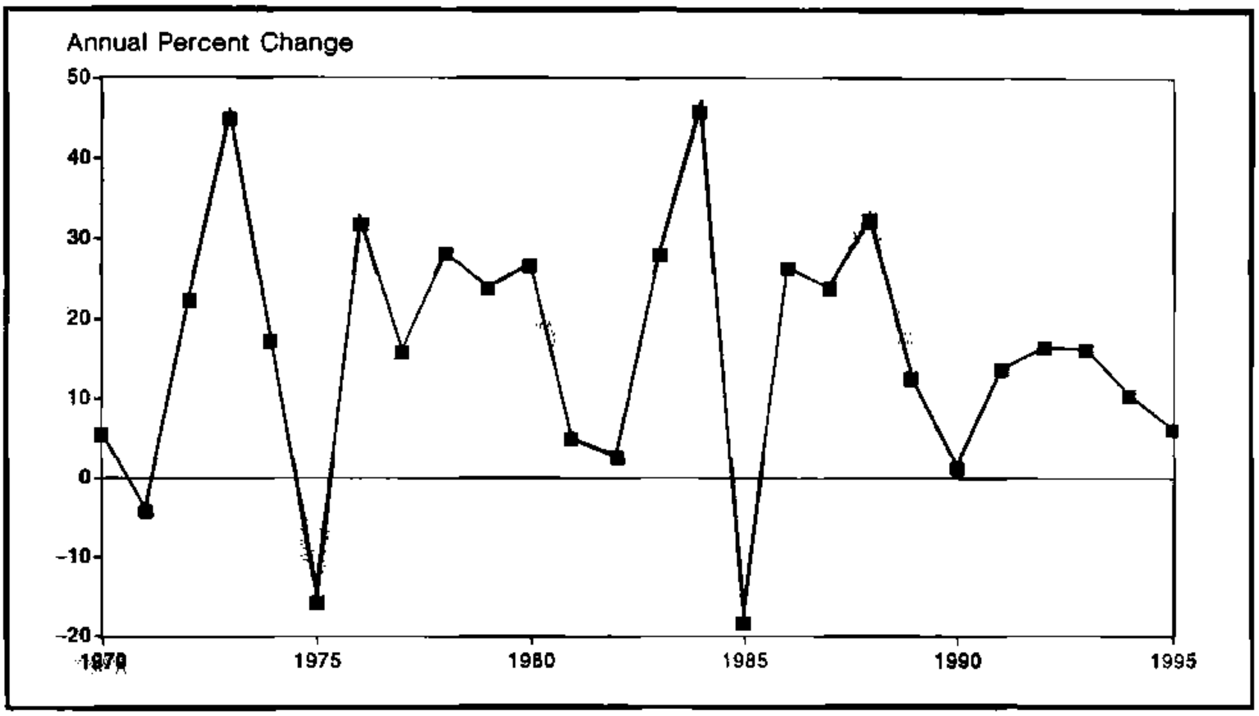
Figure 3
Worldwide Semiconductor Consumption Long-Term Trend
(Annual Percentage Change)



Source: Dataquest (May 1991)

Table 3
Worldwide Semiconductor Consumption by Region
(Factory Revenue in Millions of Dollars)

Company:	All	Distribution Channel:	NM
Product:	Total Semiconductor	Application:	All
Region of Consumption:	Each	Specification:	All

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
North America	17,386	18,761	21,386	24,810	26,895	28,001	10.0
Percent Change	-3.1	7.9	14.0	16.0	8.4	4.1	
Japan	22,508	26,354	30,762	34,655	38,200	40,762	12.6
Percent Change	-2.1	17.1	16.7	12.7	10.2	6.7	
Europe	10,661	12,274	14,416	17,313	19,326	20,764	14.3
Percent Change	9.3	15.1	17.5	20.1	11.6	7.4	
Asia/Pacific-ROW	7,670	8,834	10,625	13,025	14,804	16,004	15.8
Percent Change	17.6	15.2	20.3	22.6	13.7	8.1	
Total Worldwide	58,225	66,223	77,189	89,803	99,225	105,531	12.6
Percent Change	1.8	13.7	16.6	16.3	10.5	6.4	

NM = Not meaningful
Source: Dataquest (May 1991)

traditional market drivers of U.S. presidential elections and the Olympic games. We believe that the market will soften slightly in 1994 and 1995. Throughout the forecast period, we expect Europe and Asia/Pacific-ROW to consistently outperform North America and Japan.

Table 4 shows our worldwide semiconductor forecast by product category. We expect MOS memory and MOS microcomponents to continue to be the fastest-growing product categories. Analog and MOS logic will also do well. (We include mixed-signal analog/digital integrated

Table 4
Worldwide Semiconductor Consumption by Product Category
(Factory Revenue in Millions of U.S. Dollars)

Company:	All	Distribution Channel:	NM
Product:	Each	Application:	All
Region of Consumption:	Worldwide	Specification:	All

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Total Semiconductor	58,225	66,223	77,189	89,803	99,225	105,531	12.6
Percent Change	1.8	13.7	16.6	16.3	10.5	6.4	
Total IC	47,303	54,103	64,221	75,522	83,934	89,840	13.7
Percent Change	0.8	14.4	18.7	17.6	11.1	7.0	
Bipolar Digital	4,440	4,624	4,668	4,683	4,480	4,256	-0.8
Percent Change	-1.6	4.1	1.0	0.3	-4.3	-5.0	
Bipolar Memory	459	440	423	433	402	375	-4.0
Percent Change	-15.0	-4.1	-3.9	2.4	-7.2	-6.7	
Bipolar Logic	3,981	4,184	4,245	4,250	4,078	3,881	-0.5
Percent Change	0.3	5.1	1.5	0.1	-4.0	-4.8	
MOS Digital	32,292	37,709	46,294	55,628	62,243	66,906	15.7
Percent Change	-2.2	16.8	22.8	20.2	11.9	7.5	
MOS Memory	13,091	14,974	18,798	23,001	26,078	28,283	16.7
Percent Change	-20.0	14.4	25.5	22.4	13.4	8.5	
MOS Microcomponent	10,068	12,118	14,907	17,917	20,076	21,604	16.5
Percent Change	22.8	20.4	23.0	20.2	12.1	7.6	
MOS Logic	9,133	10,617	12,589	14,710	16,089	17,019	13.3
Percent Change	7.9	16.2	18.6	16.8	9.4	5.8	
Analog	10,571	11,770	13,259	15,211	17,211	18,678	12.1
Percent Change	12.6	11.3	12.7	14.7	13.1	8.5	
Total Discrete	8,235	9,112	9,714	10,721	11,342	11,513	6.9
Percent Change	7.5	10.6	6.6	10.4	5.8	1.5	
Total Optoelectronic	2,687	3,008	3,254	3,560	3,949	4,178	9.2
Percent Change	2.3	11.9	8.2	9.4	10.9	5.8	

NM = Not meaningful
Source: Dataquest (May 1991)

circuits, a very fast-growing technology, in the Analog category.) We expect bipolar digital memory and logic to continue to decline as this technology is replaced by high-speed CMOS and BiCMOS.

Dataquest Perspective

The semiconductor industry of the 1990s will be different than that of the 1980s. Growth will be more moderate and less cyclical, as the electronics industry in general becomes a large enough component of the world economy to be driven by it, rather than to drive it.

Although growth rates will not be as high and as dynamic as in the past, opportunities still exist. The geographic regions of greatest opportunity will be Europe and Asia, driven by growing economies, communications standardization, and both new and reindustrialization. The applications with greatest opportunity will be personal communications, personal data processing equipment (such as laptop and palm-top PCs, personal faxes), workstations, and—particularly in Europe—transportation. ■

By Patricia S. Cox

Product Analysis

A User's Perspective on ASICs—Supplier Base, Technology Cycles, and Product Choices

Executive Summary

Based on Dataquest's final estimate of suppliers' 1990 application-specific IC (ASIC) market shares and related information, this report examines the technology life cycle for ASIC products as of May 1991 and provides users with an evaluation of the supply/supplier base for these ICs during the 1990s.

Overview

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

This article focuses on gate arrays and CBICs. It provides ASIC users with practical and strategic information for choosing which devices to use and from which supplier or suppliers. (This report replaces the "Application-Specific IC (ASIC) Product Trends" section of the *Industry Trends* binder of the former Semiconductor User Information Service.)

As in the former product trends series, this article contains three sections. The first section develops a guide to cost-effective, long-term procurement by analysis of the ASIC technology migration path. The second section examines the product strategies, merchant/captive market postures, and strategic alliances of the leading ASIC suppliers. The third section combines the analyses of ASIC life cycles and the supplier base. This formation gives users a practical way of assessing their ability to obtain a supply of these devices from the various suppliers during the 1990s. Cumulatively, this information enables users to develop a sound strategy for satisfying ASIC demand on a consistent cost-conscious basis over the long term, despite shifts in supplier base.

ASIC Technology Life Cycles

This section uses information on ASIC product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. To some extent, an ASIC does not easily lend itself to product life cycle analysis because an ASIC is as much a technology as a product. Nevertheless, a look at ASIC product technology life cycle curves can assist users in positioning ASIC products among other IC life cycles such as standard logic. For example, although any given gate array is not at a specific point on the life cycle curve, the various gate array technology levels as measured in line geometry tend to follow the movement of the curve.

Figure 1 shows the life cycle stage for gate arrays, CBICs, field programmable gate arrays (FPGAs), and PLDs as of May 1991.

Figure 1 shows that the ASIC product technology life cycle, which runs six to eight years excluding R&D, is shorter than most IC life cycles. ASICs can hit the peak stage as soon as the third year following introduction.

Figure 1 shows that 3-micron gate arrays will be phased out in the next several years. The 3-micron CBIC is now approaching the phaseout period. The 2-micron gate arrays and 2-micron CBICs are nearing the decline stage—with phaseout to occur about 1995.

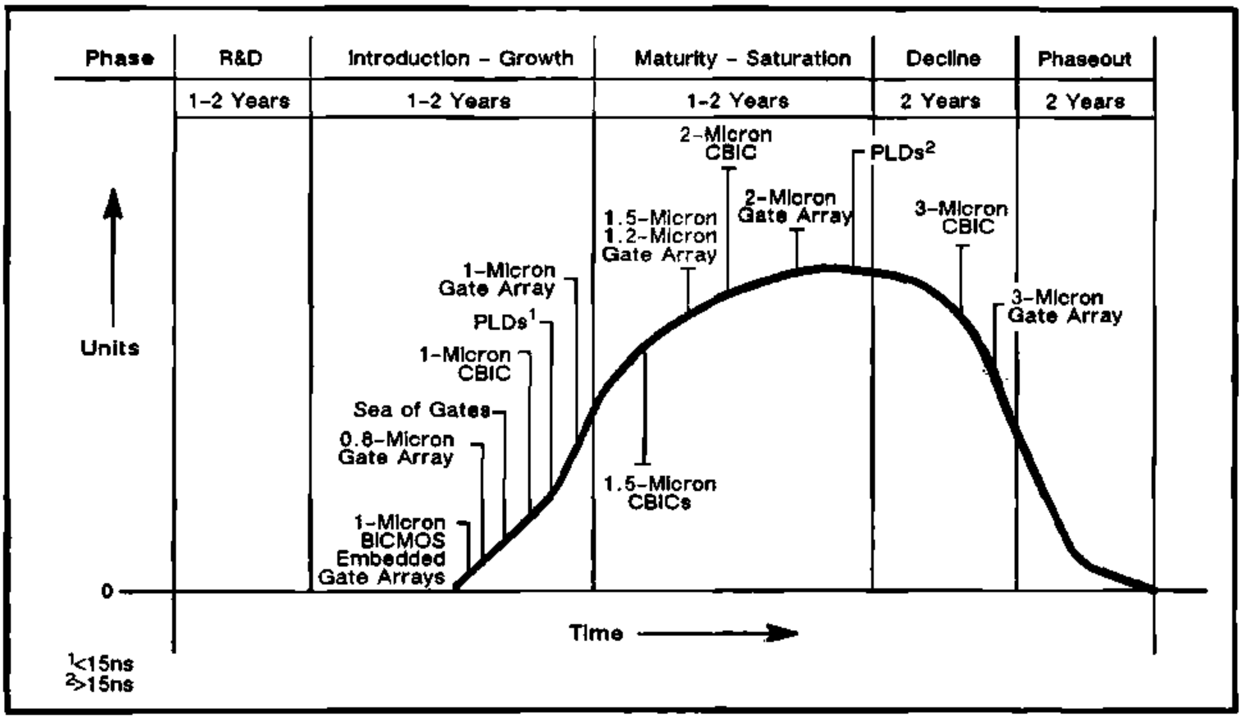
As depicted by Figure 1, 1.5-micron gate arrays, 1.2-micron gate arrays, and 1.5-micron CBICs are now approaching the peak or maturity stage of the life cycle. Their life cycle should extend until 1996 or longer.

The life cycle of ASICs, which are in the growth stage, should extend until 1998. As shown in Figure 1, these devices include 0.8- and 1.0-micron gate arrays, 1.0-micron CBICs, sea of gate arrays, FPGAs, and 1.0-micron BiCMOS gate arrays.

Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of ASIC products. This analysis covers product positioning, market ranking, and related issues.

Figure 1
ASIC Product/Technology Life Cycle as of May 1991
(Production Unit Volume)



Source: Dataquest (May 1991)

Table 1 shows Dataquest's final 1990 worldwide ASIC market share ranking of the top fifteen suppliers in dollars. The information in this table serves as the background for the analysis of the top 10 suppliers and also the analysis of product life cycles by supplier.

Fujitsu

Fujitsu continues to maintain its stature as the top-ranked supplier of ASICs in terms of total factory revenue, which consists of captive consumption and merchant market sales. Fujitsu's position as a vertically integrated electronics manufacturer means competitive economies of scale for ASIC production.

Table 1 shows that Fujitsu ranks first among suppliers of bipolar gate arrays and second in the CMOS array business. The company is also one of the early leaders in the emerging BiCMOS gate array segment. Fujitsu holds fifth position among suppliers of CBICs. ASIC users can expect a firm commitment by Fujitsu to serve demand for these products.

Fujitsu has earned an excellent reputation in the merchant marketplace as a supplier of bipolar ECL and TTL gate arrays. Fujitsu maintains a strategic alliance/ownership interest with Amdahl for supplying ECL gate array products that are used in Amdahl's high-performance computers. The company supplied no PLDs at the time this article was written.

Fujitsu is the top-ranked supplier of ASICs in terms of total revenue (that is, captive consumption plus merchant market sales), while LSI Logic leads in terms of merchant market sales of ASICs.

NEC

Second-ranked NEC also capitalizes on its position as a vertically integrated manufacturer to achieve economies of scale in ASIC production. Table 1 shows that NEC ranks third among suppliers of CMOS gate arrays and second in the bipolar (ECL) array business. The company is the early leader in the nascent BiCMOS array arena. These products represent an important part of NEC's future product direction in ASICs.

NEC currently ranks 13th among suppliers of CBICs; however, users can expect it to make a

Table 1
ASIC Suppliers Ranking (Factory Revenue in U.S. Dollars)

1990 Overall Ranking	Market Share (Percentage)	Company	Product Ranking: Gate Arrays MOS	Bipolar	BiCMOS	CBICs	PLDs CMOS	PLDs Bipolar
1	13.0	Fujitsu	2	1	3	5		
2	9.1	NEC	3	2	1	13		
3	7.5	LSI Logic	1		6	12		
4	6.2	Toshiba	4			7	17	
5	5.7	Texas Instruments	16	14	7	2	14	2
6	5.4	Hitachi	5	3	2	25		
7	5.4	AT&T		5		1	17	
8	4.5	AMD		12			4	1
9	3.4	HP				2		
10	3.1	VLSI	11	·		4		
11	2.6	Motorola	12	4	4			
12	2.3	GEC Plessey	8	7		11	14	
13	2.1	National Semiconductor	9	8		26	8	4
14	1.7	Oki	6	13		24		
15	1.7	Seiko-Epson	7			15	13	
Subtotals of Segments ($B)			2.56	1.17	0.13	2.09	0.41	0.42
Total Market ($B)	6.78							

Source: Dataquest (May 1991)

concerted effort during 1991 and thereafter to advance its position in the CBIC business. The company currently supplies no PLDs.

LSI Logic

Third-ranked LSI Logic ranks first in the CMOS gate array marketplace. The company's product strategy also calls for a stake of the BiCMOS gate array business. It holds 12th position among CBIC suppliers.

LSI Logic's strategy calls for ASIC technology to be pushed as fast as possible into submicron line geometries and into high-density configurations (for example, 200K plus gate arrays). LSI has earned a reputation in the marketplace for the excellence of its software including silicon compilers.

LSI Logic's future product direction in ASICs calls for more of the same—pushing the development of CMOS gate arrays and CBICs in terms of technology, performance, and software. It supplied no PLDs at the time this article was written. LSI Logic, which is not vertically integrated, relies in part on strategic alliances as a way of strengthening its competitive position in the ASIC business vis-à-vis huge Japanese competitors.

Toshiba

As with the other leading Japanese ASIC suppliers, fourth-ranked Toshiba draws on its position as a vertically integrated manufacturer to achieve economies of scale in ASIC production. Toshiba's current position as a leading supplier of CMOS gate arrays stems in part from a strategic alliance with LSI Logic. Users should note that Toshiba earns a large share of its ASIC revenue from merchant market demand.

Table 1 shows that Toshiba ranks fourth among suppliers of CMOS gate arrays and seventh in the CBIC marketplace. The company ranks 17th among suppliers of CMOS PLDs. The company's future product direction targets high-count CMOS gate arrays and CMOS CBICs.

Toshiba's alliance with Motorola continues although the boundaries appear more limited than envisaged one or two years ago. For Toshiba, the Motorola/Toshiba alliance provides Toshiba with access to Motorola's microprocessor cores for the Toshiba cell library.

Texas Instruments

Table 1 shows that fifth-ranked Texas Instruments ranks second among suppliers of CBICs and in the bipolar PLD business. TI is a supplier on the move in the CBIC marketplace.

The company targets BiCMOS as a key product technology for the 1990s as shown by its seventh-place rank in the emerging BiCMOS gate array market. In the gate array business, TI ranks 14th in the bipolar segment and 16th in the CMOS segment. The industry giant holds 14th position among suppliers of CMOS PLDs.

Hitachi

The information in Table 1 reveals that sixth-ranked Hitachi—another large vertically integrated Japanese company—ranks third among bipolar gate array suppliers, fifth in the CMOS segment, and second in the BiCMOS array arena. Hitachi views the BiCMOS process as a key product technology for the long term. Internal consumption accounts for a large share of Hitachi's ASIC market revenue.

Hitachi holds 25th position in the CBIC business. It currently supplies no PLDs; however, Hitachi is positioning itself for possible entry into the PLD business.

AT&T

Table 1 shows that seventh-ranked AT&T ranks first among CBIC suppliers. Its position stems in part from captive consumption. The company also ranks fifth among suppliers of bipolar gate arrays and 17th in the CMOS PLD marketplace.

Advanced Micro Devices (AMD)

The information in Table 1 shows that eighth-ranked AMD ranks first among suppliers of bipolar PLDs. AMD ranks number 4 among suppliers of CMOS PLDs and number 12 in the bipolar gate array business.

Hewlett-Packard (HP)

Table 1 shows a leading supplier of ASICs with a name that may be less familiar to some users in this role—ninth-ranked HP. In addition to serving internal captive demand for CBICs, HP has been expanding its merchant market sale of CBICs over the last several years. CBICs will continue to represent HP's merchant market ASIC product portfolio. HP placed second for Dataquest's 1990 Semiconductor Supplier-of-the-Year Award in the medium-size supplier segment.

VLSI Technology

Table 1 shows that 10th-ranked VLSI holds fourth position among CBIC suppliers. Competition from huge Japanese/North American companies has meant a stiff challenge for VLSI in the ASIC markets. It ranks 11th in the CMOS gate array marketplace.

Supply Base Analysis

This section uses information on ASIC product/technology life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for gate arrays and CBICs. The goal of this section is to provide users with a practical means of gauging the long-term supply base for these ASICs and direction for selecting suppliers of the devices.

Each section contains a table showing the size of the market in terms of revenue during 1990, the relative market shares of the predominant devices, and a ranking including suppliers' shares in each product segment.

The product/technology life cycle analysis serves as the basis for a summary assessment from a user's perspective on anticipated availability of select gate arrays or CBICs. The summary includes a succinct statement on whether the user faces a favorable or a critical supply base for each product technology. Building on the prior sections, factors affecting the supply base such as supplier strategies are discussed here.

Supply Base for MOS Gate Arrays

Table 2 provides information on the market size and leading suppliers of MOS gate arrays.

Table 2 shows that worldwide factory revenue totaled $2.56 billion during 1990, an increase of 13 percent from 1989. The table shows an increasing level of concentration in the MOS gate array supplier base: the top four suppliers account for nearly 60 percent of MOS gate factory shares.

As shown in Figure 1, Dataquest estimates that arrays in line geometries between 1.0 and

Table 2
Supply Base for MOS Gate Arrays
(Percent Share of Factory Revenue)

Company	Market Share (%)
LSI Logic	18.0
Fujitsu	14.4
NEC	13.3
Toshiba	13.0
Hitachi	5.9
Oki	3.4
Seiko-Epson	3.1
GEC Plessey	2.8
National Semiconductor	2.6
Matsushita	2.6
Others	20.9
Total	100.0
Total Market ($B)	2.56

Source: Dataquest (May 1991)

1.5 microns represent the predominant MOS gate array technology for 1991 and 1992. This pertains especially to arrays in gate counts of between 5,000 and 20,000 gates. The life cycle for these arrays should extend until 1995.

The 0.8-micron product technology now moves through the growth stage of the life cycle on its way to becoming a mainstream array technology (about 1993). The life cycle for 0.8-micron arrays should last until 1997. By contrast, the 2.0-micron technology nears the decline stage while 3.0-micron arrays face a virtual phaseout by 1993.

Figure 1 also reveals that sea of gate devices (that is, greater than 100,000 raw gates) represent an ongoing system design choice for the first half of the 1990s. Other MOS gate array products for which Dataquest expects growing demand in the 1990s include high-density CMOS channelless arrays and embedded gate arrays.

Users of gate arrays in line geometries between 0.8 and 1.5 microns face an ample supply situation for the next several years. Leading-edge suppliers like LSI Logic, Fujitsu, NEC, and Toshiba will battle to supply user demand for sea of gate arrays especially in line geometries of 1.0 micron and smaller. Other leading suppliers such as Hitachi, Oki, and Seiko-Epson will also make this market shift over time. Regardless, users of lower-density arrays in line geometries of 1.2 or 1.5 microns can look to a host of suppliers (as shown in part in Table 1) for product support and service.

Users can expect *some* contraction of the MOS gate array business during the midterm. As noted, 3.0-micron technology is being phased out now by some suppliers, with 2.0-micron arrays next on the list. Some suppliers such as National Semiconductor will accept no new orders and will only continue to serve the existing customer base.

Table 3
Supply Base for Bipolar Gate Arrays
(Percent Share of Factory Revenue)

Company	Market Share (%)
Fujitsu	32.3
NEC	16.1
Hitachi	14.1
Motorola	11.1
AT&T	3.8
Raytheon	3.8
GEC Plessey	3.4
National Semiconductor	2.8
Siemens	2.2
AMCC	2.1
Others	8.3
Total	100.0
Total Market ($B)	1.17

Source: Dataquest (May 1991)

Supply Base for Bipolar Gate Arrays

The bipolar ECL gate array technology should experience a market decline during the 1990s. By technology, BiCMOS gate arrays will take share from both bipolar ECL and CMOS gate arrays; however, the bipolar technology is *not* nearing the end of its life cycle. The leading bipolar gate array products are high-density ECL arrays. Users can expect a dependable supply of bipolar technology during the 1990s, although there will be some shift in the supplier base.

Table 3 provides information on the market size and leading suppliers of bipolar arrays.

Table 3 shows that worldwide factory revenue totaled $1.17 billion during 1990, an increase of 6.4 percent over 1989. The table reveals a highly concentrated supplier base: The top four suppliers—Fujitsu, NEC, Hitachi, and Motorola—account for nearly 75 percent of bipolar gate array factory revenue. In fact, the three Japan-based suppliers account for more than 60 percent of this market—in part on the basis of internal captive consumption. North American and European users can also target Motorola and AMCC. As noted, National Semiconductor will continue to support only existing customers.

Supply Base for BiCMOS Gate Arrays

BiCMOS gate arrays should take some share from both bipolar ECL and CMOS gate arrays during the 1990s. Table 4 provides information

Table 4
Supply Base for BiCMOS Gate Arrays
(Percent Share of Factory Revenue)

Company	Market Share (%)
NEC	40.2
Hitachi	26.5
Fujitsu	21.2
Motorola	5.3
AMCC	3.0
LSI Logic	2.3
Texas Instruments	1.5
Total	100.0
Total Market ($B)	0.13

Source: Dataquest (May 1991)

on the market size and leading suppliers of BiCMOS gate arrays.

Worldwide factory revenue for BiCMOS gate arrays totaled $0.13 billion during 1990, an increase of 40 percent over 1989. Table 1 and Figure 1 show that the BiCMOS gate array technology is moving through the early growth stage of a life cycle that should extend through this decade.

As shown in Table 1, both Japan-based suppliers (NEC, Hitachi, and Fujitsu) and North America-based companies (Motorola, AMCC, LSI Logic, and Texas Instruments) are targeting the BiCMOS gate arrays as a key product strategy for the long term.

The BiCMOS process technology has emerged as a viable choice for users. Current and prospective users of BiCMOS gate arrays can expect strong supplier commitment. Users should view this new product technology as dependable and evolutionary—meaning that the BiCMOS process evolves logically from the suppliers' familiar bipolar and CMOS processes and *not* as a unproven revolutionary technology.

Supply Base for CBICs

CBICs consist of precharacterized cells or macros including standard cells, megacells, and compilable cells. CMOS is the predominant process technology in cell-based designs. Key to the long-term acceptance of these products are the design tools and development software that are emerging. Electronic design automation tools play a critical role in making the cell library functionality readily usable.

Table 5 provides information on the market size and leading suppliers of CBICs. This table shows that worldwide factory revenue totaled $2.1 billion during 1990, an increase of 37 percent over 1989. The table shows less concentration of the supplier base in terms of top-tier companies than in some other ASIC categories. The top three suppliers—AT&T, Texas Instruments, and Hewlett-Packard—account for 37 percent of factory revenue. The next seven top-ranked suppliers—VLSI, Fujitsu, NCR, Toshiba, Harris, Mietec, and International Microelectronic Products—account for nearly 60 percent of the market. Other supplies generate nearly one-third of CBIC revenue.

As shown in Figure 1, the product technology life cycle for CBICs parallels that of MOS gate arrays. The geometry design trend is from 2.0 microns or 1.5 microns down to 1.0 micron or 0.8 micron. Products with line geometries between 1.0 and 1.5 microns represent the predominant CBIC technology for 1991 and 1992. Mainstream CBICs currently range in gate count from 5,000 to 20,000 gates. The life cycle for these arrays should extend until 1995. The design trend will be toward gate counts in excess of 20,000 gates.

By contrast, 3-micron CBICs face the phaseout stage of the life cycle in the next several years.

Dataquest Perspective

Current and prospective ASIC users should realize that ASIC technology life cycle analysis can serve as a tool for a long-term assessment of the supply/supplier base for these complex ICs. Dataquest's final 1990 market ranking and factory revenue for ASIC suppliers can assist users in managing the shifting ASIC supplier base. For users, the relatively short ASIC technology life cycle vis-à-vis other IC life cycles makes management of the ASIC supply base an especially challenging objective.

The 1990 ranking shows that six of the top-ten ranked suppliers are North America-based companies. Japan-based suppliers are strong in this marketplace: Three of the top four suppliers are Japan-based companies with ASIC factory revenue that includes internal captive consumption. LSI Logic ranks first in the MOS gate array business, followed by Fujitsu and NEC. AT&T leads in the CBIC marketplace—in part, through internal consumption—followed by two suppliers on the move: Texas Instruments and Hewlett-Packard.

Table 5
Supply Base for CBICs
(Percent Share of Factory Revenue)

Company	Market Share (%)
AT&T	15.3
Texas Instruments	11.0
Hewlett-Packard	11.0
VLSI	7.5
Fujitsu	5.2
NCR	4.4
Toshiba	4.1
Harris	3.3
Mietec	2.4
International Microelectronic Products	2.3
Others	33.5
Total	100.0
Total Market ($B)	2.1

Source: Dataquest (May 1991)

Users can anticipate some consolidation of the supplier base for commodity-type gate arrays and CBICs. Pricing as measured in millicents per gate for MOS gate arrays and CBICs has been quite competitive and will continue to be. Nonrecurring engineering costs should be more stable during 1991 and 1992 versus the sharp declines of the late 1980s.

Other ASIC product markets (FPGAs, PLDs) will be marked by diverse shifts among suppliers such as expansion of the supplier base for higher performance PLDs and some contraction over time of the supplier base for mature PLDs.

BiCMOS gate array suppliers such as NEC, Hitachi, Fujitsu, AMCC, Motorola, and Texas Instruments will take share from the MOS and bipolar technologies as these suppliers battle for BiCMOS design wins. The bipolar ECL business should decline during the 1990s.

Even so, users of MOS gate arrays and CBICs can expect a competitive supplier base during the 1990s. For example, in newly emerging markets such as the sea of gates segment, top suppliers from Japan and North America are committed to long-term survival and success. North America-based CBIC suppliers are determined to advance their market share despite the challenge from competitors in Japan and Europe. ■

By Ronald Bohn

In Future Issues:

The following topics will be featured in future issues of *Dataquest Perspective:*

- Finalized worldwide market share update
- European DRAM market outlook
- June *Procurement Pulse*

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Dataquest Perspective

Semiconductor Procurement

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Regional Pricing Update

DQ Monday Report Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.10	0.11	0.09	0.13
74HC138	0.14	0.15	0.14	0.17	0.15	0.21
74HC244	0.21	0.30	0.20	0.24	0.21	0.34
74HC74	0.12	0.12	0.11	0.11	0.10	0.17
Lead Time (Weeks)	2	3	NA	5	5	5
339-Com	0.14	0.15	0.12	0.13	0.11	0.13
741-Op Amp	0.13	0.24	0.11	0.13	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.08	0.08	0.07	0.10
74LS138	0.15	0.12	0.15	0.13	0.12	0.14
74LS244	0.21	0.24	0.21	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.10	0.10	0.12
Lead Time (Weeks)	2	2	NA	4	5	5
DRAM 1Mbx1-10	4.68	4.76	5.45	4.50	4.60	5.20
DRAM 256Kx1-10	1.55	1.63	2.00	1.30	1.40	1.50
DRAM 256Kx4-10	4.68	4.90	5.45	5.00	4.60	5.20
DRAM 4Mbx1-8	18.50	22.15	22.50	20.00	20.00	NA
DRAM 64Kx4-10	1.60	1.67	2.00	1.70	1.50	1.50
EPROM 1Mb, 200ns	4.88	5.56	5.00	5.50	5.20	4.20
EPROM 256K, 200ns	1.83	2.07	1.80	1.75	1.65	1.55
SRAM 1MB, 128KX8	18.50	19.24	16.50	NA	NA	NA
SRAM 256K, 32Kx8	4.25	4.21	4.25	4.95	4.90	4.80
SRAM 64K, 8Kx8	1.65	1.56	1.70	1.23	1.40	1.55
Lead Time (Weeks)	6	4	4	2	7	3
68000 12MHz	4.95	5.01	5.40	4.00	3.10	4.00
68HC11	8.40	7.99	8.00	8.75	8.60	NA
80286 12MHz	6.88	14.52	8.00	9.35	9.70	6.80
80386SX-16	55.00	54.45	55.00	64.50	65.00	57.00
8051	1.65	2.11	1.90	2.50	1.80	1.80
Lead Time (Weeks)	8	4	4	3	4	6

NA = Not available
Source: Dataquest (May 1991)

Market Analysis

May Procurement Pulse: Inventories Controlled While System Sales Forecast Improves

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Semiconductor Orders Stabilize, Systems Outlook Brightens

This month's respondents expect to maintain last month's booking rate in order to contain inventory levels and balance incoming orders with current system shipment rates (see Figure 1). The outlook for overall system sales over the next six months jumped from 3.4 percent noted last month to a current positive 6.5 percent forecast. The computer segment is even more optimistic, going from last month's 7 percent to a healthy 10 percent six-month sales growth average. It appears that the near-term system sales outlook is fluctuating around 5 percent for our overall sample and averaging out about 8 percent for the computer segment of our respondents. This low-to-moderate growth scenario ties in with Dataquest's forecast in that we foresee no significant disruption to

Figure 1
Averaged Monthly Semiconductor Orders

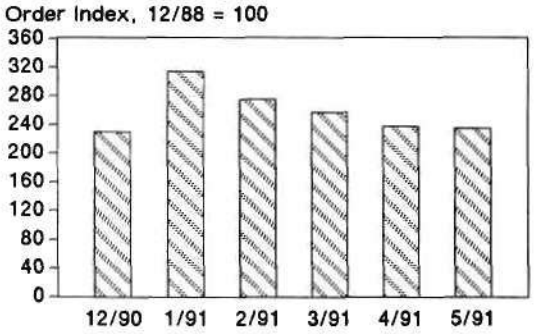


Figure 2
Averaged Semiconductor Lead Times

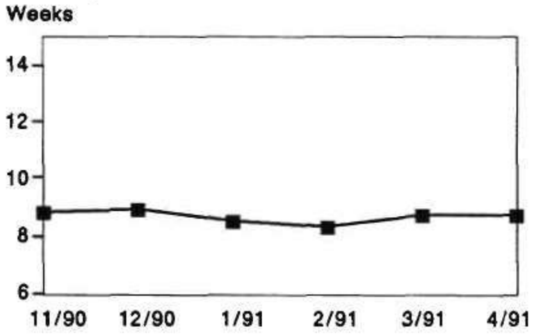


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

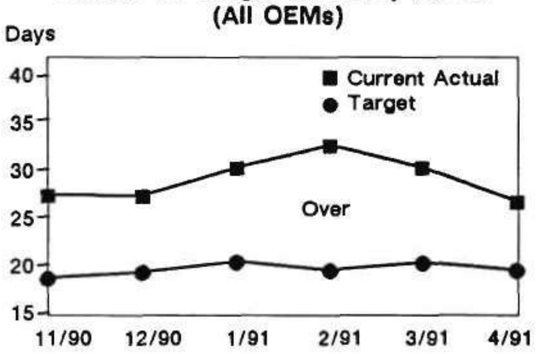
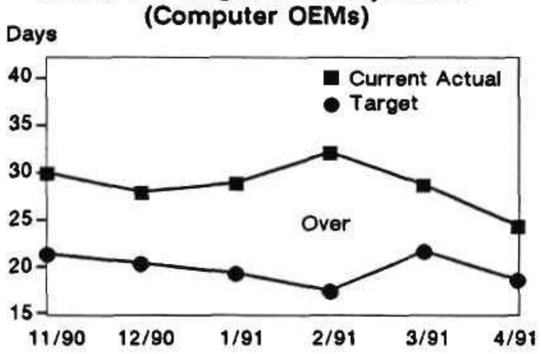


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (May 1991)

semiconductor supplies nor a quick upturn in electronics growth that would disrupt the current market balance.

Stable Lead Times Allow for Order Flexibility

As seen in Figure 2, lead times remain on average under nine weeks (unchanged since last month at 8.8 weeks). The stability in lead times continues to reflect a supply/demand balance that is also seen in flat to slightly lower prices compared with last month's levels. The overall availability of semiconductors remains excellent; however, there are isolated problems associated with some standard logic products that are expected to be corrected within two months. A notable percentage of last month's respondents mentioned quality as a key issue. This month, fewer respondents have noted quality as being a problem, but it still concerns 17 percent of our sample. Another area of consternation is the artificial price floor situation (particularly in Europe) for 4Mb DRAMs. Barring any dramatic price breaks after the current U.S.-Japan Semiconductor Trade Arrangement expires, Dataquest expects overall stability of price and availability through the end of summer.

Semiconductor Inventories Continue to Get Pared Back

Figures 3 and 4 highlight the approximate two-month lag time it takes for companies to correct inventory excesses. For both the overall and computer samples, target and actual inventory levels have declined. The current overall targeted and actual inventory levels went from last month's respective 20.6 and 30.6 days to this month's response of 19.8 and 27 days, respectively. The largest drop in inventory adjustments came from the computer segment of our sample with targeted and actual levels dropping from a respective 21.8 and 28.8 days to a current response of 17.5 targeted and 23.1 actual inventory days on hand, respectively. This month's respondents, on average, have gone below the historical overall average target and actual inventory respective levels of 20 and 30 days. A growing minority of leading-edge companies are currently holding under 15 days of inventory. As this type of inventory management becomes more common, the previous historical inventory goals will decline.

Dataquest Perspective

The outlook for system sales is improving, while cost control measures as indicated by inventory reductions give a mixed signal as to where the market is headed. At the micromarket level, there are mixed levels of semiconductor orders (some large, some delayed, others smaller than forecast) that also reflect a continued uncertainty as to how the industry will fare. On average, order rates continue to move forward and supplies are more than able to meet this level of demand. With no large change of market dynamics foreseen for the remainder of the year, Dataquest continues to forecast moderate growth for semiconductors and single-digit growth for systems companies. This month's survey reinforces this forecast.

By Mark Giudici

Product Analysis

A Users' Look at the EPROM Supplier Base and Product Life Cycles

Executive Summary

Based on Dataquest's final estimate of suppliers' 1990 EPROM market shares, this article looks at the product life stage for 64K, 128K, 256K, 512K, 1Mb, 2Mb, and 4Mb EPROMs as of May 1991 and provides users with an evaluation of the supply/supplier base for these devices during the 1990s.

Overview

This report provides EPROM users with practical and strategic information for choosing which devices to use and from which supplier or suppliers. It replaces the "EPROM Product Trends" section in the Industry Trends binder of the former Semiconductor User Information Service. For the report entitled "EC EPROM Reference Price Agreement," see the Semiconductor Procurement *Dataquest Perspective*, Vol. 1, No. 2, April 1991.

As with the former product trends series, this article contains three sections. The first section develops a guide to cost-effective, long-term procurement of EPROMs through the use of product life cycle analysis. The second section on the top-ranked EPROM suppliers looks at the market positions and future product strategies of the leading suppliers. The third section combines the analyses of EPROM life cycles and the supplier base. This formation gives users a practical way of assessing their ability to obtain a supply of these devices from the various suppliers during the 1990s. The sections include a discussion of the key industry issues affecting users now and in the future. Cumulatively, the information in these sections enables users to develop a sound strategy for satisfying demand for EPROMs on a consistent, cost-conscious basis over the long term despite shifts in the market or among suppliers.

EPROM Product Life Cycles

This section uses information on EPROM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. This section also lays the basis for other analyses based on EPROM life cycle curves.

Typical Life Cycles for EPROM Products

Figure 1 shows a series of six curves that depict the product life cycles of EPROMs with densities of 64K to 4Mb.

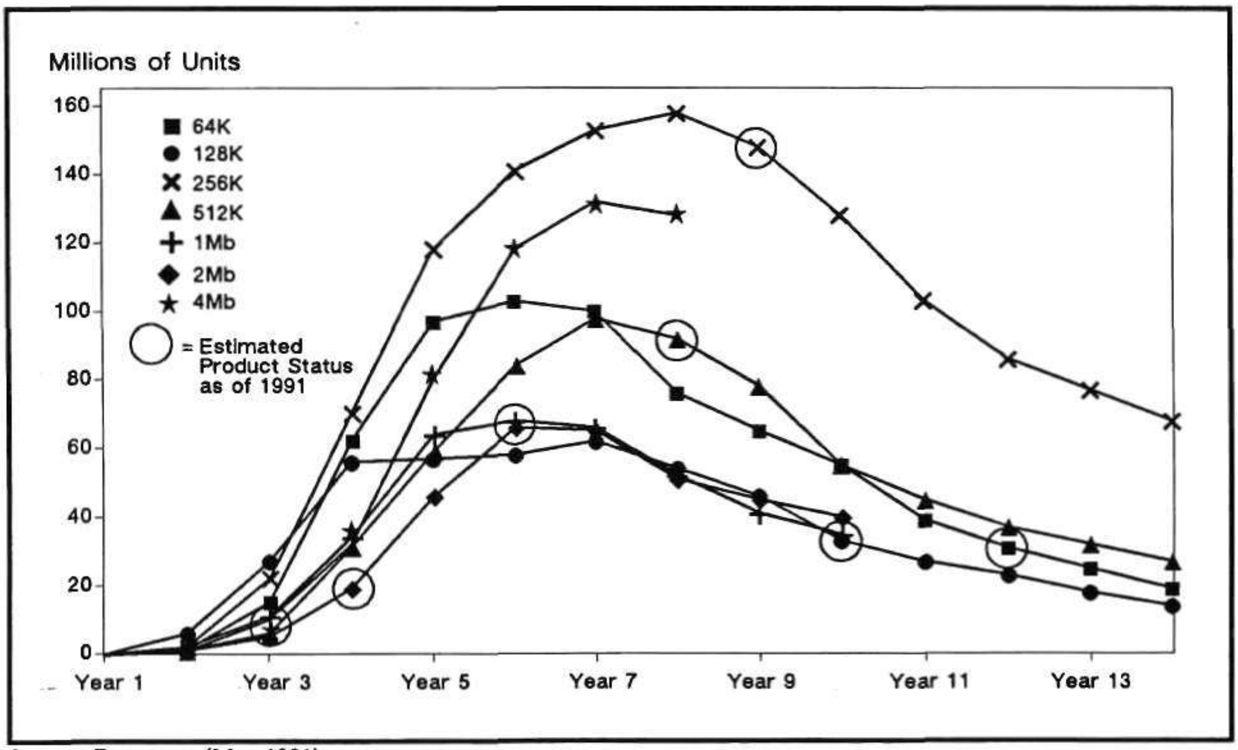
Figure 1 reveals that EPROMs typically hit the peak stage during the fifth or sixth year of the life cycle. For intermediate densities (128K, 512K, and 2Mb EPROMs), the life cycle may be somewhat shorter and less consistent vis-à-vis the pattern for mainstream densities such as 256K and 1Mb EPROMs.

Figure 2 depicts EPROM product life cycles on the basis of density and technology, breaking each stage of the cycle into specific time intervals.

Figure 2 shows that 32K EPROMs will be phased out by suppliers in the next several years. The 64K and 128K EPROMs now move through the decline stage of the cycle. The life cycle of 256K parts should extend at least to 1996, with a somewhat shorter life span for NMOS versions. High-speed CMOS versions for these densities should have the longest life cycles.

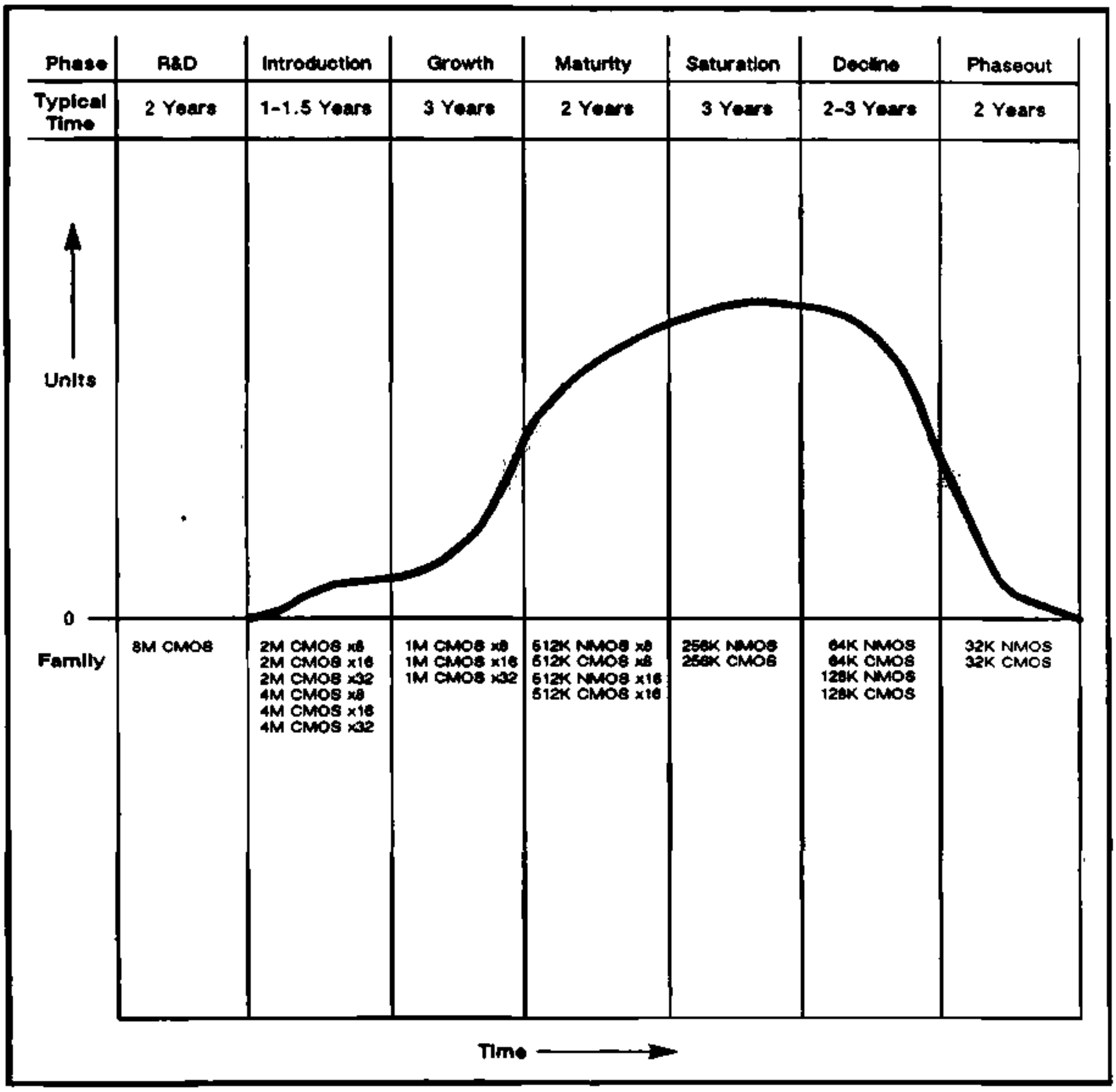
Figure 2 also shows that the life cycle of 512K EPROMs should extend until the end of the 1990s. The 1Mb EPROM cycle is likely to push beyond the year 2000. The life cycles for 2Mb,

Figure 1
MOS EPROM Product Life Cycles by Density as of May 1991



Source: Dataquest (May 1991)

Figure 2
1991 EPROM Life Cycles by Product/Technology



Source: Dataquest (May 1991)

4Mb, and 8Mb EPROMs are expected to extend into the next century.

Supplier Analysis

This section analyzes the product and market strategies of the leading EPROM suppliers. This analysis covers product positioning, market ranking, and related issues.

Table 1 shows Dataquest's final 1990 worldwide EPROM market share ranking in dollarized units (production) of the top suppliers for devices with densities of 64K to 4Mb. The information in this table serves as the background for the analysis of each supplier.

Advanced Micro Devices (AMD)

AMD ranks first among suppliers of EPROMs based on final 1990 shipments as measured in dollarized units. The U.S.-Japan Semiconductor Trade Arrangement, which was signed in 1986 but is being renegotiated during 1991, enhanced AMD's strategic position during the late 1980s as a supplier of MOS EPROMs.

Table 1
MOS EPROM Suppliers—Ranking by Density/Technology
(Percent Share of Dollarized Units)

1990 Overall Ranking	Company	64K	128K	256K	512K	1Mb	2Mb	4Mb
1	AMD	5	3	2	2	1	4	-
2	Intel	7	2	5	2	1	1	3
2	SGS-Thomson	1	4	1	5	8	6	-
2	Texas Instruments	3	1	3	1	4	-	-
5	National Semiconductor	2	7	3	6	12	-	-
6	Fujitsu	-	5	8	4	3	-	-
6	Philips-Signetics	4	-	7	6	10	-	-
8	Microchip	8	5	5	9	-	-	-
9	Mitsubishi	11	9	9	8	6	5	5
10	Hitachi	-	8	10	13	6	-	4
10	Toshiba	9	-	10	10	4	-	1
12	NEC	5	12	12	10	8	1	2
	Atmel	-	9	12	10	12	-	-
	Oki	-	9	-	13	12	-	-
	Sharp	-	-	-	-	10	-	-
	Sony	-	-	-	-	-	1	-
	WaferScale	9	9	12	13	12	-	-
Total Shipments (Millions of Units)		39	46	158	98	64	5	1

Source: Dataquest (May 1991)

As shown in Table 1, AMD ranks first—along with Intel—among suppliers of 1Mb EPROMs. AMD holds the second position in the 256K and 512K segments and third place in the 128K EPROM arena.

A key to AMD's long-term EPROM market success, however, will be its ability to successfully introduce and ramp up output of megabit density devices—2Mb, 4Mb, and 8Mb EPROMs. Table 1 shows that AMD ranked fourth among suppliers of 2Mb EPROMs during 1991 but had not yet established itself in the 4Mb segment. AMD also aims for a share of the newly emerging flash memory business. During 1990, AMD sampled 256K, 512K, 1Mb, and 2Mb flash memory.

Intel

Intel joins SGS-Thomson and Texas Instruments in a tie for second-place ranking among EPROM suppliers based on final 1990 shipments (as measured in dollarized units). The U.S.-Japan trade pact solidified Intel's position in the EPROM marketplace.

Intel has been and continues to be known as a full-range supplier of MOS EPROMs. The company supplies EPROMs with densities from 32K to 4Mb. Intel ranks second among suppliers of the 128K product, seventh in the 64K segment, and fifth in the 256K EPROM business.

The supplier's strength in the EPROM market stems from its position in the critical megabit-density segments. Intel ranks first along with AMD in the 1Mb EPROM marketplace. Intel also ranks first—joined by NEC and Sony—in the growing 2Mb arena. Intel's shipments of 4Mb EPROMs during 1990 rank the company as third among suppliers.

Intel is securing an early leadership position in the newly emerging flash memory market. Intel supplies 256K, 512K, 1Mb, and 4Mb devices. At the time this report was written, Intel had just announced that its future product direction does *not* include 8Mb EPROMs. For densities of 8Mb and above, flash memory marks Intel's future product course.

SGS-Thomson

SGS-Thomson continues with a market strategy that was developed five years ago and which enabled the company to move from tenth to second ranking in the EPROM business. The strategy is to supply lower-density devices while other suppliers depart from these product markets.

For example, based on 1990 shipments, the Europe-based company ranks as the leading supplier of 64K and 256K EPROMs. SGS-Thomson holds fourth ranking among suppliers of 128K devices and fifth place in the 512K arena. By contrast, it ranks eighth in the 1Mb marketplace and sixth at the 2Mb level. During 1990, SGS-Thomson sampled 256K and 1Mb flash memory.

Texas Instruments

Texas Instruments ranks second (along with Intel and SGS-Thomson) among EPROM suppliers. Like other North-America-based companies, this supplier has benefited against Japanese competitors from the U.S.-Japan trade agreement.

The company ranks first among suppliers of 128K and 512K devices and third in the 64K and 256K segments. Texas Instruments holds fourth place in the 1Mb EPROM arena. During 1990, it shipped 256K and 1Mb flash memory.

National Semiconductor

Fifth-ranked National Semiconductor derives its market position from shipments of lower-density EPROMs.

Table 1 shows that this supplier ranks second in the 64K marketplace and third in the 256K segment. National also holds sixth place in the 512K arena and seventh position among suppliers of the 128K device. The supplier ranks twelfth in the 1Mb EPROM market.

Fujitsu

Fujitsu, which ranks sixth along with Philips-Signetics among suppliers of EPROMs, has positioned itself for success in the current mainstream of the EPROM business.

For example, as shown in Table 1, Fujitsu ranks third among suppliers of 1Mb EPROMs and fourth in the 512K segment. By contrast, it reported no 1990 shipments of 2Mb or 4Mb devices to Dataquest.

Philips-Signetics

This sixth-ranked Europe-based supplier has targeted lower-density segments of the EPROM marketplace. Philips-Signetics ranks fourth among suppliers of 64K EPROMs, sixth in the 512K market, and seventh in the 256K arena. It holds tenth position in the 1Mb business.

Microchip Technology

A large portion of eighth-ranked Microchip's total revenue stems from EPROM sales. The North America-based supplier targets low-density devices. For example, Table 1 shows that Microchip holds fifth ranking in the 128K and 256K segments. Microchip also ranks eighth among suppliers of 64K EPROMs and ninth regarding the 512K density.

Mitsubishi

The U.S.-Japan trade agreement in part stifled Mitsubishi's goal of being a full-range EPROM supplier to users in North America and Europe. For example, during 1987, the company held the third-place ranking among EPROM suppliers versus ninth position for 1990. Mitsubishi's strategic response—which has met with mixed results—has been to focus on higher-density devices for non-Japanese business.

Mitsubishi's strategy reflects itself in the 1990 results: a ranking of sixth place or better for EPROM densities of 1Mb and greater, but a ranking of no better than eighth place for lower-density segments. As shown in Table 1, Mitsubishi's product portfolio includes 2Mb and 4Mb EPROMs. The company sampled 1Mb flash memory during 1990.

Hitachi

Like other Japan-based suppliers, Hitachi has responded to the U.S.-Japan trade pact by focusing on higher-density devices.

Table 1 shows the results for 1990: a ranking of sixth place or better for EPROM densities of 1Mb and greater, but a ranking as low as thirteenth place for lower-density segments. The company sampled 1Mb flash memory during 1990.

Toshiba

As with Mitsubishi, the U.S.-Japan trade pact hinders Toshiba's position in the worldwide EPROM business. Toshiba declined from fourth place in 1987 to a tie for tenth place in 1990.

Toshiba now ranks tenth among suppliers in the 256K and 512K markets. Nevertheless, the vertically integrated supplier remains a competitive threat. For example, Toshiba holds a fourth-place ranking among suppliers of 1Mb EPROMs. It jumped to an early leadership role in the 4Mb segment during 1990. Toshiba also lurks behind Intel as an early leader in the nascent flash memory marketplace. This supplier sampled the 1Mb flash device during 1990.

Supply Base Analysis

This section uses information on EPROM product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for EPROMs with densities from 64K to 4Mb. The goal of this section is to provide users with a practical means of gauging the long-term supply base for a given density of EPROMs and direction for selecting suppliers of the devices.

Each section contains a table showing the size of the market in terms of dollarized units shipped during 1990, the relative market shares of the predominant devices, and a ranking including suppliers' shares in each product segment.

Product life cycle analysis serves as the basis for a summary assessment from a user's perspective on anticipated supply of each density of EPROMs. The summary includes a succinct statement on whether the user faces a favorable or a critical supply base for each density. Building on the prior sections, factors such as supplier strategies that affect the supply base are discussed here. For example, as noted in the discussion of suppliers, Japan-based suppliers lost market ranking in the aftermath of the 1986 U.S.-Japan trade pact. In general, the competitiveness of Japan-based suppliers in North America should increase over time *if* the associated foreign market value (FMV) pricing system is eliminated or relaxed during 1991.

Supply Base for 64K EPROMs

Table 2 provides information on the market size and leading suppliers of 64K EPROMs.

Table 2 shows that worldwide unit shipments totaled 39 million during 1990, a decrease of nearly 30 percent from 1989. As seen in Figure 2, the final Dataquest estimates for 1990 show that 64K EPROMs are moving through the saturation stage of the life cycle.

Users of 64K EPROMs face a tighter supply situation over the long term. Users can expect this product to have a life cycle that extends at least until 1995, when we expect worldwide shipments to fall below the 10-million-unit volume.

Table 2 shows that SGS-Thomson is the leading supplier of this older product and a main choice for future product support. Another leading supplier is National Semiconductor. Texas Instruments and Philips-Signetics are two other suppliers that hold more than 10 percent share of the market and that could be targeted by users for long-term support.

Supply Base for 128K EPROMs

Table 3 provides information on the market size and leading suppliers of 128K EPROMs.

Table 2
Supply Base for 64K EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
SGS-Thomson	28
National Semiconductor	22
Texas Instruments	14
Philips-Signetics	10
AMD	9
Intel	6
Others	11
Total Shipments (Units)	39 Million

Source: Dataquest (May 1991)

Table 3
Supply Base for 128K EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
Texas Instruments	23
Intel	20
AMD	17
SGS-Thomson	14
Fujitsu	7
Microchip	7
Others	12
Total Shipments (Units)	46 Million

Source: Dataquest (May 1991)

Table 3 shows that worldwide unit shipments totaled 46 million during 1990, a decrease of over 15 percent from 1989.

As shown in Figure 2, the final Dataquest estimates for 1990 show that 128K EPROMs are declining in terms of the life cycle stage. For users of 128K EPROMs, the outlook is similar to the 64K device: Users face tighter supply as production declines over the first half of the 1990s. The life cycle for 128K EPROMs should extend until 1996.

Table 3 reveals that Texas Instruments and Intel are the leading suppliers of 128K EPROMs. AMD and SGS-Thomson are two other choices for long-term product support. SGS-Thomson's strategy has been to continue supplying older EPROM products such as this device as other suppliers leave the market.

Supply Base for 256K EPROMs

Table 4 provides information on the market size and leading suppliers of 256K EPROMs.

Table 4 shows that worldwide unit shipments totaled 158 million during 1990, a modest increase of 3.3 percent over 1989.

As shown in Figure 2, the final Dataquest estimates for 1990 show that 256K EPROMs have hit the saturation (or peak volume) stage of the life cycle. For users of 256K EPROMs, the outlook should be favorable for the first half of this decade: output volume should start declining during 1991, but worldwide shipments should still exceed 100 million through the year 1993. Figure 2 projects that the life cycle for 256K EPROMs should extend until 1997 or later.

Table 4
Supply Base for 256K EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
SGS-Thomson	15
AMD	13
Texas Instruments	11
National Semiconductor	11
Intel	10
Microchip	10
Others	30
Total Shipments (Units)	158 Million

Source: Dataquest (May 1991)

Table 4 reveals a more widely diversified supplier base for 256K EPROM vis-à-vis the concentrated base of suppliers for the old 64K/128K devices. For example, SGS-Thomson ranks as the leading supplier of 256K EPROMs, with a 15 percent market share. A host of other suppliers closely trail: AMD, Texas Instruments, National Semiconductor, Intel, and Microchip.

Users can expect some of the suppliers listed in Table 4 to eventually turn from 256K EPROMs toward newer devices such as megabit-density EPROMs/ROMs, EEPROMs, and/or flash memory. Regardless, the 256K EPROM supplier base should remain strong for the first half of the 1990s.

Supply Base for 512K EPROMs

Table 5 provides information on the market size and leading suppliers of 512K EPROMs.

Table 5 shows that worldwide unit shipments totaled 98 million during 1990, an increase of 17 percent over the 1989 level.

As seen in Figure 2, the final Dataquest estimates for 1990 show that 512K EPROMs are now moving through the maturity stage of the life cycle. For users of 512K EPROMs, the outlook should generally be favorable for the first half of this decade. Figure 2 projects that the life cycle for 256K EPROMs should extend until 1998.

Table 5 reveals a somewhat diversified supplier base for 512K EPROMs. For example, three suppliers, Texas Instruments, AMD, and Intel, hold a combined market share of 52 percent. The next four leading suppliers—Fujitsu, SGS-

Table 5
Supply Base for 512K EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
Texas Instruments	18
AMD	17
Intel	17
Fujitsu	9
SGS-Thomson	8
National Semiconductor	7
Philips-Signetics	7
Others	17
Total Shipments (Units)	98 Million

Source: Dataquest (May 1991)

Thomson, National Semiconductor, and Philips-Signetics—hold nearly one-third of the market. Other suppliers command a 17 percent share.

Users must note that the 512K EPROM is an intermediate density device, that is, between higher volume/mainstream 256K and 1Mb products. The supplier base for 512K EPROMs is likely to contract sooner than for other EPROMs but in a nondramatic fashion. Users should be prepared to requalify some new suppliers over time. Again, the 512K EPROM supplier base should be healthy for the foreseeable future.

Supply Base for 1Mb EPROMs

Table 6 provides information on the market size and leading suppliers of 1Mb EPROMs.

Table 6 shows that global unit shipments totaled 64 million during 1990, nearly *double* the level of 1989.

As shown in Figure 2, the final Dataquest estimates for 1990 show that 1Mb EPROMs continue to move through the growth stage of the life cycle. For 1Mb EPROM users, the outlook should be favorable through 1995. Figure 2 projects that the life cycle for 1Mb EPROMs should extend until the year 2000.

Table 6 reveals a wide supplier base for 1Mb EPROMs with AMD and Intel as leaders, each having 20 percent market share. The combined share of the next five leading suppliers—Fujitsu, Texas Instruments, Toshiba, Mitsubishi, and Hitachi—accounts for another 40 percent of the marketplace. As shown in Table 1, other suppliers such as SGS-Thomson, NEC, and Sharp combined supply 20 percent of the market.

Table 6
Supply Base for 1Mb EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
AMD	20
Intel	20
Fujitsu	9
Texas Instruments	8
Toshiba	8
Mitsubishi	7
Hitachi	7
Others	21
Total Shipments (Units)	64 Million

Source: Dataquest (May 1991)

The information in Tables 1 and 6 shows the strong presence of Japanese suppliers in the megabit-density EPROM markets. Users should monitor advisories published by Japan's Ministry of International Trade and Industry (MITI) for signals regarding 1Mb EPROM production levels, supplier direction, and price trends for Japan-based companies.

Supply Base for 2Mb EPROMs

Table 7 provides information on the market size and early leading suppliers of 2Mb EPROMs.

Table 7 shows that worldwide shipments totaled 5 million units during 1990.

As shown in Figure 2, the final Dataquest estimates for 1990 place 2Mb EPROMs in the introduction stage of the life cycle. For users of 2Mb EPROMs, the outlook is now favorable but could become less so over the next several years.

For example, Figure 2 projects that the life cycle for 2Mb EPROMs should extend beyond the year 2000. If past EPROM product life cycle trends hold, the life cycle projection should prove true. As shown in Table 7, current market leaders include Intel, NEC, and Sony. AMD, Mitsubishi, and SGS-Thomson also shipped 2Mb EPROMs during 1990.

However, several factors could result in a shorter life cycle for the 2Mb EPROM than currently projected. First, as with the 512K device, 2Mb EPROMs represent intermediate-density devices—between higher volume 1Mb and 4Mb parts.

Table 7
Supply Base for 2Mb EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
Intel	26
NEC	26
Sony	26
AMD	10
Mitsubishi	8
SGS-Thomson	4
Total Shipments (Units)	5 Million

Source: Dataquest (May 1991)

Second, and more significantly, EPROM suppliers anxiously eye the newly emerging flash EPROM marketplace. Flash has the potential of keeping pace with other nonvolatile devices in systems applications. Dataquest expects flash memory to win its place in higher-density nonvolatile applications. For example, AMD has publicly stated a strong commitment to megabit-density EPROMs. Other suppliers such as Intel see a brighter future for flash memory for densities of 4Mb and greater. Users should monitor supplier base trends on an annual or semiannual basis including MITI's periodic advisories.

Supply Base for 4Mb EPROMs

Table 8 provides information on the market size and early leading suppliers of 4Mb EPROMs.

Table 8 shows that worldwide shipments totaled 1 million units during 1990.

As shown in Figure 2, the final Dataquest estimates for 1990 place 4Mb EPROMs in the introduction stage of the life cycle. For users of 4Mb EPROMs, the outlook is similar to the 2Mb scenario—favorable now, but perhaps less favorable several years in the future. Figure 2 projects that a life cycle for 4Mb EPROMs should extend beyond the year 2000.

Table 8 shows that early market participants include Toshiba, NEC, Intel, Hitachi, and Mitsubishi. Users should note that the 4Mb EPROM supplier base at this early point in the life cycle is similar to, but not exactly the same as, the 2Mb device supplier base. For example, Intel, NEC, and Mitsubishi also shipped 2Mb EPROMs during 1990. By contrast, Toshiba and Hitachi did not.

As noted, EPROM users and suppliers anxiously watch the newly emerging flash memory

Table 8
Supply Base for 4Mb EPROMs
(Percent Share of Dollarized Units)

Company	1990 Market Share (%)
Toshiba	36
NEC	25
Intel	24
Hitachi	8
Mitsubishi	6
Total Shipments (Units)	1 Million

Source: Dataquest (May 1991)

marketplace, which means added challenge for users that must manage the 4Mb EPROM supplier base during this decade. For example, Intel has announced that it will ship no EPROMs of density greater than 4Mb and that 4Mb and greater flash devices mark its future product direction. Current and prospective users of 4Mb EPROMs must monitor supplier base trends on an annual/semiannual basis including MITI's advisories.

Dataquest Perspective

Product life cycle analysis serves as a key tool for a long-term assessment of the supply/supplier base for ICs such as EPROMs. Dataquest's final 1990 market ranking/total shipments data on EPROMs in turn allow fine tuning of the product life cycle outlook.

The 1990 EPROM market share information shows that two North America-based suppliers—AMD and Intel—rank as the world's leading EPROM suppliers in terms of unit production during 1991. SGS-Thomson, a Europe-based company, ranks third. Texas Instruments and National Semiconductor, North American companies, follow in the ranking.

Users should remember that the 1986 U.S.-Japan Semiconductor Trade Arrangement blunted the effort of Japan-based suppliers in the North American market and also in Europe. These suppliers targeted higher-density/higher-speed EPROM segments. Dataquest's 1991 market ranking shows a gain in the megabit-density EPROM arenas for suppliers such as Fujitsu, Toshiba, Mitsubishi, and Hitachi. The likely demise during 1991 of the FMV system of pricing established by the 1986 trade pact should allow Japan-based suppliers to make a stronger marketing presence in regions such as North America.

Nevertheless, users can expect continual competitive effort by suppliers such as AMD, Intel, and SGS-Thomson during the 1990s. For example, in newly emerging segments such as 2Mb devices, suppliers from Europe, Japan, and North America are all staking long-term positions. The global network of EPROM suppliers will battle to expand their shares of a market marked by product life cycles that extend beyond the year 1995 and in some cases beyond the year 2000.

EPROM product technology also faces long-term competition from the newly emerging flash memory product, which means an additional burden for users in terms of managing the nonvolatile memory supply base. Suppliers such as Intel already state that flash memory will replace EPROMs in their nonvolatile memory product portfolio at densities of 8Mb and greater. By contrast, other suppliers such as AMD also announced their plan to introduce 8Mb EPROMs in several years. What will Japanese suppliers do? Look for MITI's advisories and future *Dataquest Perspective* reports.

By Ronald Bohn

The Demise of the FMV—A Preview of the Upcoming Semiconductor Agreement

Executive Summary

This article updates the status of the current U.S.-Japan Semiconductor Trade Arrangement and provides analysis on the most likely outcome of these talks. The five-year 1986 semiconductor arrangement expires at the end of August 1991. Unlike its predecessor, the terms of the current pact include issues involving both the semiconductor *and* electronic system industries in dealing with Japanese trade.

The Past Five Years Summarized

The history of the 1986 U.S.-Japan Semiconductor Trade Arrangement goes back to the boom/bust period of 1984 to 1985. The scenario involved an extremely large amount of DRAM capacity being built and coming on-line to supply optimistic system forecasts that did not materialize. The ensuing DRAM price war left the U.S. DRAM industry in ruin and was the cause of antidumping allegations against Japanese suppliers that began in 1985. The legal proceedings culminated in the historic U.S.-Japan Semiconductor Trade Arrangement signed on September 2, 1986.

Although open markets and attainment of increased market share in Japan are important, the key issue affecting U.S. semiconductor users is the proposed dissolution of the FMV system.

After five years of enactment, the intent of the arrangement—to prevent selling of semiconductors below cost (dumping) and increase U.S. semiconductor industry access to the Japanese home market)—has met with mixed results. From a semiconductor user's perspective, the 1986 agreement initially raised prices and added uncertainty to a volatile commodity market. It took approximately 18 months for the worldwide market to adjust to the externality of foreign market values (FMVs), which are individualized, cost-based price floors quarterly set for each Japanese company involved in the arrangement by the U.S. Department of Commerce (DOC). Another intent of the pact was to indirectly encourage U.S. DRAM production by providing a price "safety net" so that a return on investment was not in jeopardy due to below-cost pricing.

A renewal of the U.S.-Japan Semiconductor Trade Arrangement bodes well for semiconductor users and promises to increase access to the largest electronics market in the world.

The safety net incentive of the agreement was not enough to entice additional U.S. suppliers to reenter the DRAM market. In the absence of a balanced regional supply of these commodity devices, the "management" of Japanese DRAM supplies resulted in spot shortages during the 1988 to 1989 period as forecasting accuracy was forced to improve. Most of 1990 to present has been witness to a careful balance of supply with demand, due partly to improved forecasting and partly to the lack of a large increase in aggregate equipment demand.

Fast Forward to 1991

A replacement to the 1986 arrangement has been in formulation since mid-1990. The current proposal involves both the semiconductor and electronics industries with the main focus concentrating on open markets (Japanese markets) while keeping antidumping of semiconductors a secondary issue. Both the Semiconductor Industry Association (SIA) and the newly formed Computer Systems Policy Project (CSPP) petitioned President George Bush in October 1990 with a unified position to update the soon-to-expire 1986 pact.

Since October 1991, the DOC has been in discussion with Japan's Ministry of

International Trade and Industry (MITI), basically promulgating the joint position set forth in the October letter to President Bush. The main points are as follows:

- Attainment of 20 percent foreign (not necessarily U.S.) market share of semiconductors in Japan by the end of 1992
- Reduction of government involvement in monitoring antidumping mechanisms of semiconductors
- The DOC ending collection of cost/price data or issuing FMVs for DRAMs and EPROMs (The DRAM dumping case is to be dropped, and a modified version of the EPROM suspension agreement is to be maintained.)
- The DOC maintaining the "fast-track" antidumping investigation procedure to deal quickly with any future dumping allegations

FMVs Soon to Be a Part of History

In discussions with the DOC, Dataquest has learned that the SIA/CSPP guidelines set forth in the October letter to the President have been left primarily unchanged as the official U.S. position in dealing with the Japanese government regarding a new semiconductor/electronics trade pact. Although open markets and attainment of increased market share in Japan are important, the key issue affecting U.S. semiconductor users is the proposed dissolution of the FMV system.

The upcoming changes to semiconductor trade between the United States and Japan will allow for more responsive memory pricing in the United States and, correspondingly, the world.

Now that the only potential proponent to a constructed cost/price scheme has concurred with industry to focus on market access, it is almost academic that the FMV system (or a like replacement) will not exist after the end of August 1991. The response to dumping allegations will most likely be a strengthened fast-track antidumping investigative procedure that will hasten legal proceedings through the courts.

Without FMVs, What Happens to Prices?

Assuming that the FMV system is scrapped, the following scenarios could occur after August:

- Overall DRAM prices will maintain their gradual price decline as seen over the past six months due to improved forecasting of demand and the lack of a high-growth product(s) that could quickly unbalance the market.
- In a flat-demand environment, DRAM prices will experience step function price declines due to the high level of capacity on hand worldwide and the relatively high cost of idle capacity primarily affecting new generations of DRAM (that is, 4Mb).
- Regional pricing of DRAM becomes more homogeneous (except for Europe's reference price system) and will better reflect local market conditions rather than follow a constructed price lead.

Dataquest expects to see continued gradual price declines for densities under and including 1Mb while a potential exists for faster declines in the 4Mb device. With the majority of memory capacity controlled by Japanese suppliers, pricing based on capacity utilization is under Japanese control. A concerted effort by non-Japanese suppliers to increase market share via price reductions may start prices falling at a faster rate.

Dataquest Perspective

A renewal of the U.S.-Japan Semiconductor Trade Arrangement bodes well for semiconductor users and promises to increase access to the largest electronics market in the world. The removal of direct government intervention in the market is a positive sign and one that acknowledges that market dynamics (especially the volatile DRAM market) can adjust quicker and more equitably than a well-intentioned but cumbersome government pricing system. Putting Japanese market access issues aside, the upcoming changes to semiconductor trade between the United States and Japan will allow for more responsive memory pricing in the United States and, correspondingly, the world.

By Mark Giudici

Conferences and Exhibitions

1991 Dataquest Conference Schedule

Table 1 below describes the upcoming Dataquest conferences.

For reservations or further information, call London, 895-835050; San Jose, (408) 437-8245; or Tokyo, 3-5566-0411.

Table 1
Upcoming Dataquest Conferences

Topic	Date	Location
North America		
Semicon/West	May 22	Redwood City
Computer Storage	June 19-20	San Jose
Document Management	June 27-28	San Francisco
Personal & Wireless Communications	August 12-13	Monterey
Portable Computing	September 11-12	San Jose
Semiconductor	October 14-15	Monterey
Europe		
Semiconductor	May 29-31	Marbella
Printer	June 11-12	Amsterdam
Colour Market	June 12-13	Amsterdam
Copying & Duplicating	June 13-14	Amsterdam
Telecommunications	November 7-8	London
Japan and Asia		
Computer & Telecommunications	June 25-26	Tokyo
Strategic Industry	September 24-25	Taipei
Peripherals	October 1-3	Tokyo

Source: Dataquest (May 1991)

In Future Issues

The following topics will be featured in future issues of *Dataquest Perspective:*

- Semiconductor Capital Spending Trends
- ASIC Product Trends
- May *Market Watch*

For More Information . . .

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Dataquest Perspective

Semiconductor Procurement

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Regional Pricing Update

DQ Monday Report Volume Mean Pricing

Table 1
DQ Monday Report
Volume Mean Prices

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.11	0.09	0.10	0.11	0.09	0.13
74HC138	0.14	0.15	0.14	0.17	0.15	0.21
74HC244	0.21	0.30	0.20	0.25	0.21	0.35
74HC74	0.12	0.12	0.11	0.11	0.10	0.17
Lead Time (Weeks)	2	3	NA	5	5	5
339-Com	0.14	0.15	0.12	0.14	0.11	0.13
741-Op Amp	0.13	0.23	0.11	0.14	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.08	0.08	0.07	0.10
74LS138	0.15	0.13	0.15	0.13	0.12	0.15
74LS244	0.21	0.24	0.21	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.09	0.10	0.12
Lead Time (Weeks)	2	2	NA	4	5	5
DRAM 1Mbx1-10	4.68	4.82	5.45	4.50	4.60	5.20
DRAM 256Kx1-10	1.50	1.61	2.00	1.30	1.40	1.50
DRAM 256Kx4-10	4.68	4.89	5.45	5.00	4.60	5.20
DRAM 4Mbx1-8	18.75	3.19	22.50	20.00	20.75	NA
DRAM 64Kx4-10	1.60	1.64	2.00	1.70	1.50	1.50
EPROM 1Mb 200ns	4.90	5.67	5.00	5.88	5.20	4.20
EPROM 256K, 200ns	1.83	2.04	1.80	1.75	1.65	1.55
SRAM 1MB, 128KX8	18.75	21.41	16.50	NA	NA	NA
SRAM 256K, 32Kx8	4.25	4.36	4.25	5.10	4.90	4.80
SRAM 64K, 8Kx8	1.60	1.54	1.70	1.23	1.40	1.55
Lead Time (Weeks)	6	4	4	2	7	3
68000 12 MHz	4.95	5.14	5.40	4.00	3.10	4.00
68HC11	8.40	8.03	8.00	8.75	8.60	NA
80286 12 MHz	7.00	14.63	8.00	6.85	9.70	6.80
80386SX-16	57.00	53.51	55.00	65.00	65.00	57.00
8051	1.55	2.07	1.90	3.50	1.80	1.80
Lead Time (Weeks)	4	4	4	3	4	6

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (April 1991)

Market Analysis

April Market Watch: Semiconductor Business Climbs Amid Flat Systems Market

The *Market Watch* is a monthly Dataquest article that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

The Book-To-Bill Stabilizes at 1.09; Business Is Brisk

As seen in Figure 1, the book-to-bill ratio for March remained at a very healthy 1.09 compared with February's 1.09 ratio and a revised January ratio of 1.03 (up from 0.96). The figures behind the ratio continue to reflect positive business activity. The March three-month average bookings level climbed 7.2 percent over February, and the respective billings level was up 17.4 percent over last month. The steady

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

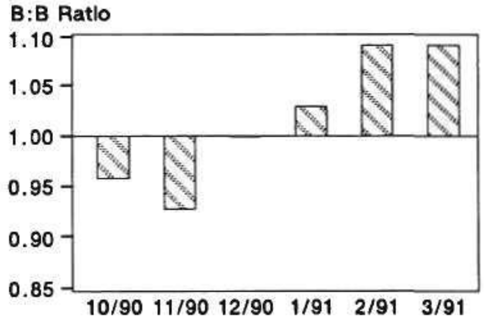


Figure 2
DOC Computer Demand

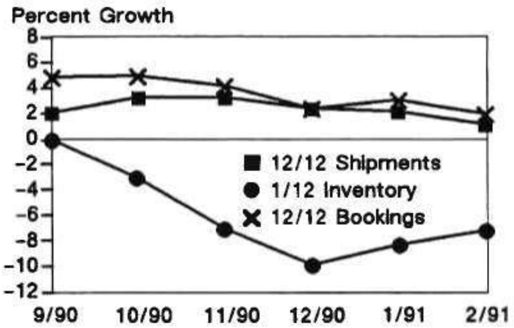


Figure 3
Semiconductor Inventory Level

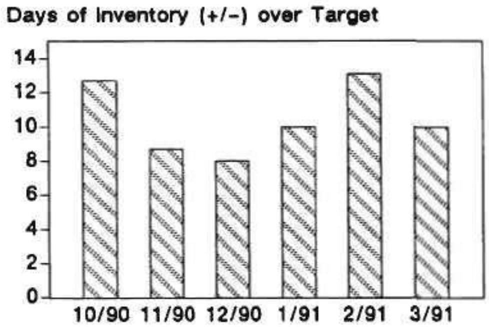
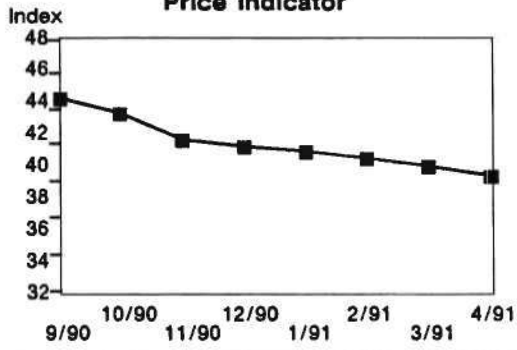


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (April 1991) systems sales expectations noted in our monthly procurement surveys are quickly being translated into semiconductor shipments due to consistent lead times and low inventory levels. The six-month electronics sales outlook per our sample returned to a realistic 3.4 percent forecast, down from the postwar optimistic 5.2 percent revised average rate noted last month.

Computer Booking and Billing Rates Dip; Inventory Rate Rises

Figure 2 shows that the Department of Commerce's (DOC's) February booking and billing rates for computers and office machines has declined slightly to 2.0 percent and 1.2 percent from a respective January rate of 3.1 percent and 2.1 percent. The 1/12 inventory rate again rose slightly, but it is still way below the annualized shipment rate.

Slow growth at the systems level combined with low inventory levels and abundant semiconductor supplies are allowing procurement managers to further hone forecasting methods and communication levels.

The flat electronics market reflects a very good balance between supply and demand from both a systems and a semiconductor perspective. In the absence of any new high-volume product or system, Dataquest continues to forecast low, gradual growth for the semiconductor market. Economic indicators point to a possible resumption of cautious consumer confidence that may push growth rates in electronics upward now that the uncertainty of war is past.

Semiconductor Inventories Remain Controlled

Figure 3 highlights the fact that semiconductor inventory levels remain controlled with the difference between target and actual levels now at 10.0 days, down from last month's 13.1-day delta. As mentioned in last month's *Market Watch*, our procurement sample appears to be gravitating toward a "golden mean" of 20 days targeted and 30 days actual inventory levels. Last month's correction of targeted and actual levels of inventory resulted in golden mean 20.6-day target and 30.6-day actual levels for March. Adjustments to inventory variances within a month as noted here exemplify how communications have improved within organizations as well as with suppliers.

Overall Prices Remain Stuck, Deliveries on Schedule

The overall pricing situation is one of stasis as the high-volume memory market slowly moves along without noticeable price declines, and the high-priced microprocessor segment is in relative balance with demand. Availability for all semiconductors remains very good, yet 1Mb DRAMs still have the longest lead times (as high as 10 to 12 weeks) while the rest of the market averages 6 to 8 weeks.

Dataquest expects this supply/demand balance to continue for the next three to six months as suppliers continue to match levels of semiconductor users' needs.

The impact of increases in non-Japanese DRAMs on the world market may begin to be seen in the next few weeks, which may depress average prices. Components delivery times are expected to remain predictable because of the balance of supply with current demand. The good communications that exist would alert suppliers to any future changes.

Dataquest Perspective

The second month of semiconductor booking and billings growth is encouraging and corroborates what the respondents to our monthly procurement survey have noted. Slow growth at the systems level combined with low inventory levels and abundant semiconductor supplies are allowing procurement managers to further hone forecasting methods and communication levels.

Any change to system demand is quickly being transmitted to the semiconductor supplier. Dataquest expects this supply/demand balance to continue for the next three to six months as suppliers continue to match levels of semiconductor users' needs.

By Mark Giudici

European Semiconductor Procurement Survey 1990 Trend Analysis

Introduction

This article analyzes the results of Dataquest's annual European semiconductor procurement survey conducted by the European Components Group. The survey serves two major purposes. First, it indicates key trends in semiconductor procurement from the purchasing community, which is used as an input to modeling future semiconductor demand by product category. Second, it provides an insight into the buying habits of the purchasing community in different equipment sectors.

Overview—The Customer Is Still Always Right

The issues most frequently cited by buyers are quality, on-time delivery, and price. This article shows that a huge gap remains between the requirements of the buying community and the performance of major vendors in meeting these requirements. Dataquest believes that as the new decade advances, service will become a major battleground; it will be used increasingly by buyers to differentiate between otherwise successful vendors. This, together with buyers' desire to reduce the number of vendors they use, will require vendors to carefully balance their future investment between R&D, manufacturing, and customer service. Customer service includes electronic data interchange (EDI) for purchase orders, invoicing, and order acknowledgement; technical and application support; and logistic planning of purchases through to final, timely delivery at the specified quality and price.

Survey Results

Data Processing—Europeans Need to Adapt Internationally

In our survey, all purchasing executives of the data processing segment indicated that purchasing of semiconductors in 1990 was reduced by a factor of at least 10 percent, compared with 1989. Their 1991 semiconductor spend is expected to recover to the 1989 level.

In the mainframe sector, more than 50 percent of the revenue from ICs purchased is accounted for by memory devices, followed by 21 percent ASICs and 20 percent microcomponents. Of the ASICs purchased, 50 percent are standard cells, 40 percent gate arrays, and 10 percent programmable logic. Discrete devices comprise the smallest revenue at 3 percent.

In the personal computer sector, 50 percent of revenue from ICs purchased is from memory devices, 25 percent from ASICs, followed by 20 percent from microcomponents. Of the ASICs purchased, 70 percent are gate arrays and 20 percent are standard cells.

Dataquest found some major differences in the purchasing methods between certain computer manufacturers, namely North America–owned multinationals and Europe-owned companies. While North American computer manufacturers hardly used any distribution suppliers, European computer manufacturers purchased up to 10 percent of their semiconductor supply from distributors. This suggests that European inventory control is inadequate, occasionally relying on the spot market for top-ups.

North American multinationals ran the tightest inventory, currently carrying 2 weeks stock with a goal to reduce to 1 week. Their European counterparts carry an inventory of 5 weeks with a long way to go for a desired goal of 1 week. One leading North American multinational in Ireland has a current inventory of 8 days with a goal to reduce it to 4 days. A sizable European computer company is carrying 50 days of inventory, with a goal to reduce this in the long term, but does not expect it to change in 1991.

European computer companies' usage of ASICs is relatively low compared with the North American multinationals. Clearly, one area that European computer manufacturers need to address immediately is their purchasing strategies. In 1990, most multinational computer companies decreased their semiconductor spending, and some European companies increased their spending. This indicates that European companies either lack the bargaining power associated with volume purchases or increase inventory after misreading price trends.

Buyers' overall concerns in the data processing sector are volatility of memory prices and the large number of vendors they currently do business with.

Communications—Consistent Growth

This was the most optimistic and buoyant of all the end-user segments surveyed. Purchasers in this segment increased their 1990 semiconductor spend by up to 10 percent. Most expect this to increase in 1991 by between 12 and 20 percent.

Currently, the switching market is the most dynamic sector. This is due to the success of major telecom vendors in their export markets, some of which include Eastern Europe. Transmission is another strong area, consuming more discrete components than the switching sector; consumption of these areas are 25 percent and 10 percent, respectively.

The switching sector uses a large percentage of ASIC devices (72 percent of total ICs used) of which 50 percent are gate arrays and 30 percent full-custom. This sector has a relatively low penetration rate for standard cells and programmable logic. In the transmission sector, of the ASICs purchased, 50 percent are standard cells and 40 percent gate arrays.

Buyers are generally becoming more strategic in their purchasing plans, thereby reducing short-term spot market and distribution purchases.

It is interesting to note that while vendors of semiconductor memory devices continue to focus on the highly volatile EDP market, buyers in the communications sector indicated that their third-largest purchase is memory devices. In the transmission sector, 30 percent of all ICs purchased are memory-based, while in switching, 16 percent are memory-based.

In the cellular communications sector, buyers expect a growth in semiconductor revenue of 15 percent in 1991, compared with a growth of 18 percent in 1990. The survey shows that 33 percent of semiconductors purchased in this sector are discrete, with RF components being the most expensive items. The next-largest product group is ASICs at 20 percent of total expenditure, of which 60 percent are gate array, 30 percent are full-custom, and less than 5 percent are programmable logic.

The communications segment has come a long way in managing its inventory. Equipment manufacturers from this segment currently carry two to four weeks of inventory, with a goal of reducing this to between one and two weeks.

Users' major concerns in this segment are product obsolescence, the reduction of vendor base, increased quality, and on-time delivery.

Industrial—A Mixed Bag of Surprises

Up to 50 percent of semiconductor consumption in the industrial segment is in discrete devices. Next in rank are commodity analog at 25 percent, followed by memory and logic devices accounting for another 25 percent collectively.

This segment has the lowest penetration of ASIC products. Most purchasers indicated that less than 10 percent of their revenue was in ASICs, and 40 percent of this is programmable logic due to relatively short production runs.

Inventory levels vary considerably between companies. The highest level recorded was 10 weeks, with a plan to reduce this to 6 weeks. The lowest level was 4 weeks with a goal to reduce to 2 weeks.

This remains a good segment for semiconductor distributors, with up to 30 percent of purchases made via distribution channels, which is the highest percentage across all segments. The bad news is that many respondents indicated that they plan to reduce the number of distributors they trade with.

Overall, the industrial users surveyed increased their semiconductor purchasing by 8 percent in 1990. The majority of respondents indicated an expected or planned increase of 11 percent in 1991. The major concerns in this segment are the reduction of vendor base, implementation of EDI, pricing, and inventory cost control.

Consumer—Linked to Local Economies

It was difficult to get an adequate snapshot of this segment due to a low response level to the survey. The inputs of the few that responded suggest that spending in this segment will decline by 10 percent in 1991, with 1990 being flat compared to 1989.

This segment still uses a large percentage of discrete devices, amounting to about 35 percent of total expenditure. Many consumer segment OEMs have offshore purchasing offices, mainly in the Far East, which may affect the potential of European IC demand. Between 10 and 15 percent of purchases are placed with local distributors.

Inventories are currently running at three weeks and are expected to remain the same in 1991. Major concerns in this sector are quality, packaging, price, and on-time deliveries.

Military—Perestroika Strikes a Blow

Of all the segments surveyed, the military segment was the most pessimistic. Some purchasers recorded as much as a 50 percent decrease in semiconductor spending for 1990, although some end users in France maintained their spend at the same level as 1989. Most purchasers expect 1991 to remain flat, or with a slight growth, depending partly on the outcome of the Gulf crisis, which may drive up the replacement market.

A large percentage of military standard parts are procured through distribution channels—as much as 40 percent for sonar equipment and 20 percent for aerospace equipment. The general downturn in this segment is also affecting the purchasing organization of these companies. With recent cutbacks, many new purchasing executives have had to go through a learning curve, which disrupts traditionally long-established relationships between the manufacturer and the vendor.

Inventories are difficult to measure in this sector, but most respondents indicated a desire to reduce them by 30 percent. Major concerns include the reduction of vendor base, product obsolescence, and the general health of the military equipment industry.

Automotive—Shining Light and Example for the Future

This segment currently carries the leanest inventory level in the industry, with typically two weeks of supply in stock. The goal for most automotive segment buyers is to reduce stock supply to one week. These buyers regard their vendors' current performance of just-in-time delivery, quality, and pricing as insufficient to achieve this goal.

The trends in product consumption, across many different automotive segment buyers, will vary considerably because of the range of end products that are manufactured. In Germany, up to 25 percent of semiconductor consumption in this segment is in discrete components and 38 percent in ASICs, of which almost all are full-custom designs. Meanwhile, in Italy, only 17 percent of semiconductor spend is in discrete components, but, on the other hand, these users spend 66 percent in ASICs, of which 70 percent are cell-based designs.

Microcontrollers account for 40 percent of semiconductor demand in Germany, while in Italy only 7 percent of the demand is in microcontrollers. Across the automotive segment there is relatively low demand for commodity analog or logic devices.

This segment increased its semiconductor purchase by 12 to 15 percent in 1990. Due to recessionary fears, buyers expect to increase their purchase by only 8 to 10 percent in 1991. Major concerns in the segment are on-time delivery, quality, and price.

Dataquest Perspective

One of the key issues this survey has brought forward is that OEMs, in most segments, wish to reduce the number of vendors with whom they do business. The motivation is to minimize unneccesary paperwork and maximize large-volume discounts. Buyers are generally becoming more strategic in their purchasing plans, thereby reducing short-term spot market and distribution purchases. The emphasis is on building up strong relationships with key vendors.

Table 1 summarizes the factors that will determine the success or failure of vendors in the 1990s. These include on-time delivery, quality, and pricing. It is clear that vendors must refocus on service as well as price in order to win their customers' loyalty. Many OEMs evaluating the total cost of ownership of a product realize that unit price is just the tip of an iceberg.

By Bipin Parmar
Byron Harding

(This article is reprinted with the permission of Dataquest's European Semiconductor Application Markets service.)

Table 1
Summary of Respondents' Issues

Application Segment	Data Processing	Communications	Industrial	Consumer	Military	Automotive
Respondent's Expectations						
Growth 1989-1990	-10%	+10%	+8%	No Change	-30%	+12-15%
Growth 1990-1991	+10%	+12-20%	+11%	-10%	No Change	+8-10%
Present Inventory Level (Weeks)	1-7	2-4	4-10	3	Indefinite	2
Target Inventory Level (Weeks)	0.5-2	1-2	2-6	3	Indefinite	1
Procurement Issues						
1 = Weakest Issue						
10 = Strongest Issue						
ASICs	4	7	5	5	8	3
Availability	7	10	8	NA	4	2
Cost Control	5	6	6	NA	3	7
Fluctuating Exchange Rates	5	4	3	NA	2	4
Forecasting	7	6	8	NA	6	5
Inventory Control	5	6	7	5	7	7
Memories	6	6	7	5	6	2
Product Obsolescence	7	7	4	NA	5	3
Offshore Procurement	4	6	2	NA	1	2
On-Time Delivery	8	7	9	5	7	5
Pricing	8	8	9	5	9	9
Quality and Reliability	8	8	9	5	10	10
Reduce Vendor Base	6	7	9	5	9	4
Second Sourcing	4	6	6	NA	7	5
Surface Mounts	3	8	8	NA	1	4
Other Issues	NA	NA	9	NA	5	NA

NA = Not available
These results reflect the views of respondents to the procurement survey and are not aggregated to reflect total market statistics.
Source: Dataquest (April 1991)

Product Analysis

Challenge for Supply Base Managers: The Shifting World of Microprocessors

Executive Summary

Dataquest's preliminary 1990 estimate of suppliers' microcomponent market shares shows that the microprocessor (MPU) marketplace remains familiar—although the underlying market dynamics are changing rapidly. For users, this article reviews the product life stage for 8-, 16-, 16/32-, and 32-bit MPUs as of April 1991 and provides an assessment of the supplier/supply base for these devices for the rest of this decade.

Overview

This article provides MOS microcomponent users with practical and strategic information for choosing which devices to use and from which supplier or suppliers. MOS microcomponents are defined by Dataquest as including MOS MPUs, MOS microcontrollers, and MOS microperipherals. The *focus* is on 8-bit, 16-bit, 16/32-bit, and 32-bit MPUs. (The report replaces the "MOS Microcomponent Product Trends" section of the *Industry Trends* binder of the former Semiconductor User Information Service.)

The 8 top-ranked suppliers maintained the previous year's ranking.

This article contains three sections. The first section develops a guide to cost-effective, long-term procurement of MPUs through the use of product life cycle analysis. The second section, on the top-ranked suppliers of MOS microcomponents, examines the current and future product strategies, merchant and captive market postures, legal positioning, and strategic alliances of the leading suppliers of MPU devices. The third section combines the analyses of the MPU life cycles and the supplier base. This formation gives users a practical way of assessing their ability to obtain a supply of these devices from the various suppliers during the 1990s.

The sections blend a discussion of the key industry issues that affect MPU users now and in the future. Cumulatively, the information in these sections enables users to develop a sound strategy for satisfying demand for MOS MPUs on a consistent, cost-conscious basis over the long term despite shifts in the supplier base.

MOS Microprocessor Product Life Cycles

This section uses information on MOS MPU product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. This section also lays the basis for other analyses based on MOS MPU life cycle curves.

Typical Life Cycles for MOS Microprocessor Products

Figure 1 presents the product life cycle for 8-, 16-, 16/32-, and 32-bit MOS MPUs through the year 1990 using historical unit-shipments data.

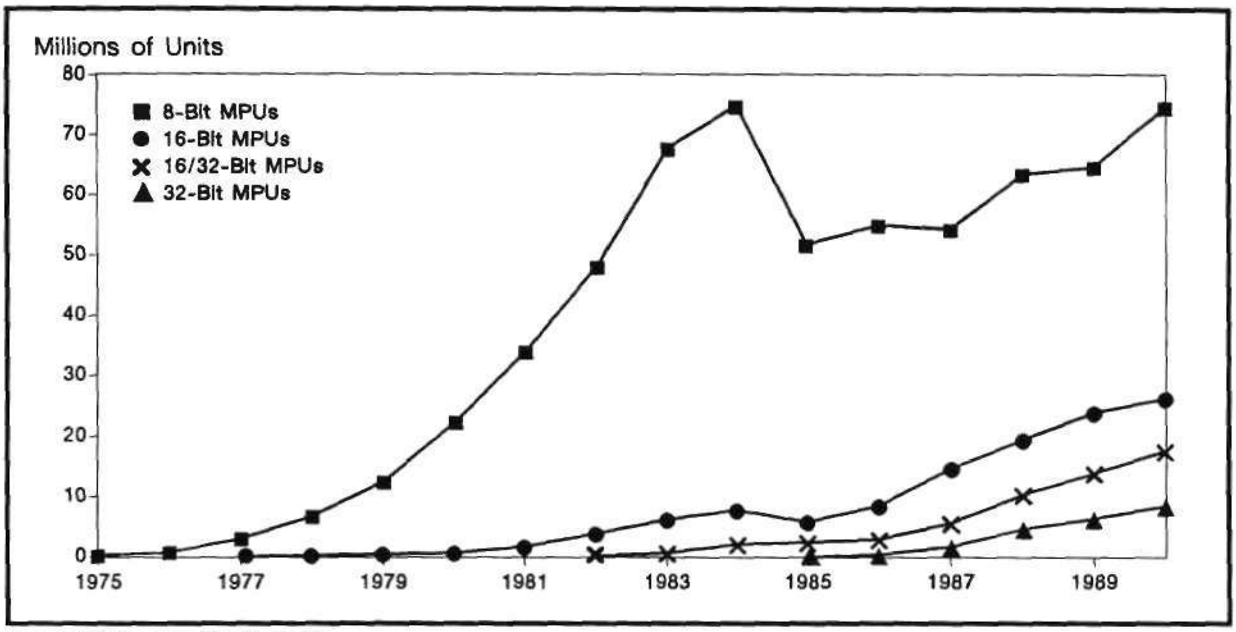
This figure shows that MPU life cycles can last as long as 20 years. Figure 2 projects the MPU life cycle stages for 8-, 16-, 16/32-, 32-, and 64-bit devices during the 1990s and beyond.

As depicted in Figure 2, following a long R&D stage, the product moves through a relatively short introductory stage (6 to 18 months) and then spends 10 to 12 years winding through the growth, maturity, saturation, and decline stages of the cycle. The phaseout period can last from 5 to 6 years.

For users, the lengthy R&D stage provides a valuable opportunity to monitor the vendor's pace of technical achievement as well as the supplier's timetable for bringing the state-of-the-art device to the marketplace. Designers of high-performance systems that call for leading-edge devices should *communicate* with prospective vendors as early in a MOS MPU's product life as possible in order to minimize users' learning-curve headaches.

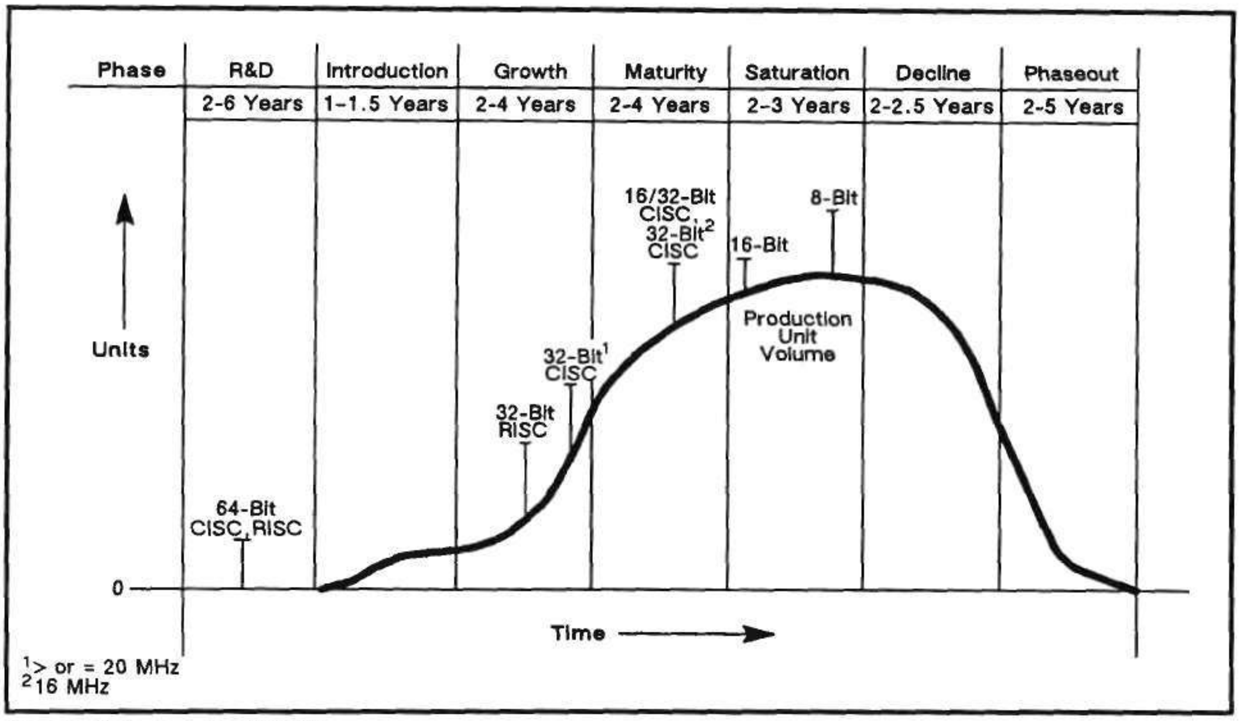
At the other end of the product life cycle, the prolonged phaseout stage generates time during which users can redesign systems (or otherwise adapt system life cycles) in line with the impending obsolescence of a given device.

Figure 1
Unit Shipments of 8-, 16-, 16/32, and 32-Bit Microprocessors through 1990



Source: Dataquest (April 1991)

Figure 2
Microprocessor Product Life Cycle as of April 1991



Source: Dataquest (April 1991)

Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of MOS microprocessors. This analysis covers product positioning, market ranking, legal issues, and strategic alliances.

Table 1 shows Dataquest's preliminary 1990 worldwide MOS microcomponent market share ranking of the top 12 suppliers. As the table shows, the 8 top-ranked suppliers maintained the previous year's ranking. The strength of these companies in holding market ranking reflects the high degree of concentration in the MOS microcomponent arena: the top 10 suppliers command more than 77 percent of total market share.

Intel

As shown in Table 1, Intel, the top-ranked supplier of MOS microcomponents, commanded more than 25 percent of this expanding market during 1990. Led by high-priced complex-instruction-set computing (CISC) MPUs such as the 80386 and 80486, Intel generated $2.7 billion in revenue from microcomponent sales during 1990. This volume of business nearly equals the *combined* microcomponent revenue of the second-, third-, and fourth-ranked suppliers.

Intel's product strategy calls for a constant push for state-of-the-art MPUs in terms of density, functionality, and performance. Users can expect Intel to make massive expenditure on capital equipment and R&D during the 1990s in order to protect its leadership position.

As noted, the 80386SX MPU (16/32-bit device) and the 80386 and 80486 MPUs (32-bit devices) generate impressive streams of revenue for Intel. A number of companies plan to clone these devices. Intel continues to state that no supplier will be licensed to produce these lucrative MPUs for merchant market sales.

Intel firmly grounds its current success and future plans on aggressive legal protection of its intellectual property. A major legal issue is the ability of other suppliers to end Intel's monopoly on these ICs.

A practical concern for users centers on Intel's plans during the 1991 to 1992 period for the 80386SX, 80386, and 80486 families of MPUs. For example, users can expect Intel to continue its campaign to kill the 80286, but it will shift the fight from the 80386SX to other products such as the 80386SL.

At the time this article was written, Intel—clearly the prevailing global power in the MPU business—had started to set new long-term rules for users. As noted in prior articles, Intel's product/pricing strategy will no longer be based on a simple and straightforward premium

Table 1
Preliminary 1990 Worldwide MOS Microcomponent Market Share Rankings (Thousands of Dollars)

1990 Rank	1989 Rank	Company	1990 Revenue	1989 Revenue	Percent Change
1	1	Intel	2,718	1,929	41
2	2	NEC	1,083	937	16
3	3	Motorola	1,002	803	25
4	4	Hitachi	648	554	17
5	5	Mitsubishi	462	435	6
6	6	Toshiba	449	407	10
7	7	Texas Instruments	320	252	27
8	8	Matsushita	240	217	11
9	10	Fujitsu	239	211	13
10	11	National Semiconductor	237	172	38
11	9	Chips & Technologies	230	216	6
12	12	Advanced Micro Devices	200	172	16

Dataquest (April 1991)

charge for a higher-speed version of a device. For example, by varying the architecture of the 80486 IC, Intel will be able to meet users' precise requirements regarding product price/performance tradeoffs. Functions such as floating point capability or cache can be disabled in line with users' needs, and power management capability could be added.

Users can periodically expect an apparent proliferation of new product offerings from Intel before Intel decides which MPUs are the market winners.

Intel will keep its future product direction obscure in order to maximize its profit stream. Generically, users can expect the development of faster and more powerful MPUs such as an 80586. Intel will use current reduced-instruction-set computing (RISC) products (for example, the 80860 and the 80960) as the first step for the company's long-range RISC MPU technology road map. After 1992, some 80486 users are likely to migrate to the 80586 device, a RISC product, or special versions of the 80486.

NEC

Like other Japanese suppliers of MOS microcomponents, second-ranked NEC draws on its position as a vertically integrated supplier to guide its strategy for serving the merchant market. As a full-line semiconductor supplier, NEC remains fully committed to being a major participant in the global microprocessor/microcomponent business. This supplier holds nearly an 11 percent share of the microcomponent market.

In its current product portfolio, NEC's V-series of 8-, 16-, and 32-bit MPUs continue to anchor the strategy for serving this market. Although a past legal battle with Intel is receding from users' minds, the lawsuit caused NEC to lose ground in the 16-bit MPU segment. Users can expect NEC to strengthen its position in the MPU segment during the 1990s. The company has positioned itself well for the long term regarding use of the CMOS process technology in microcomponent production.

Motorola

Third-ranked Motorola continues to target the microprocessor segment as being vital to both short-range and and long-term strategic goals. Motorola draws on its experience as a vertically integrated captive manufacturer to generate a full range of competitive MOS microcomponents.

Motorola won Dataquest's Semiconductor Supplier-of-the-Year Award for 1988, 1989, and 1990 (in the large company category). In the microcomponent business, Motorola's engineering efforts have won the company an excellent reputation as a supplier of 8-, 16-, 16/32, and 32-bit MPUs. Motorola has successfully penetrated the fast-growing technical workstation market with its high-performance 32-bit MPUs (68020s and 68030s).

Motorola's delay of 68040 MPU shipments—from the second half of 1990 to early 1991—caused consternation for select users as well as Motorola. Many customers have held steady in their commitment to use of this 32-bit MPU; however, *some* users are evaluating alternate MPU sources for now or the future.

Advances in the CISC-based 68000 family—the 68040 and its likely successor, the 68050—represent, in part, Motorola's long-term strategy for competing against the innovative new RISC architectures. Another prong of the strategy is Motorola's development of the 88000 series of RISC MPUs.

Hitachi

Hitachi continues to draw on its position as a vertically integrated manufacturer and its expertise in CMOS technology as keys to its fourth-place ranking in the global MOS microcomponent business. Hitachi's primary strength, however, lies in microcontrollers. Hitachi's current product direction is derived largely from its role as a second source for several major MPUs. For example, Hitachi developed its best-selling 8-bit MPU—the 64180—from Zilog's Z80 architecture. Hitachi subsequently licensed the 64180 to Zilog. Hitachi also supplies the Motorola-based 68000 device.

Hitachi has played a major role in Japan's The Real-Time Operating Nucleus (TRON) project. This government-backed effort by Japanese suppliers has aimed at the development of a workable operating system and architecture for MPUs and microcontrollers to break Japan's dependence on U.S. standards. However, TRON has had no major market impact to date.

Mitsubishi

Like other Japanese producers, fifth-ranked Mitsubishi draws on its position as a vertically integrated manufacturer and its expertise in CMOS technology to guide its strategy for serving the demand for MOS microcomponents. Regarding MPUs, Mitsubishi serves as a second source of Intel's 8-bit MPUs (8085 and 80C85).

This supplier, in part, staked its claim in the 32-bit microprocessor business on participation in Japan's TRON project.

Toshiba

Toshiba, a vertically integrated manufacturer, has won the sixth-place ranking in the microcomponent marketplace through its expertise in CMOS process technology. Toshiba's MPU product portfolio continues to center on the 8-bit Z80C devices. Toshiba developed Zilog's Z80 microprocessor into a line of CMOS devices.

Toshiba, in part, based its future product direction in the MPU business on participation in the TRON project. With TRON apparently languishing, strategic alliances should play a major role in Toshiba's future product strategy.

Toshiba's well-publicized strategic alliance with Motorola, however, has not yet served as an avenue for Toshiba into the 32-bit MPU arena. Through an alliance with Sun Microsystems, Toshiba's future 32-bit microprocessor product portfolio could include SPARC-based devices.

Texas Instruments (TI)

Seventh-ranked TI targets demand for specialized MPUs and microperipherals as the key to its MOS microcomponent strategy. The industry giant joins Motorola as one of only two U.S.-based microcomponent vendors that are fully vertically integrated. Although neither company is integrated to the same extent as their Japanese competitors, this integration nevertheless translates into a technological advantage in terms of identifying and serving specialized microcomputing needs.

TI's current product portfolio does not place the company among the mainstream suppliers of MPUs. TI's major efforts in the MPU arena are in supplying MPUs and microperipherals for graphics, speech, DSP, and other specialized applications. TI remains the world's leading supplier of digital signal processing (DSP) devices. TI's future product portfolio will offer a wide range of CMOS devices. The company is likely to place future emphasis on specialized MPUs (34010 and 34020). TI is also moving aggressively into the PC logic chip set business.

A key to TI's long-term strategy will be fierce protection of intellectual property rights. At the time this article was written, TI had just filed suit to overthrow the "Hyatt" patent, which claims to cover all MPUs. If TI wins this patent claim, at a minimum, TI would be shielded from future MPU royalty payments—and in position to seek them.

Matsushita

Like other Japanese suppliers, Matsushita draws on its strength as a vertically integrated manufacturer and its skill in CMOS technology to achieve its eighth-place ranking in MOS microcomponents. Matsushita's current product strategy focuses on supplying microcontrollers, which account for the bulk of the company's microcomponent shipments.

Participation in Japan's TRON project represents Matsushita's major strategic alliance in the MOS microcomponent arena.

Fujitsu

Ninth-ranked Fujitsu's product portfolio in the microcomponent arena derives from the microcontroller side of the business.

Strategic alliances could be the key to Fujitsu's future MPU product direction. Fujitsu has a licensing agreement with Sun Microsystems, which serves Fujitsu a stake in the rapidly growing 32-bit SPARC arena. The TRON alliance, however, offers less promise as a long-term alternative.

National Semiconductor

Tenth-ranked National Semiconductor has secured a solid stake in the MPU arena. National Semiconductor's line of 16/32-bit MPUs and 32-bit MPUs has quietly emerged as an industrial application leader.

Users can expect firm long-term commitment by the company to the 320XX and 32X32 product families.

Chips & Technologies

Eleventh-ranked Chips & Technologies earns its microcomponent revenue through the sale of chip sets. The year 1990 was challenging for chip set suppliers, as shown by the company's decline in ranking from ninth position during 1989 to its current rank.

Advanced Micro Devices (AMD)

Twelfth-ranked Advanced Micro Devices held ground during 1990 in the midst of continuing marketing and legal wars with Intel. Shipments of 80286 MPUs kept AMD's fabs busy during 1990 as demand surged from newly expanding markets such as Eastern Europe.

Clearly, the company is staking its long-term position in the MPU arena on the just-introduced Am386 device. AMD just won a legal trademark case over Intel on use of the 386 name; however, AMD's right to use Intel's 80386 microcode awaits judicial resolution—and may not be finally decided until 1992 or even 1993. Regardless of the outcome, Advanced Micro Devices has begun to ramp up production of its banner 32-bit product, the 40-MHz Am386.

Supply Base Analysis

This section uses information on MOS microcomponent product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for 8-bit, 16-bit, 16/32-bit, and 32-bit MPUs. As noted in the discussion of Japan's TRON project, North American producers have maintained a technological lead over Japanese competitors in the MPU segment of the semiconductor business. Nevertheless, design engineers and procurement managers will have *some* new opportunities in terms of the selection of dependable long-term suppliers of these devices. North American, Japanese, and European companies will battle for a share of this rewarding market. The goal of this section is to provide users with a practical means of gauging the long-term supply base for a given density of MOS MPUs and direction for selecting the suppliers of these devices.

On the basis of preliminary results, the top three suppliers of microcomponents during 1989—Intel, NEC, and Motorola—held their rankings during 1990.

Each section contains a table showing the size of the market in terms of units shipped during 1990, the relative market shares of the predominant devices, and a ranking of the suppliers of these devices including suppliers' shares in each product segment.

Product life cycle analysis serves as the basis for a summary assessment from a user's perspective on anticipated supply of each density of MPU. The summary includes a statement on whether the user faces a favorable or a critical supply base for each density. Building upon the prior sections, factors affecting the supply base, such as supplier strategies and strategic alliances, are discussed here. Table 2 provides information on the market size and leading suppliers of the predominant 8-bit MOS microprocessors as of 1990.

Supply Base for 8-Bit MOS Microprocessors

The preliminary Dataquest estimates for 1990 show continuing growth in supply of 8-bit

Table 2
Supply Base for 8-Bit Microprocessors (1990*)

Leading Products	Product's Share of Total 8-Bit MPU Market (%)	Supplier's Share of Product Segment (%)
Z80	55.8	
Family		Zilog—47.3
		SGS-Thomson—16.7
		Hitachi—14.6
		Toshiba—12.4
		Sharp—5.9
		NEC—3.1
8085	9.6	
Family		Intel—26.0
		Oki—24.0
		NEC—19.7
		Toshiba—8.2
		Siemens—7.8
		AMD—7.6
		Mitsubishi—6.7
8088	7.9	
Family		AMD—50.8
		Intel—19.1
		Siemens—13.2
		Oki—9.5
		Fujitsu—4.3
		Harris—2.5
		Others—<1
Other ICs	26.7	
Total Market Size = 74.9 Million Units		

*Preliminary
Source: Dataquest (April 1991)

MPUs as the device moves through the saturation stage of the life cycle. The table shows that worldwide unit shipments totaled nearly 75 million during 1990, an increase of 15 percent over 1989. The 8-bit MPU device remains the largest segment of the microprocessor marketplace.

Users of 8-bit MOS MPUs face a favorable supply situation over the long term. As shown in Table 2, most of these products are widely licensed so that users can continue to enjoy the security and low prices of a broad supplier base. Users can expect 8-bit MPUs to have a life cycle that extends at least until 1995. Some life cycles could persist until 1999.

The suppliers shown in Table 2 will support users that clearly signal steady long-term demand via long-term projections and/or procurement agreements. For the Z80 family of MPUs, users should look to Zilog, SGS-Thomson, and Hitachi (64180). For CMOS versions, the leading suppliers are, in descending order, Toshiba, SGS-Thomson, NEC, and Sharp.

The information in Table 2 reveals that for the 8085 family of devices, users can look primarily to Intel, Oki, and NEC. For the 8088 family, leading suppliers include AMD, Intel, and Siemens.

Supply Base for 16-Bit MOS Microprocessors

Table 3 provides information on market size and the leading suppliers of the predominant 16-bit MOS microprocessors as of 1990.

As shown in Table 3, unit shipments of 16-bit MPUs expanded 9.6 percent during 1990 to a total of 26.3 million units versus the 1989 level. Like 8-bit MPUs, 16-bit devices tend to be multisourced. The preliminary Dataquest estimates place 16-bit MPUs in the late maturity stage of the life cycle. The life cycle of these devices should extend at least until 1997.

For example, trends during 1990 signal some extension of the life cycle for the 80286 MPU. During 1990, demand for this mature processor surged in newly emerging markets in Eastern Europe and the USSR—to the pleasant surprise of suppliers such as Advanced Micro Devices and Siemens. Demand from manufacturers of notebook PCs in regions such as Rest of World and Asia could translate into a boost in demand for low-power versions. For some products in *some* regions (for example, the 80286 in Eastern Europe), the cycle could last until the year 2000.

Table 3
Supply Base for 16-Bit Microprocessors (1990*)

Leading Products	Product's Share of Total 16-Bit MPU Market (%)	Supplier's Share of Respective Product Segment (%)
80286, 80C286	49.6	Intel—41.4
		AMD—36.7
		Harris—11.1
		Siemens—9.4
		Fujitsu—1.4
80186, 80C186	16.3	Intel—76.1
		AMD—17.7
		Fujitsu—3.5
		Siemens—2.6
V30/V50	14.6	NEC—>99
		Sharp—<1
8086, 80C86	11.6	NEC—36.6
		AMD—23.1
		Intel—22.8
		Siemens—10.7
		Fujitsu—5.5
		Harris—1.3
Z8000	6.3	Zilog—55.0
		SGS-Thomson—37.2
		Others—7.8
Others	1.6	
Total Market Share = 26.3 Million Units		

*Preliminary
Source: Dataquest (April 1991)

For users of second-sourced ICs, the MPU world should remain familiar over the long term.

Users of 16-bit MOS MPUs face a favorable supply situation over the long term. The supplier base should narrow over time but without major disruption of the supply chain. For example, Intel will gradually depart from this market but will work carefully with users in making the transition.

Users for 80286 MPUs can continue to target AMD, Intel, Harris, and Siemens; however, the low level of pricing probably means one or two suppliers will leave this arena during 1992 or 1993. Harris specializes in higher-speed CMOS versions.

Regarding other families, users of 80186 devices should turn to either Intel or AMD. Intel is the sole source for 80C186 MPUs. NEC is, in effect, the sole source for the V30/V50 series.

As shown in Table 4, unit shipments of 16/32-bit MPUs expanded at a robust 27.3 percent rate during 1990 to a total of 17.7 million devices. These products, which bridge the 16- and 32-bit worlds, reflect the multisourced character of the 16-bit segment and the sole-sourced reality of the 32-bit arena.

For example, Motorola holds the lion's share of the market for its 68000 MPU—but multiple sources exist. By contrast, Intel is the only current legal source for the 80386 device. Users can expect a long life cycle for the 68000 MPU. It is likely to extend at least until 1998.

Depending on the speed choice and Intel business relationship, users of the 80386SX face an uncertain outlook regarding long-term supply. For example, Intel started to migrate *some* major users from the 16-MHz 80386SX to the 20-MHz 80386SX during late 1990 and early 1991. The life cycle of the 16-MHz 80386SX could terminate by 1993 or 1994. *Other* users of 80386SX devices are shifting or will be shifted to a newer low-power IC, the 80386SL; its life cycle could extend to 1995 or beyond.

Advanced Micro Devices or other suppliers are likely to offer 386SX devices, but market and legal uncertainty could delay market acceptance until 1992 or 1993—if ever.

Table 4
Supply Base for 16/32-Bit Microprocessors (1990*)

Leading Products	Product's Share of Total 16/32-Bit MPU Market (%)	Supplier's Share of Respective Product Segment (%)
68000	63.9	Motorola—71.8
		Signetics—9.8
		Hitachi—8.5
		SGS-Thomson—6.4
80386SX	26.8	Intel—100
Total Market Share = 17.7 Million Units		

*Preliminary
Source: Dataquest (April 1991)

Supply Base for 32-Bit MOS Microprocessors

Table 5 provides information on the market size and leading suppliers of the predominant 32-bit MOS MPUs as of 1990.

As shown in Table 5, unit shipments of 32-bit MPUs increased to 8.5 million pieces during 1990, a 33 percent increase over 1989. MPU products such as the 80386, 80486, 68020, and 68030 have life cycles that should extend beyond the year 2000, although the life cycle for some 16-MHz versions are likely to terminate sooner.

Table 5 shows that most 32-bit MPUs are sole-sourced with a glaring exception—RISC devices such as the R3000. Intel and Motorola broke the prior bond between multisourcing and market acceptance; however, the following trends during the 1990 to 1991 period could disturb users' comfort with single-sourced suppliers:

- Advanced Micro Devices continues to undermine Intel's position as the sole-sourced supplier of 80386 devices. A host of suppliers intend to end Intel's monopoly of the 32-bit microperipheral arena.
- Motorola's inability to ship the 68040 device on schedule during the second half of 1990 caused some users to miss a window of market opportunity—which underscores the risk of single-sourced ICs.

Table 5
Supply Base for 32-Bit Microprocessors (1990*)

Leading Products	Product's Share of Total 32-Bit MPU Market (%)	Supplier's Share of Respective Product Segment (%)
80386	42.3	Intel—100
68020	16.3	Motorola—100
68030	13.5	Motorola—100
32x32	5.1	National Semiconductor—100
80486	4.8	Intel—100
R3000	3.0	LSI Logic—36.7
		IDT—32.8
		Performance Semiconductor—30.5
Others	15.0	
Total Market Share = 8.5 Million Units		

*Preliminary
Source: Dataquest (April 1991)

- As noted in Table 5, developers of RISC architectures have licensed second sources in order to win market acceptance, undercutting single-sourced suppliers in the process. Single-sourced suppliers such as Intel and Motorola offer RISC 32-bit MPUs, but their major efforts are still focused on CISC ICs.

Users of 32-bit MPUs face a more favorable supply outlook than several years ago—when the choice was either a sole-source device or an unproven architecture—but the shifting 32-bit MPU scenario remains problematic. For example, it is still uncertain if the early supply snafus will have an impact on the life cycle of Motorola's 68040 product. As of the first half of 1991, Dataquest expects a long 68040 life cycle.

Another example: an apparent benefit of RISC ICs such as the R3000 (multiple sources) means user concerns regarding pin-for-pin IC compatibility (*or* incompatibilities) or long-term supplier viability. Even so, the MIPS architecture won a boost in April 1991 when the Advanced Computing Environment (ACE) consortium selected the family as a standard.

Users of Intel devices can expect a severe challenge in terms of supply base management. Intel is likely to remain a leading supplier the rest of this decade, but Intel's product direction could seem obscure to some users. Why? Intel will be facing a lack of new market demand syndrome (chicken-and-egg struggle): the company will strive to define its MPU product commitment on the basis of user demand; however, Intel must see the demand, which will shift, before Intel can determine which architectures/speeds to support.

Users can periodically expect an apparent proliferation of new product offerings from Intel—some which may seem to overlap—before Intel decides which MPUs are the market winners. Another unsettling issue for users of Intel's 32-bit devices is the emergence, if ever, of legal second sources.

Dataquest Perspective

The MPU marketplace remains quite familiar—although it is changing rapidly. For example, Table 1 shows that, on the basis of preliminary results, the top three suppliers of microcomponents during 1989—Intel, NEC, and Motorola—held their rankings during 1990. Intel, in fact, increased the market distance between itself and the contenders for the top ranking. Another major name in MPUs—Advanced Micro Devices—continues to hold 12th-place ranking in the microcomponent business.

For users of second-sourced ICs, the MPU world should remain familiar over the long term. For example, users of 8-bit devices such as the Z80 family can expect a dependable supply base for these MPUs through 1995 and perhaps as long as through 1999. For 16-bit devices such as the 80286 MPU, the product life cycle should extend through the 1990s for users in newly emerging regions such as Eastern Europe. Suppliers will depart, but will do so in a largely nondisruptive manner.

The sole-sourced supplier will be able to emphasize or de-emphasize support within a product family on the basis of speed, packaging, and other specifications—and also by the user's world region.

Users of sole-sourced MPUs such as Intel's 80386SX (16/32-bit) IC will be on less familiar ground. Prior MPU life cycle analysis, which centers on multisourced products, becomes less applicable. Sole-sourced suppliers such as Intel have much greater power in ascertaining the length of the product's life cycle. The sole-sourced supplier will be able to emphasize or de-emphasize support within a product family on the basis of speed, packaging, and other specifications—and also by the user's world region.

This perspective on the supplier/product life cycle outlook is doubly true in the 32-bit MPU segment regarding sole-sourced suppliers such as Intel and Motorola—but growth of the RISC IC alternative is likely to diminish the market power of sole-source suppliers over users. In effect, during the 1990s, the availability of 32-bit RISC devices and later 64-bit versions—along with some consolidation of the RISC supplier base—could make the rapidly shifting and somewhat bewildering 32-bit MPU marketplace of today similar to the relatively steady 16-bit segment of today.

By Ronald Bohn

Conferences and Exhibitions

Users' 1991 Perspective on Managing Supplier Relationships

Executive Summary

On March 28, 1991, the Purchasing Management Association of Silicon Valley (PMASV), a chapter of the National Association of Purchasing Management (NAPM), held a panel discussion in Santa Clara, California, on "The Buyer/Seller Relationship." The author attended the panel discussion for two reasons. First, the PMASV panel discussion hit on key issues during 1991 for IC users—our clients. Second, the panel presentation is similar to a series of "Buyers' Roundtables" and associated "Buyer Briefings" that the Semiconductor Procurement and Component Engineering Service (SPS) plans to hold for Dataquest clients in North America and Europe later this year.

Dataquest Connection

The panel membership, in part, connects with the Dataquest network: Charles Noland (C.P.M., PMASV-Purchasing) serves as a supply base manager for Apple Computer, a client of Dataquest's SPS. Anthony Bozzini, director of Worldwide Marketing and Sales for Fujitsu Microelectronics, has been a binderholder of Dataquest services such as Semiconductor Application Markets (SAM).

Key Issues

At the outset, moderator John Wooldridge, materials manager for Watkins-Johnson (PMASV-Purchasing) underscored two issues: most users *dislike* breaking prior supplier relations, and delivery by suppliers of *quality parts on time* is a key factor for retaining customers.

Supply Base Management: The Heart of the Issue

A question to the panel for resolving user/supplier disagreement on the maximum level of service elicited a response from Mr. Noland that signals a challenge for SPS clients during 1991 and over the long term. In regard to supply base management, he said that supplier selection represents about 40 percent of the effort—the easier part. System product life cycles now run just 18 to 60 months. Once the supplier has been selected, the stiff challenge for users (60 percent of their time) becomes the management of the supplier, especially when the supplier's performance slips somewhat. In particular, for Apple Computer, the trend in supplier base management has been toward a "participatory" decision-making framework with suppliers and away from the more familiar authoritarian stance of the past. Mr. Noland said that in many cases, Apple Computer is *not* in complete agreement with its top strategic partners—a hint that such a goal is unrealistic for supply-base managers during the 1990s.

The trend toward supplier base reduction—also known as strategic partnering—continues despite trade press reports to the contrary.

A logical subsequent question is how can users lower the rejection rate of sole-sourced suppliers? Mr. Bozzini bluntly stated that any sole-sourced supplier accepts *added* responsibility regarding delivery, price, and quality. He advises that users should demand *immediate* positive results.

Mr. Noland stated that users *must* have a feedback structure—a total quality program with concrete data on mean time between failures—in order to communicate deficiencies to sole-source suppliers. SPS clients have expressed growing interest to Dataquest in developing such programs and measurements, while both users and suppliers clamor for the data behind Dataquest's Semiconductor Supplier-of-the-Year award. He said that the results of the quality program enable users to distribute negative sanctions or positive rewards depending on the sole-source supplier's performance.

Mr. Bozzini made another recommendation in line with prior recommendations regarding the use of sole-sourced products: users must develop different scenarios regarding suppliers' quality goals and the way in which the user/supplier relationship will evolve depending on the achievement of those goals. For example, in ascertaining use of sole-sourced MPUs from Intel or Motorola, Dataquest recommends that users examine these suppliers' worldwide network of fab capacity *for a given sole-sourced*

MPU with a view to users' global system-production plans.

He also pinpointed the obvious disadvantage of using a sole-sourced part versus a multisourced IC: if a user has two suppliers and one supplier's performance outshines the other, the outstanding supplier should be rewarded with an increased share of the business.

The Trend toward Supplier Base Reduction

The final question centered on the panel participants' approach to the trend toward supplier base reduction. Despite some contrary views expressed recently in the trade press—for example, "Our company never reduced its supplier base" or "Our firm is expanding its supplier base"—the panel members endorsed the ongoing reality of the trend.

Mr. Bozzini answered that Fujitsu looks for users/prospective partners that are moving in the same long-term technological direction as Fujitsu—toward computer and telecommunication systems. Deeper issues include the prospective partners' global needs in terms of IC manufacturing processes, products, and related R&D activities.

Although too often taken for granted, old buzzwords such as quality and communication still rank as key elements for successful long-term buyer/seller relationships.

Mr. Noland noted that for his company, user/supplier strategic partnering has outweighed and will continue to outweigh "parochial" buyer/seller interests of the past. For Apple Computer, the formulation of strategic partnerships with suppliers does mean a reduction in the supplier base—with each strategic partner becoming in effect a sole-sourced supplier in Apple's eyes.

Communication, Communication, Communication

Regarding Apple Computer's approach for managing its select strategic partners toward the objective of total quality control (over product specs, JIT, competitive global pricing), Mr. Noland stressed "communication, communication, communication" between users and suppliers as the single most critical element for success. In doing so, he reiterated Mr. Bozzini's advice to suppliers: learn each customer's *culture*, because communicating effectively in each customer's culture is a key factor behind long-term buyer/seller relations.

Dataquest Perspective

The recent PMASV panel discussion hit on key 1991 issues for IC users. The trend toward supplier base reduction—also known as strategic partnering—continues despite trade press reports to the contrary. For companies such as Apple Computer, selecting strategic suppliers is relatively easy—the daunting task is managing these quasi-sole-source vendors during short system life cycles that allow little, if any, room for supplier error. Although too often taken for granted, old buzzwords such as quality and communication still rank as key elements for successful long-term buyer/seller relationships.

Dataquest's Semiconductor Procurement service (SPS) plans to hold a series of Buyers' Roundtables during 1991, at which a panel of SPS clients will assess the critical trends and issues for users. The first of these roundtables will be held in San Jose, California, in May 1991.

Dataquest analysts anticipate practical value for both IC users and suppliers that attend programs such as the PMASV panel discussion and Dataquest's upcoming Buyers' Roundtables.

By Ronald Bohn

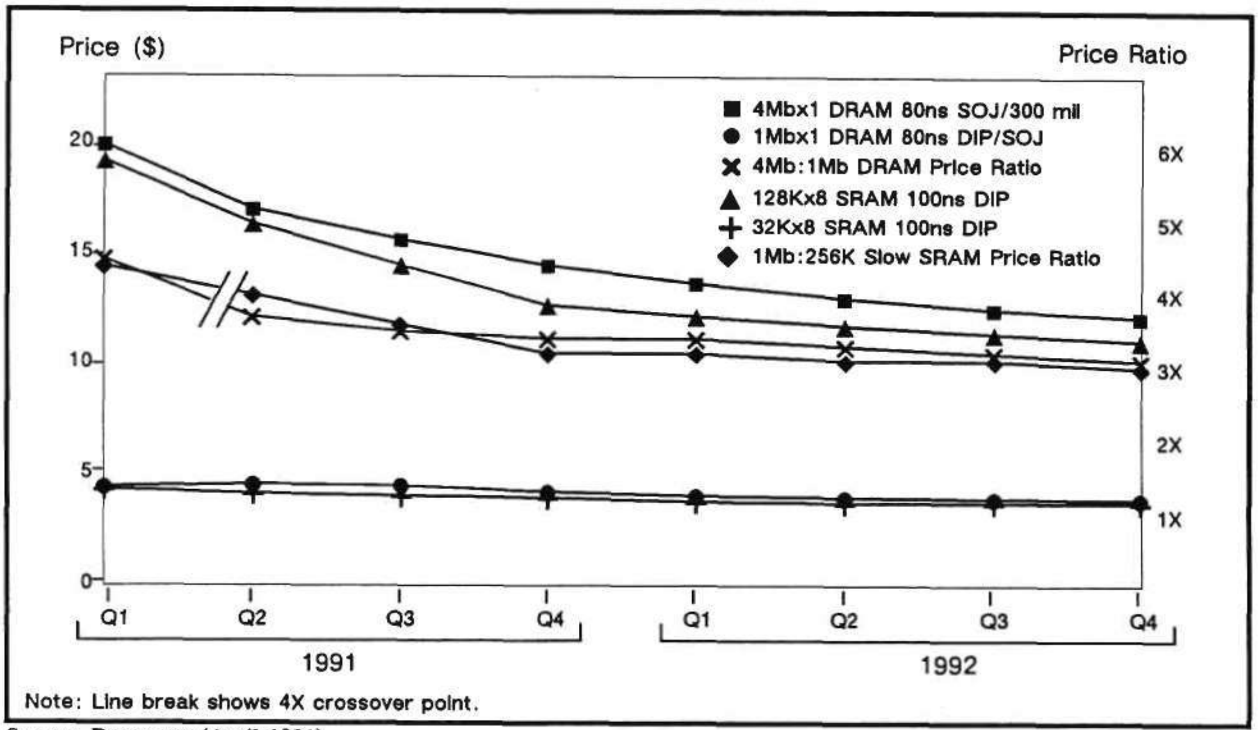
In the Next Issue

The following topics will be featured in the next issue of *Dataquest Perspective*:

- Semiconductor capital spending update
- EPROM product/supplier trends
- May *Procurement Pulse*
- Finalized 1990 semiconductor market shares

Errata

Figure 1
4Mb DRAM and 1Mb Slow DRAM Crossovers



Note: Line break shows 4X crossover point.

Source: Dataquest (April 1991)

In the article entitled "Semiconductor Price Survey: The 4Mb DRAM Crossover Looms—and the AM386 Ramps Up" in Semiconductor Procurement *Dataquest Perspective* Volume 1, Number 2, Figure 1 was incorrectly depicted. The revised figure shows the impending 4Mb DRAM crossover and 1Mb slow SRAM crossover (4:1 unit/price ratio).

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 2 April 1991

Regional Pricing Update

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0010032

Regional Pricing Update

DQ Monday Report Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	South Korea
74HC00	0.11	0.09	0.10	0.11	0.09	0.13
74HC138	0.14	0.16	0.14	0.17	0.15	0.21
74HC244	0.21	0.30	0.20	0.25	0.21	0.35
74HC74	0.12	0.12	0.11	0.11	0.10	0.17
Lead Time (Weeks)	2	3	NA	5	5	5
339-Comp.	0.14	0.15	0.12	0.14	0.11	0.13
741-Op Amp	0.13	0.24	0.11	0.14	0.11	0.11
7805-TO92	0.14	0.18	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.11	0.09	0.08	0.08	0.07	0.10
74LS138	0.15	0.13	0.15	0.13	0.12	0.15
74LS244	0.21	0.25	0.21	0.21	0.21	0.23
74LS74	0.12	0.09	0.12	0.09	0.10	0.12
Lead Time (Weeks)	2	2	4	5	5	NA
DRAM 1Mbx1-10	4.68	4.94	4.70	4.50	4.60	5.20
DRAM 256Kx1-10	1.40	1.61	1.60	1.30	1.40	1.50
DRAM 256Kx4-10	4.68	4.94	4.70	5.00	4.60	5.20
DRAM 4Mbx1-8	20.50	24.88	18.00	20.00	20.75	NA
DRAM 64Kx4-10	1.45	1.65	1.60	1.70	1.50	1.50
EPROM 1Mb, 200ns	4.90	5.82	5.00	5.88	5.20	4.20
EPROM 256K, 200ns	1.80	2.09	1.75	1.75	1.65	1.55
SRAM 1MB, 128Kx8	18.50	21.95	18.00	NA	NA	NA
SRAM 256K, 32Kx8	4.23	4.47	4.10	5.10	4.90	4.80
SRAM 64K, 8Kx8	1.55	1.58	1.75	1.23	1.40	1.55
Lead Time (Weeks)	6	4	4	2	7	3
68000 12 MHz	4.95	5.27	5.40	4.00	3.10	4.00
68HC11	8.35	8.78	8.00	8.75	8.60	NA
80286 12 MHz	8.25	15.00	8.60	6.85	9.70	7.00
80386SX-16	57.50	54.86	52.00	65.00	65.00	57.00
8051	1.52	2.13	1.90	3.50	1.80	1.80
Lead Time (Weeks)	6	4	4	3	4	6

NA = Not available
Source: Dataquest (April 1991)

Market Analysis

April Procurement Pulse: Business Stable and Poised for Pickup

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Semiconductor Orders Taper Off, System Outlook Still Positive

Respondents to this month's survey expect to order 8 percent fewer semiconductors in April relative to last month (see Figure 1). This slight decline in order activity is occurring in concert with inventory control programs and more realistic postwar system sales forecasts. It appears that the post-Gulf War euphoria has worn off from last month's system sales expectations of 5.2 percent to the current six-month outlook of 3.4 percent. The computer subset of respondents' outlook also dipped, going from last month's 8.4 percent to a current 7 percent six-month growth rate. This dip in system sales

Figure 1
Averaged Monthly Semiconductor Orders

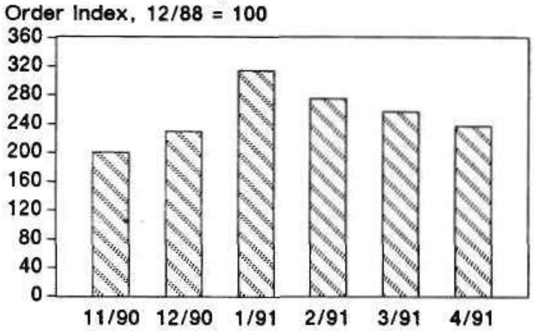


Figure 2
Averaged Semiconductor Lead Times

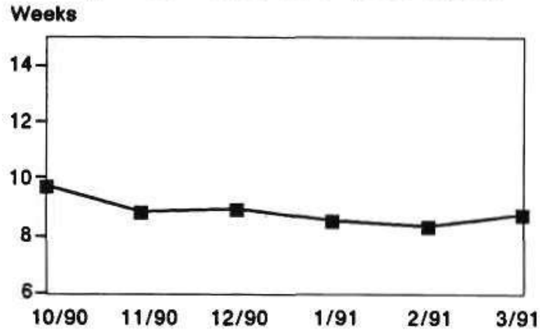


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

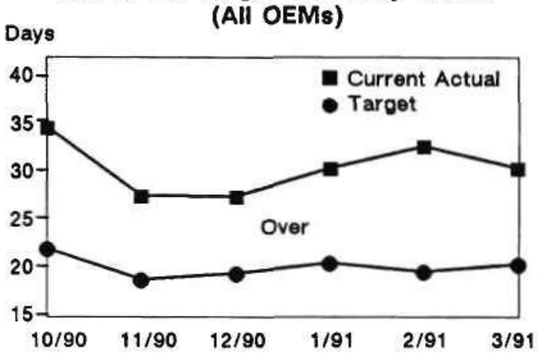
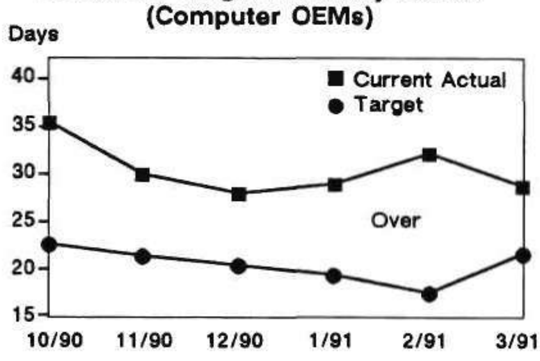


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (April 1991)

expectations should be looked at in perspective. The positive forecast during the past nine months in the face of a war, uncertain business conditions, and governmental recessionary reports highlights the resiliency of the electronics industry.

Average Lead Times Did Not Change; It Just Felt That Way

Figure 2 shows that, during the past six months, there has been very little, if any, average lead time movement from a mean of 9 weeks. The current 8.8-week average is up slightly from last month's 8.4 weeks, reflecting minor lengthening of some 1Mb DRAM deliveries.

After many months of dealing with a few isolated issues, 23 percent of respondents in this month's survey highlighted quality as a key issue needing attention.

All other semiconductors are currently in good supply with all but one of this month's respondents not having any product problems. (One respondent noted some standard logic high-reliability package problems that were planned to be corrected.)

After many months of dealing with a few isolated issues, 23 percent of respondents in this month's survey highlighted quality as a key issue needing attention. Although critical to today's semiconductor user, quality has lately been taken for granted because "all semiconductors are good quality." That cliche is not being upheld by some suppliers of major system companies. The current flat market, combined with abundant supplies of semiconductors, can become precarious for semiconductor suppliers that do not provide the basis for lower total cost—which is quality. Pricing remains flat on average, and Dataquest does not expect to see changes to the current semiconductor supply situation during the next six months.

Semiconductor Inventories Get Back to Where They Once Belonged

The two-month run-up in semiconductor inventories was corrected, as noted in this month's survey response and shown in Figures 3 and 4. Targeted levels rose slightly, while actual levels fell. The current overall targeted and actual inventory levels went from last month's respective 19.8 and 32.9 days to this month's reported 20.6 and 30.6 days. The computer company respondents also reported inventory improvements, with target and actual levels going from last month's respective 17.6 and 32.2 days to a current respective 21.8- and 28.8-day level. The semiconductor inventory correction seen this month coincides with progressive order level reductions over the past three months for our sample. For now, the historical average 20-day target and 30-day actual level of inventories has again been reached. Because availability remains very good, cost control through inventory management is still a very tangible way to meet cost reduction goals, because most commodity semiconductors are at historically low price levels. Dataquest continues to see inventories being pared wherever possible, but the historical golden mean of 30 days of actual inventories on hand may prove difficult to improve.

Dataquest Perspective

The slow growth trend of system sales and correlated semiconductor business is still chugging along in the absence of any high-volume product or segment able to push growth. Dataquest believes that the relative stability of demand also allows for gradual manufacturing and product changes to occur without the disruption caused by hyper over- or under-forecast demand levels.

As mentioned previously, we noted only one problem product area, which involved packaging and not the chip itself. Besides that isolated instance, availability, prices, and lead times remain predictable and in balance. The quality issue remains key to all total cost improvement plans and should not be taken for granted, as a group of respondents are now communicating to their suppliers. Amid inventory shifts, supply/demand balances, and economic uncertainty, the transition to surface-mount components is now complete for our sampled respondents, and only one is noting a minor handling problem. Dataquest continues to forecast gradual growth for semiconductors for the rest of this year, and the current survey reinforces our forecast.

By Mark Giudici

Product Analysis

EC EPROM Reference Price Agreement

Introduction

The European Commission (EC) has introduced a definitive antidumping duty of 94 percent on all Japanese-manufactured EPROM products. Concurrently, the EC has accepted that seven Japanese EPROM manufacturers will undertake to abide by reference prices (RPs), which provides for a conditional suspension of this duty. The regulation and undertakings were published in the "Official Journal of the European Communities" on March 12, 1991, and came into effect the following day. This newsletter examines the agreement and comments on the likely effects on the market.

Summary

The introduction of the EPROM reference price agreement is in response to a complaint received by the EC in December 1986 from the European Electronic Components Manufacturers Association (EECA). It was made on behalf of SGS Microelettronica and Thomson Semiconducteurs and concerned Japanese-manufactured EPROMs that had been dumped in the market.

In April 1987, the EC opened an investigation and the following companies were named: Fujitsu, Hitachi, Mitsubishi, NEC, and Texas Instruments Japan. In addition to these are Sharp and Toshiba, which came forward voluntarily at a later stage in the proceedings. These seven manufacturers comprise the participants of the new agreement; all have been provided with reference prices which apply to orders confirmed from March 13, 1991. Any EPROM products sourced from Japan, but not manufactured by one of the above companies, will be subject to a mandatory 94 percent import duty.

EC EPROM Product Definition

The agreement covers all densities of EPROM-based memory products. These are ultraviolet (UV) EPROM, one-time-programmable (OTP) EPROM, and flash memory based on an EPROM cell structure. A separate reference price is calculated for each of these three products by density and is issued quarterly by the European Commission.

The inclusion of flash memory in the EPROM definition is interesting. Dataquest expects flash memory to be the only EPROM-based product developed beyond the 16Mb density. The value of the flash memory market is forecast to be 60 percent of the size of the standard (UV and OTP) EPROM market in Europe by 1995. This is because flash memory offers all the functions of EPROM with the bonus of electrical erasure, and all for a similar price to EPROM in the long term. Although none of the participants in the EPROM RP agreement have any significant share of the flash memory market today, they are all at the sampling stage. With the exception of Texas Instruments, all these companies plan flash memory products based on an EPROM cell.

Main Features

The EPROM RP agreement follows the same ground rules as for DRAM. However, there are areas in which the EPROM RP agreement differs. These reflect the difference between the EPROM market and the DRAM market, as well as the fact that the EC has learned some lessons from the operation of the DRAM RP agreement over the last year. These differences are discussed below.

Weighted Average Costs

The cost of manufacture, a key element in the calculation of the RP, is averaged across all types of Japanese EPROM at a given density. For the DRAM RP, only the cheapest version of the product is considered in the cost calculation. The cheapest type of DRAM is always the leader in terms of unit shipments and is referred to by the European Commission as the "0" type. But EPROM products consumed in Europe cover a broad range of packages and speeds, so there is no clear leading type. The net effect is that the calculated cost of manufacture will be above that of "0"-type EPROMs alone, which consequently raises the EPROM RP threshold.

Actual Cost of Production

EPROM RPs will be based on *actual* cost of production, unlike DRAM RPs which are based on *projected* cost of production. As an illustration, EPROM RPs for the first quarter of 1991 are based on actual costs from the third quarter of 1990, whereas DRAM RPs for the first quarter of 1991 are based on projected costs from the fourth quarter of 1990, calculated in the third quarter. The reason for the different approach is that projected costs always contain an element of error. For the DRAM RP, this error is measured as soon as actual costs become available, and is then used as corrective feedback in the next cost projection. One of the net effects of using actual costs in the EPROM RP agreement is a reduction of administrative overhead for the EC and its RP participants. More important, an element of RP control is taken away from the participants, which should make EPROM RPs more predictable than DRAM RPs.

Profit Margin

The EPROM RP assumes a 12.5 percent profit on cost of sales, while the DRAM RP assumes a 9.5 percent profit. The choice of a higher profit margin in the EPROM RP agreement is made to prevent all possible injurious dumping, rather than just to provide a rock-bottom price safety net as in the case of DRAM. This also raises the EPROM RP threshold.

Free Samples

Each user is allowed 20 free samples from each EPROM RP participant for qualification purposes. For DRAM, the user may receive 1,000 pieces. The reason for this difference is that OEM volume shipments in EPROM are typically smaller than those for DRAM. An exception is made when an OEM trade association wishes to qualify an EPROM on behalf of its members; in this case, the free sample size is increased to 350 pieces.

New Generations

The introduction of a new EPROM density poses a special problem: The cost of manufacturing is very high. Traditionally, a new density is first sold below cost until unit demand brings the cost down and the product becomes profitable. Without this approach, it would never attract any business, and the production line would not ramp up to profitability. To enable a new generation of EPROM to enter the market, the RP agreement allows this practice to continue. For a new generation of EPROM, the RP applicable is 6 times that of its predecessor. However, as soon as the cost of manufacture is reduced enough so that the normally calculated RP drops below this level, then the usual RP applies. In the case of the DRAM, the reference price for the new generation is 10 times that of its predecessor. The reason for this difference is plain. Each successive generation of EPROM is twice the density of its predecessor, while for DRAM the increase is fourfold. In the case of a manufacturer skipping an intermediate EPROM density, the predecessor factor would be the same as for DRAM.

Dataquest Analysis

Vendor Perspective

Many vendors believe that the EC EPROM RP agreement is unwarranted, because sales of Japanese-manufactured EPROMs in 1990 accounted for no more than 15 percent of the total European market. This proportion has steadily declined from 1985, when Japanese market share is estimated to have been in excess of 35 percent. The decline in market share is widely believed to be the result of guidelines set by the U.S. Department of Commerce (DOC) on foreign market values (FMVs). This followed the U.S.–Japan trade agreement of 1986. As a consequence, Japanese EPROM prices currently range between 10 and 40 percent higher than European market average prices.

Japanese EPROM manufacturers choosing not to participate in the EPROM RP agreement include Oki, Ricoh, and Seiko-Epson. In addition, NMBS, which is not a manufacturer of EPROMs, is developing an EPROM-based flash memory. These companies will face a 94 percent duty if they choose to ship EPROM-based products into Europe; but none of these manufacturers currently feature in the European EPROM market. Each of these companies will have the option of entering into the RP undertaking at a later stage if necessary.

The top five suppliers to the European EPROM market in 1990 were three North American and two European suppliers. Collectively, they control an estimated 85 percent of the total market. Fierce competition exists between these five suppliers, and in the past year there have been several open accusations of dumping between them. However, no formal complaints have been filed with the European Commission or the U.S. Department of Commerce. This is not really surprising because these five vendors have significant business in both Europe and North America. Any complaint against a foreign EPROM vendor is likely to be followed by a counter-complaint in that vendor's home market. The result is a stalemate. Of course, Japanese vendors do not currently benefit from such protection.

The top five suppliers to the European flash memory market in 1990 were four North American and one Japanese supplier. One of these suppliers, Intel, controls an estimated 90 percent of the market in terms of sales, but Japanese companies have made little impact to date. This is a traditionally Japanese approach—waiting until a product market has been established before entering it. Japanese flash memory products will benefit from Japan's strength in high-density EPROM technology. Dataquest believes that manufacturing costs associated with flash memory will not be so great as to generate prohibitively high reference prices. However, if RPs do appear to prevent market entry, it is believed there may be an opportunity for Japanese companies to negotiate with the European Commission to prevent market entry being obstructed by exceptionally high RPs. A solution of the nature already discussed in the section entitled "New Generations" would probably suffice.

User Perspective

Memory users in Europe have recently made strong complaints to the European Commission about the use of reference prices. These have come via trade associations such as Standard Computer Komponenten GmbH (Stack GmbH) and Eurobit, as well as via the governments of the United Kingdom and Ireland where there is a strong base of memory users. The main issue is that European users believe they are being forced to pay higher prices for their memory than they would in a free trade environment. They are not impressed by arguments that RP agreements protect local suppliers of memory, to prevent European users being dependent on memory from Japanese vertically integrated (and therefore competitive) suppliers. They claim that European memory suppliers are also vertically (or at least virtually) integrated and so pose the same threat.

The sample size required by a medium-size user for the qualification of an EPROM is believed to be in the region of 200 pieces. The EC has set a limit of 20 on the number of free samples available for this purpose before reference prices come into play. We understand that many users disagree with this low sample size, believing it to be unrealistic.

Another criticism is that RPs should not start to increase as a product approaches maturity. It is intuitive that the cost of manufacture of a memory product should continue to decline with age until falling demand and fixed overheads force an inflection. For example, Dataquest forecasts that 1991 will be the demand peak year for the 1Mb DRAM, and yet the 1Mb DRAM RP increased by an estimated 15 percent between the fourth quarter of 1990 and the first quarter of 1991. This reverse trend has angered many DRAM users who declare that the RP agreement does not match industry trends.

Dataquest notes that DRAM RPs of the first quarter of 1991 are based on cost estimates made in the third quarter of 1990, at which time there was a slowdown in DRAM demand. The increase in RPs for the first quarter of 1991 reflects a slowdown in DRAM production in response to the demand slump of the third quarter of 1990. There is thus a six-month dislocation between production fluctuations and reference prices.

The final analysis shows that users want the lowest total cost of ownership, regardless of origin.

Dataquest Perspective

On the face of it, it would appear that the European Commission is too late in responding to the original complaint of December 1986. This is because Japanese companies do not feature strongly in the European market and they are not competitive on pricing.

Although this criticism is valid to some extent, looking beyond Europe, a different story emerges. Japanese companies' share of the Japanese and North American EPROM markets are estimated at 85 and 30 percent, respectively. This positions Japanese companies with approximately a 50 percent share of the worldwide EPROM market. Furthermore, Japanese companies dominate the markets for high-density EPROM (1Mb and above) while North American and European companies dominate the lower densities.

For example, based on estimated 1989 worldwide unit shipments, Japanese companies supplied 65.2 percent of the 1Mb EPROM, 96.2 percent of the 2Mb, and 79.8 percent of the 4Mb. In contrast, North American companies are estimated to have supplied 67.0 percent of the 128K EPROM, 55.4 percent of the 256K, and 57.1 percent of the 512K. European vendors' share of these markets are 11.4 percent, 16.4 percent, and 14.5 percent, respectively.

This proves that Japanese companies are not just world leaders in DRAM, but also lead in high-density EPROM technology and have a strong commitment to product development. The concept of the EPROM RP agreement is therefore supported from the point of view that Japanese companies continue to represent a major competitive force in the worldwide EPROM market.

Of course, competition today in the European market is being fought between European and

North American suppliers, and this will continue regardless of the existence of the EPROM RP agreement. If EPROM RPs from the EC are lower than the equivalent FMVs from the DOC, then it is conceivable that Japanese companies will find themselves in a position to lower their prices. This will then increase their competitiveness and possibly their market share.

In the case of the DRAM RP agreement, there has been widespread leakage of the RPs to the trade press and users. This has been seen to modulate market prices, as buyers use an RP as the target price to pay when it offers them an advantage. Dataquest believes that, in the second half of 1990, this was a contributing factor to Europe becoming one of the cheapest markets for 1Mb DRAMs in the world. However, as the 1Mb DRAM RP increased in the first quarter of 1991, so 1Mb DRAM prices in Europe immediately rose by an estimated 10 percent. The slowdown in 1Mb DRAM production by Japanese manufacturers would have led to increased market prices anyway, but the quarterly transitions between RPs are thought to be producing sudden market price changes. These are all the more noticeable when market prices and RPs follow each other closely. In the case of EPROM, it is not yet known how closely market prices and RPs will track each other and, therefore, whether market price modulation is an issue.

While the European flash memory market is in its infancy, it does hold great promise for sales in the long term. This has not been lost on the EPROM RP participants, all of which are understood to have accelerated their flash memory development programs. But if the EPROM RP agreement fixes a high price on Japanese flash memory, then North American vendors may continue to be the competitive leaders in the European market.

In conclusion, Dataquest believes that the EPROM RP agreement will not be as controversial as the DRAM agreement, if only because the market is smaller and less volatile. However, the strategic nature of flash memory will make the inclusion of this product in the agreement the subject of much debate.

By Byron Harding

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Semiconductor Price Survey: The 4Mb DRAM Crossover Looms—and the AM386 Ramps Up

Executive Summary

The results of Dataquest's first quarter 1991 North American bookings price survey are here! Figure 1 reveals that contract-volume buyers of 4Mb DRAM can expect price cuts that spell "crossover" during the second quarter. More quietly, the market is also making the crossover to 1Mb slow SRAM. Meanwhile, the volatile 1Mb DRAM product commands higher prices now—but for how long remains uncertain. Prospective users of BiCMOS standard logic face possible product and pricing confusion. What *is* certain is that the 40-MHz Am386 is on its way, but do not look for a 386 price war soon.

Please note that the price analysis presented here correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement Service (SPS) clients on March 20, 1991. For SPS clients that use the SPS on-line service, the prices presented here correlate with the quarterly and long-range price tables dated March 1991 in the SPS on-line service. For additional coverage and more detailed product specifications, please refer to those sources.

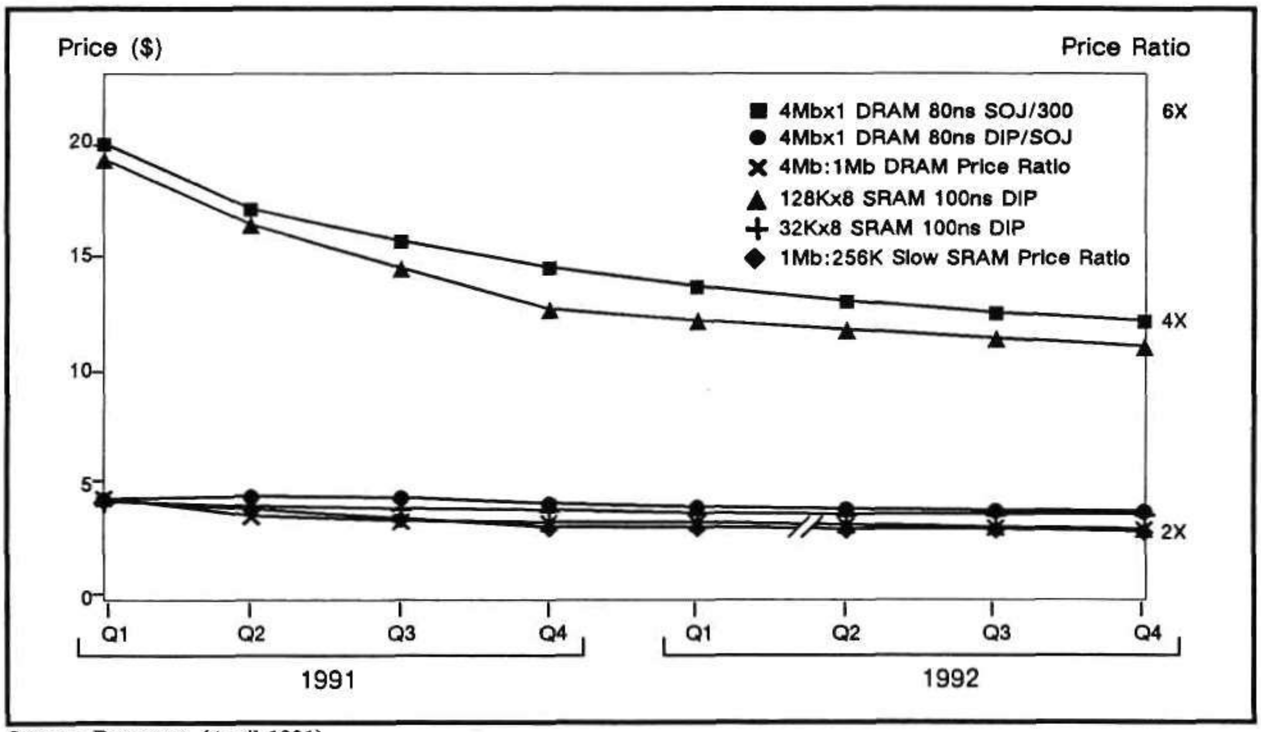
Memory Trends

Last quarter's rumor—that DRAM prices would rise as the supply contracted—has become true regarding the 1Mb DRAM. Prices for other DRAMs, SIMMs, and VRAMs either continue to decline or have stabilized at low levels. Supply and demand remain in balance for other memory devices such as SRAM and nonvolatile memory, although some SRAM lead times have been extended.

Megabit-Density DRAM

As shown in Table 1 and Figure 1, large-volume contract buyers in North America can expect an uptick in pricing for 1Mbx1 DRAM 80 to 100ns (DIP/SOJ) during the second quarter of 1991. In North America, the large-volume bookings price for the 1Mb DRAM should reach the $4.56 level during the second quarter of 1991 vis-à-vis a price of $4.47 for the first quarter. Lead times, which run as short as 1 week

Figure 1
4Mb DRAM and 1Mb Slow DRAM Crossovers



Source: Dataquest (April 1991)

Table 1
Estimated Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

Part	1991 Price Trend (Dollars) Estimated First Quarter Price Range	Forecast for Second Quarter	Estimated Fourth Quarter Price Range	Lead Times
1Mbx1 DRAM 80ns, DIP/SOJ	4.10 to 5.00	4.56	4.00 to 5.25	1 to 12 weeks
4Mbx1 DRAM 80ns, SOJ 300 mil	19.00 to 29.00	17.07	11.00 to 17.00	2 to 10 weeks
64Kx4 SRAM 25ns, PDIP	10.50 to 11.50	9.90	8.60 to 9.55	5 to 10 weeks
128Kx8 SRAM 25ns, PDIP	80.00 to 90.00	70.00	55.00 to 66.00	8 to 14 weeks
80286-12 PLCC	7.65 to 8.27	7.48	7.00 to 7.34	2 to 14 weeks
80386SX-16 PQFP	59.95 to 62.00	58.88	55.00 to 57.50	9 to 14 weeks
74F138	0.155 to 0.200	0.160	0.158 to 0.180	0 to 6 weeks
74AC138	0.345 to 0.480	0.344	0.336 to 0.360	0 to 6 weeks

Source: Dataquest (April 1991)

or as long as 12 weeks, reflect market volatility, stemming in part from recent Japanese production cutbacks.

The 4Mb DRAM Crossover

In line with Dataquest's prior forecasts, the recent rate of 4Mb DRAM price erosion means a second-quarter crossover (4:1 unit/price ratio). Table 1 and Figure 1 show the large-volume price for 4Mb DRAM 80ns SOJ (300 mil) decreasing from nearly $20 in the first quarter of 1991 to $17.07 in the second. Figure 1 depicts the impending 4Mb DRAM crossover.

The Range of DRAM Prices

Survey confidentiality limits disclosure of exact pricing points; however, the survey's range of prices as shown in Table 1 reflects the dynamics behind Dataquest's forecast. For example, Dataquest bases the first quarter 1991 price of $4.47 for the 1Mbx1 DRAM on actual first quarter 1991 prices that ranged from $4.10 to $5. Likewise, the first quarter 1991 price estimate of $19.99 for the 4Mbx1 DRAM is based on actual first quarter prices from $19 to $29.

Table 1 shows that survey participants expect prices for 4Mb DRAMs to range from $11 to $17 in the fourth quarter of 1991. By contrast, survey responses signal 1Mb DRAM prices in a range of $4 to $5.25 for the fourth quarter of this year. Both the high and low ends of the 4Mb DRAM price range should decline during 1991; however, the 1Mb DRAM price ranges show diverging patterns. During 1991, the high end of the 1Mb DRAM price range should *increase*, but the low end should *decrease*.

Third Quarter 1Mb DRAM Price Break?

Dataquest assumes that current market conditions—marked by Japan-based price "leadership" in terms of upward pressure on 1Mb DRAM prices with other suppliers opportunistically following—will hold true for the first half of 1991. The assumption is that first-tier Japanese suppliers will make an orderly ramp to 4Mb DRAMs this year, meaning lower 4Mb DRAM prices and more stable or higher 1Mb DRAM prices.

As noted, North American bookings prices for the 1Mbx1 DRAM are expected to increase in the second quarter of 1991. Figure 1 depicts a relatively flat 1Mb DRAM price profile of $4.50 to $4.55 for the second and third quarters. The fourth quarter 1991 forecast calls for a 1Mbx1 DRAM bookings price of $4.24.

An Alternate Scenario

Dataquest recognizes an alternate "scenario" to the 1Mb DRAM forecast. This scenario does *not* constitute Dataquest's operating assumptions for megabit-density DRAM during 1991, but instead stems from Dataquest's recognition that the apparently "flat" 1Mb DRAM price profile contains a tremendous amount of hidden volatility. If the following scenario becomes reality, Dataquest believes that the third quarter could be *the* key period during 1991 for users in terms of 1Mb DRAM price relief.

The elements of the scenario? First, suppliers from the newly industrializing countries (NICs) bring on excess 1Mb DRAM capacity during 1991. Next, suppliers from other regions such as Europe and North America break rank from the current supplier stance, which calls for revenue/profits and not market share. Some suppliers are likely to respond to the threat from the NIC suppliers by cutting 1Mb DRAM prices to maintain market share—especially in the face of excess capacity. Another element would be any slowdown in the 4Mb DRAM ramp, which would force *some* first-tier Japanese suppliers back to the 1Mb arena. If several of these elements converge, 1Mb DRAM prices could take a step-function down during the third or fourth quarter of 1991.

4Mbx1 DRAM: Consistent Price Forecast

The 4Mb DRAM bookings price forecast shown in Figure 1—with the first quarter 1991 price of $19.99 dropping to $14.52 by the fourth quarter—remains consistent with Dataquest's original expectations. Our operating assumption for 4Mb DRAMs has proven to be sound: First-tier Japanese suppliers along with other world suppliers will ramp up production during 1991 and cut prices to win business in line with historical crossover experience. Lead times—running from 2 to 10 weeks—support this outlook.

Fast SRAM

MITI Guidelines, Part I

In general, users of 64K fast SRAMs can expect competitive pricing during 1991; but lower sides of the price ranges should stabilize. The influence of Japan's Ministry of International Trade and Industry (MITI) partly accounts for this bottom floor on prices. By contrast, prices for the 256K fast SRAM—a younger product—should continue declining across the board this year.

For example, the survey results show a bookings price for 16Kx4 SRAM 25ns (PDIP) during the first quarter of 1991 in the range of $3.20 to $4.16 for 20,000-unit orders. Lead times now run from 7 weeks to a lengthy 18 weeks. Under MITI guidance, Japanese suppliers will be reluctant to lower prices for fast 64K SRAM to a price below $3. For the fourth quarter, the top end of the range declines to a price of $4.05—but the low end remains stable at $3.20. Similarly, the top end of the price range for 8Kx8 SRAM 45ns (PDIP) in 20,000-piece volume should decline from $3.50 during the first quarter to $3.30 in the fourth quarter of this year. The low end remains more stable—$3.20 for first quarter 1991 and $3.10 for the fourth quarter—as the price approaches the $3 barrier.

Users of the 64K fast SRAM can look to more aggressive declines for products that are still well above the $3 floor level. Specifically, the survey reveals that bookings prices for 8Kx8 SRAM 25ns (PDIP) ranged during the first quarter of 1991 from $4 to $4.50 for 20,000-unit orders. Lead times range widely—from 6 to 20 weeks. For the fourth quarter, the low end of the range should drop sharply to $3.30, still above $3.

Competitive Pricing for Higher-Density Fast SRAM

Prices for 256K fast SRAM and 1Mb fast SRAM will erode steadily—if not aggressively—as suppliers compete for users' demand. For example, as shown in Table 1, Dataquest forecasts that the North American bookings price for 64Kx4 SRAM 25ns (PDIP) in 20,000-piece orders will fall below the $10 mark for the second quarter of 1991. For fourth quarter 1991, the survey results estimate a price range of $9.55 on the high side and $8.60 on the low end.

1Mb Slow SRAM Crossover

MITI Guidelines, Part II

As shown in Figure 1, users of slow SRAMs can plan for the 1Mb market crossover (4:1 unit/price ratio). The North American bookings price for 128Kx8 SRAM 100ns (PDIP) in 50,000-piece orders should fall to $16.40 during the second quarter of this year. By contrast, under MITI "guidance" pricing for 32Kx8 slow SRAM should stabilize over the first half of 1991 in the range of $4 to 4.50. The survey results indicate a fourth quarter 1991 price range of under $4 to over $5.50 for 256K slow SRAMs. Under these market conditions, the 1Mb slow SRAM crossover should occur during the second quarter of this year.

Microprocessor Trends

As noted last quarter, users should look for a major break in pricing for 25-MHz 80486 CPGA in volumes of 1,000 to 5,000 units during the second and third quarters of 1991. As Intel expands production, the North American bookings price for the 25-MHz 80486 should slide from $690 for the first quarter of 1991 to $585 for the second quarter. Lead times are manageable, running six to eight weeks. By the fourth quarter, users can anticipate a price of less than $430 for this device.

Intel's Rules of the Game Change

Somewhat obscured in the glare of the anticipated pricing breaks for the 25-MHz 80486 lies a changing reality for users: Intel will set new rules in the MPU game as the market moves to the 80486 and its likely successor, the 80586. These MPUs—unlike prior generations—offer on-board microperipheral functions (for example, floating-point, memory management) that can be dropped from the MPU depending on a customer's need. Intel's product pricing strategy will no longer be based on a straightforward premium charge for higher-speed versions of a device; instead, by varying the MPU's architectural mix, Intel will be able to "tailor" 32-bit devices to customers' micro-market requirements regarding product price/performance tradeoffs. For example, at the start of the second quarter of 1991, the market buzzes over Intel's precise plans for the 80486 family of products. Users can anticipate a competitive response by Intel during 1991 to these changing market dynamics.

The AM386 Wild Card

Intel just lost the trademark battle with Advanced Micro Devices (AMD) over rights to the name "386." The next legal issue awaiting resolution: Advanced Micro Devices' right, if any, to sell 386 devices that utilize Intel's microcode. If AMD has no right to the Intel code, the next issue becomes Advanced Micro Devices' ability to engineer 386-compatible microcode. Another issue: a possible effort by Intel to dissuade customers from using non-Intel 80386 devices in exchange for future product support from Intel.

When this report was written, AMD had indicated that its pricing strategy on its 386 device would *not* be a price war against Intel's 25-MHz 80386 or 33-MHz 80386 ICs. Instead, AMD plans to introduce a 40-MHz 386 device at the price that is competitive with the 25-MHz 80386. At this time, users should not expect the introduction or ramp up of the AM386 to initiate a 386 price war.

Intel's 80386

The North American bookings price for Intel's 25-MHz 80386 CPGA in orders of 1,000 to 5,000 pieces should give *some* ground as competition heats up—but more so if demand slows because of weaker economic conditions during 1991. Bookings prices for this device—which was $162.20 for the first quarter of 1991—should decline slightly to $159.95 for the second quarter and end this year at just under $151. Survey results indicate that prices for the 25-MHz 80386 MPU should fall below $140 for the fourth quarter of 1992.

The supply of Intel's 80386SX devices does not yet meet all demands. Table 1 shows that lead times for 16-MHz 80386SX and 20-MHz 80386SX (PQFP) run from 9 to 14 weeks, an increase of 2 weeks on the long side since last quarter.

The forecast on Intel's 16-MHz 80386SX calls for a bookings price of $58.88 during the second quarter for orders of 1,000 to 5,000 units, moving down to $56.25 for the fourth quarter of 1991. Survey results signal less stable prices for this device during 1992 than originally expected—with the forecast calling for a price of $52 by the final quarter of 1992.

Standard Logic Trends

As shown in Figure 2 and Table 1, pricing of standard logic products should be stable except for price declines among younger families such as 74BC or 74AC. Lead times run from off-the-shelf (0 weeks) to 7 weeks. Table 1 shows, however, a wide and meaningful range of standard logic prices. For many users, the key standard logic price issue for 1991 is not the overall price trend—stability—but if the price they pay is stable at the high *or* low end of the price range.

1991: A Year of Decision for Users of Standard Logic

The year 1991 will mark a time of decision for many standard logic users. The supplier base remains subject to change. Suppliers' commitment to this mature market will depend in part on this year's contract wins *and* loses. As the second quarter begins, bipolar device suppliers generally affirm their commitment to users in North America. By contrast, *some* suppliers of older bipolar families signal a wavering of support for users in Europe.

This year, users can expect some narrowing of the supplier base for declining families such as 74LS or 74HC. Conversely, users will also see a growing supplier base for the new BiCMOS families that are targeted for high-speed/low-power bus-interface and bus-drive applications.

For users, standard logic can mean some tough choices. For example, should systems move entirely away from standard logic to application-specific IC (ASIC) alternatives such as programmable logic devices (PLDs) or gate arrays? If standard logic is the choice, then which family?

Why BiCMOS Standard Logic?

Figure 2 shows price trends for three products—74F244, 74AC244, and 74BC244—each of which may serve a given user's system performance needs. When noise minimization is a major issue, users typically focus on either 74F or 74BC products. Even then, users face a dilemma.

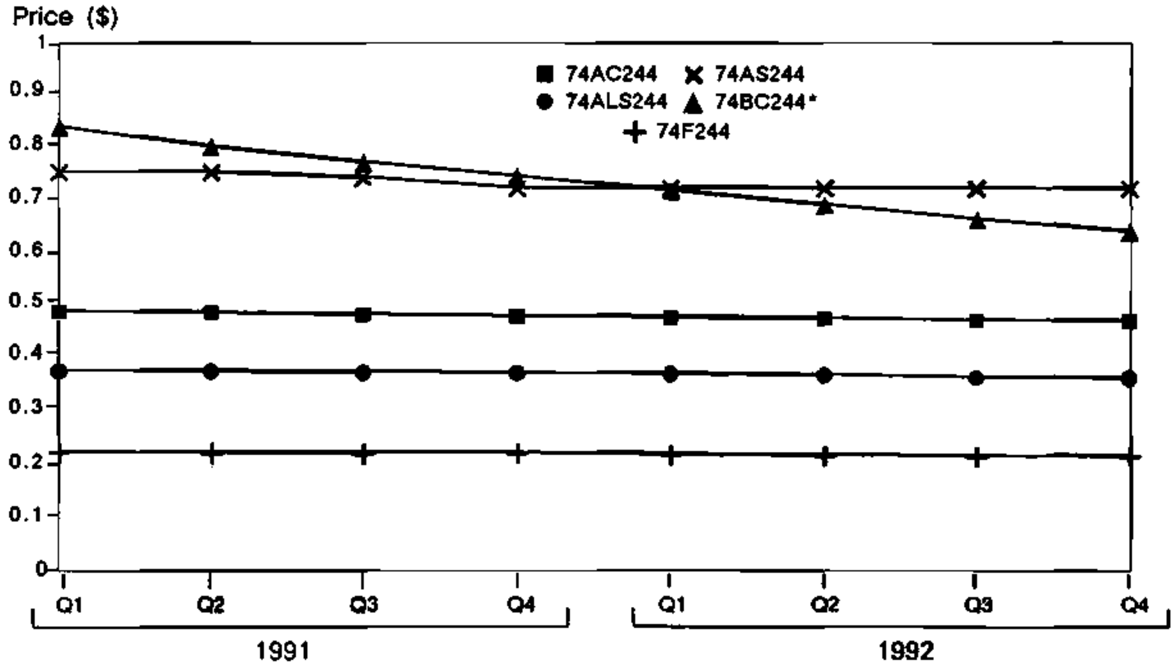
BiCMOS standard logic might be a good choice for systems with the following requirements: wide word size (16-bit and greater), high-speed bus interface and drive capability, and low power consumption. Also, system performance *must* outweigh cost constraints.

In contrast to an unproven standard logic technology like GaAs, users can view BiCMOS as a newer but proven product technology evolving from the familiar bipolar and CMOS processes. Users can depend on a strong and expanding supplier base for BiCMOS parts. To date, suppliers include the following companies: Harris, Hitachi, Motorola, National Semiconductor, Philips-Signetics, Texas Instruments, and Toshiba.

If system needs differ from those described, prospective users can ask this blunt question: "Why BiCMOS—especially at such a high price (as shown in Figure 2)—when the FAST family can satisfy system needs for the next three to five years and at a much lower price?"

The impressive growth in the supplier base could become a problem; the BiCMOS supplier base is expanding *so* quickly, users face BiCMOS product-proliferation confusion a la the "center pin/corner pin" controversy of

Figure 2
Standard Logic Price Trends



*Prices for 74BC244 are preliminary and exclude 74ABT244 and 74BCT244.
Source: Dataquest (April 1991)

several years ago. For example, suppliers such as Hitachi and Motorola designate their products as 74BC, National Semiconductor uses 74BCT, Texas Instruments and Philip-Signetics emphasize the 74ABT nomenclature, and Harris lists the BiCMOS devices within the FCT family.

In the absence of a steady downward trend in pricing and a supplier effort to minimize user confusion, BiCMOS standard logic might be consigned to niche market applications.

ASICs

Pricing for ASICs remains competitive.

PLDs: CMOS PLD Pricing Break

As noted last quarter, suppliers of CMOS PLDs send signals of a sharp break downward in pricing. For a close look at 1991 as well as long-term PLD price trends, see the report entitled "Users' Long-Range PLD Price Outlook," *Dataquest Perspective* (Semiconductor Procurement), Volume 1, No. 1, March 22, 1991.

Prices for gate arrays and cell-based ICs remain competitive, however. The results of the latest survey show higher nonrecurring engineering (NRE) charges and an increase to the *high* side of the price range versus prior quarters.

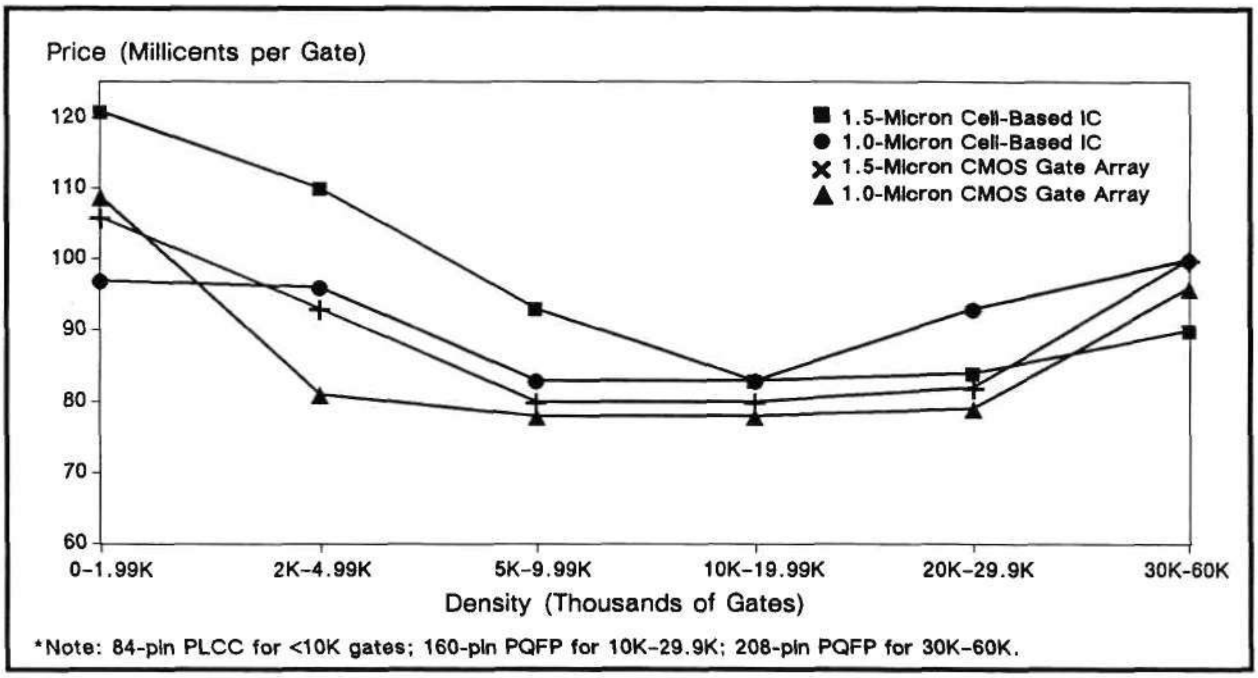
As Figure 3 shows, price declines for 1.0- and 1.5-micron CMOS gate arrays and 1.0- and 1.5-micron cell-based ICs (CBICs) in 1991 will be competitive, if not aggressive. The low end of the price range will be 40 to 60 millicents per gate—but few suppliers seem willing or able to price at this level. Figure 4 shows that pricing for 1.0- and 1.5-micron CMOS gate arrays may be quite competitive during 1992.

Dataquest Perspective

The results of Dataquest's February-March 1991 quarterly survey of semiconductor users and suppliers bring valuable news to users. In general, pricing remains competitive and lead times manageable with some exceptions.

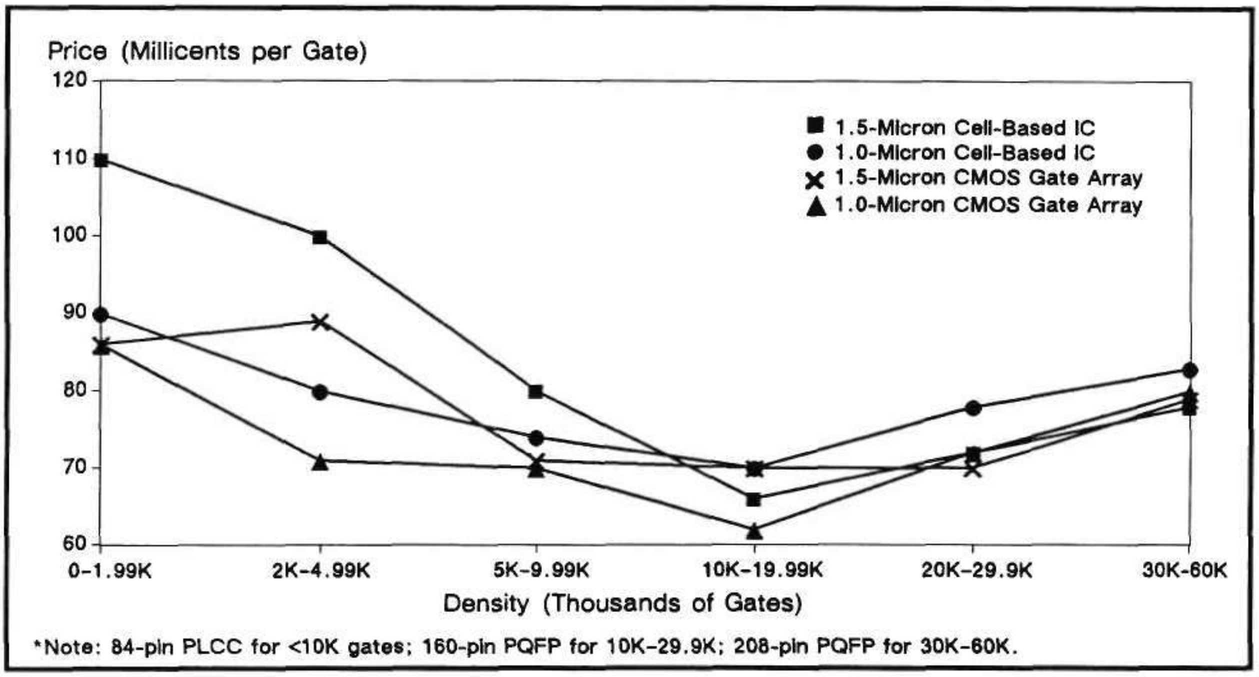
Procurement teams can look forward during the second quarter to the 4Mb DRAM and 1Mb slow SRAM *crossovers* (4:1 unit-price ratio). The 1Mb DRAM pricing is likely to be stable at a high level this year. The 1Mb DRAM price profile could take a step-function down during

Figure 3
Estimated 1991 ASIC Price Trends
(North American Production Bookings)



Source: Dataquest (April 1991)

Figure 4
Estimated 1992 ASIC Price Trends
(North American Production Bookings)



Source: Dataquest (April 1991)

the second half of this year *if* suppliers build excess capacity and other factors converge.

Intel continues to change the rules of the MPU game with market eyes now focused on its evolving strategy for users of 80386 and 80486 devices. Users of the 80486-25 can expect sharp price declines during the second and third quarters of 1991. The availability of the AM386, however, does *not* auger a 386 price war.

Users can expect lower prices for CMOS PLDs. Users of gate arrays and CBICs face higher NRE costs—and *some* supplier resistance to price declines as expressed in millicents per gate. For users of standard logic, high prices and product proliferation/confusion could relegate the newer BiCMOS family to niche market applications.

By Ronald Bohn

News and Views

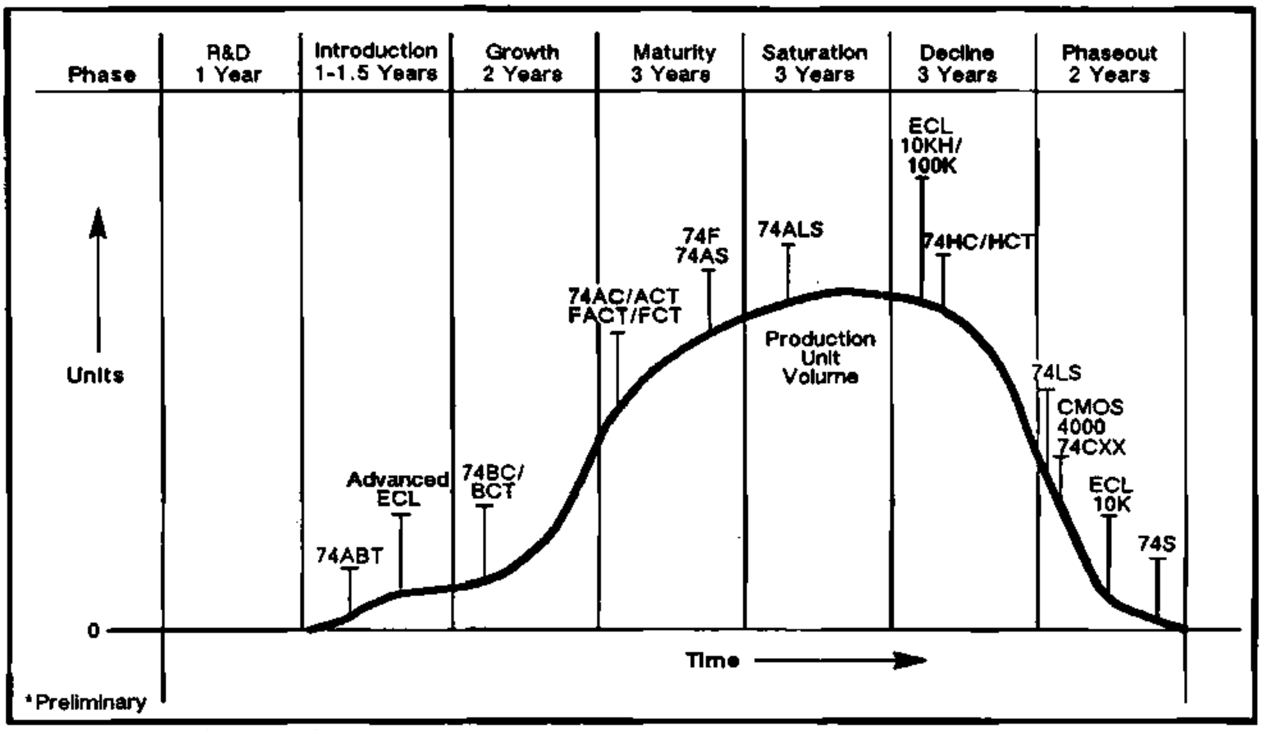
Standard Logic Product Life Cycles

Users and suppliers continue to evaluate their commitment to standard logic, and product life cycle analysis plays a key role in the decision-making process. Figure 1 shows Dataquest's preliminary estimate on standard logic life cycles as of April 1991.

Dataquest Perspective

Figure 1 shows two areas of concern for users: products in the introduction/early growth stage of the cycle such as the 74BC/BCT/ABT and declining families such as the 74LS and 74HC. As noted before, for some users no convincing reason exists yet to shift from proven products like the 74F—which has several years of life

Figure 1
Standard Logic Life Cycle as of April 1991



Source: Dataquest (April 1991)

before its decline—to the newer BiCMOS technology. Regarding older products like the 74HC, for *select* suppliers (for example, Philips-Signetics), the product's life cycle may stretch longer vis-à-vis the general market expectation as depicted in the figure because a company's strategy calls for long-term support of key customers. More and more, users of older standard logic families like 74LS and 74HC should be prepared to examine the life cycle on a *supplier-by-supplier* basis.

By Ronald Bohn

In the Next Issue

The following topics will be featured in the next issue of *Dataquest Perspective:*

- The latest *DQ Monday Report* regional pricing update
- The April 1991 Market Watch
- Capital spending trends
- Microprocessor product/supplier trends

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Dataquest Perspective

Semiconductor Procurement

Vol. 1, No. 1 March 22, 1991

0009689

Regional Pricing Update

*DQ Monday Report Volume Mean Pricing**

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74HC00	0.12	0.09	0.10	0.11	0.09	0.13
74HC138	0.15	0.16	0.14	0.17	0.15	0.21
74HC244	0.21	0.32	0.20	0.25	0.21	0.35
74HC74	0.13	0.13	0.11	0.11	0.10	0.17
Lead Time (Weeks)	2	3		5	5	5
339-COM	0.14	0.16	0.12	0.14	0.11	0.13
741-OP AMP	0.14	0.25	0.11	0.14	0.11	0.11
7805-TO92	0.14	0.19	0.14	0.15	0.14	0.11
Lead Time (Weeks)	4	3	4	4	4	5
74LS00	0.12	0.10	0.08	0.08	0.07	0.10
74LS138	0.15	0.13	0.15	0.13	0.12	0.16
74LS244	0.21	0.26	0.21	0.21	0.21	0.22
74LS74	0.13	0.10	0.12	0.09	0.10	0.12
Lead Time (Weeks)	2	2		4	5	5
DRAM 1Mbx1-10	4.63	5.14	4.70	4.40	4.60	5.15
DRAM 256Kx1-10	1.35	1.68	1.60	1.30	1.40	1.50
DRAM 256Kx4-10	4.63	5.33	4.70	5.00	4.60	5.15
DRAM 4Mbx1-8	20.75	25.90	18.00	20.00	21.00	NA
DRAM 64Kx4-10	1.45	1.71	1.60	1.70	1.50	1.50
EPROM 1Mb, 200ns	4.90	6.06	5.50	5.88	5.20	4.40
EPROM 256K, 200ns	1.80	2.17	1.60	1.75	1.65	1.55
SRAM 1MB, 128Kx8	18.50	22.85	18.20	NA	NA	NA
SRAM 256K, 32Kx8	4.20	4.65	4.10	5.10	4.90	4.80
SRAM 64K 8Kx8	1.50	1.64	1.90	1.23	1.40	1.55
Lead Time (Weeks)	6	4	4	2	7	3
68000 12 MHz	4.95	5.49	5.40	4.00	3.10	4.00
68HC11	8.35	9.14	8.00	8.75	8.60	NA
80286 12 MHz	8.25	17.33	8.80	9.10	9.70	7.00
80386SX-16	58.50	57.12	52.00	65.00	65.00	57.00
8051	1.50	2.21	1.90	3.50	1.80	1.80
Lead Time (Weeks)	4	4	4	3	4	6

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (March 1991)

Market Analysis

March Market Watch: System Demand Steady While Semiconductor Bookings Jump

The *Market Watch* is a monthly Dataquest bulletin that is released after the SIA book-to-bill Flash Report. It is designed to give a deeper insight into monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

The Book-to-Bill Ratio Skyrockets, and the Numbers Look Good

February's book-to-bill ratio jumped 13 points (1.09) from last month's level (0.96), as seen in Figure 1, while the actual booking-and-billing dollars reflect the increase in this business index. The three-month average bookings level rose 14.9 percent from January's level, while the corresponding billings average rose 1.1 percent. This is the first positive change in the

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

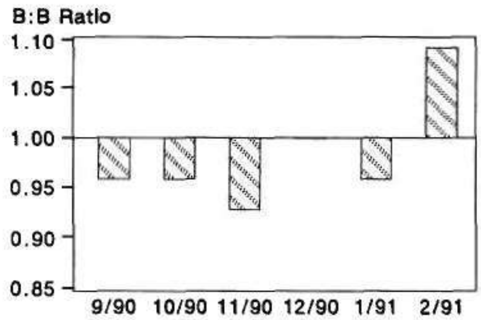


Figure 2
DOC Computer Demand

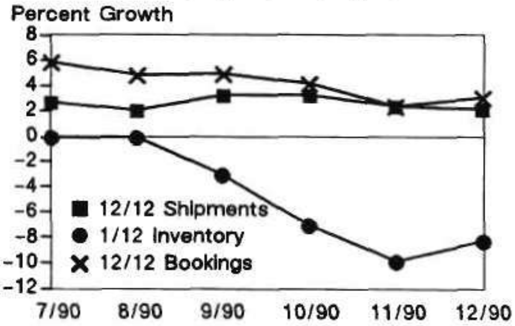


Figure 3
Semiconductor Inventory Level

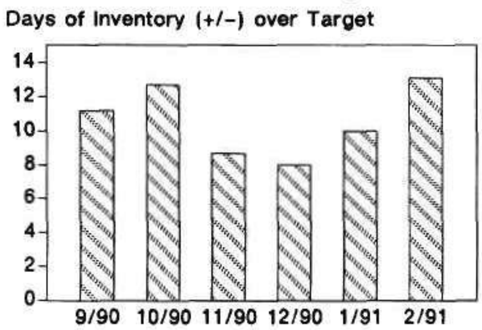
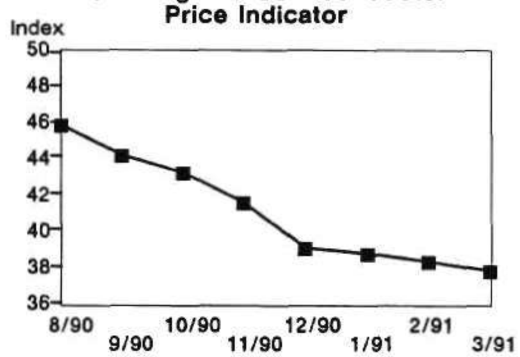


Figure 4
U.S. Weighted Semiconductor Price Indicator



Source: WSTS, U.S. Department of Commerce, Dataquest (March 1991) semiconductor market in the past four months, and it correlates with data gathered in Dataquest's monthly procurement surveys that show steady expected system growth.

The Gulf War's resolution has removed one level of uncertainty in the market, and prewar economic concerns are again taking precedence.

The six-month system sales outlook increased this month to 6.1 percent over last month's 3.7 percent forecast (see the March *Procurement Pulse)*. As noted in previous issues of *Market Watch*, the current historically low semiconductor inventory levels quickly translate into bookings when system sales rise.

Computer Bookings Up, Inventory Rate Stabilizes

Figure 2 shows a slight increase in the Department of Commerce's computer annualized booking rate, while annualized shipments remained unchanged. The 1/12 system inventory rate has stopped falling, resulting from the change from shipping increased levels of finished goods inventory to balancing shipments from WIP that require raw material (components). The 12/12 bookings and billings rates for January are 3.1 and 2.1 percent, respectively, relative to December's equal rate of 2.4 percent for both bookings and billings. The Gulf War's resolution has removed one level of uncertainty in the market, and prewar economic concerns are again taking precedence.

Semiconductor Inventories Increase Slightly as Pipeline Fills

Figure 3 illustrates that the difference between target and actual inventory levels diverged in February to 13.1 days relative to January's delta of 10 days. Although this is an increase, it is more a correction of target levels than large increases in actual inventory levels. The actual inventory level rose from 31 to 32 days, while the target level declined from 21 to 19 days. As noted in earlier issues of *Procurement Pulse*, despite intentions to reach a targeted average of 20 days, an average of 30 days appears to be the realistic goal. The golden mean of 30-day semiconductor inventory is being tested, but current inventory control measures in place should correct any large variance.

Overall Prices Stabilize, Availability Excellent

DRAMs are again the main reason why the price average shown in Figure 4 did not decline further this month. Overall availability remains very good; the only exception is that some of the above-mentioned DRAMs have extended lead times of 10 to 12 weeks for some (not all) suppliers.

The current increase in semiconductor booking activity is an encouraging sign that the procurement community's outlook for system sales is being acted on with increased semiconductor orders.

The overall forecast slow growth in electronics will continue to keep semiconductor availability good because of improved forecasting for these parts that is keeping semiconductor capacity in line with system demand. The current flattening of DRAM prices is partly the result of this supply/demand balance. As non-Japanese DRAM suppliers react to the relatively static price situation, we can expect to see increased supplies within the next 6 to 8 weeks and some increased competition in the 1Mb market.

Dataquest Perspective

The current increase in semiconductor booking activity is an encouraging sign that the procurement community's outlook for system sales is being acted on with increased semiconductor orders. Availability still remains excellent despite price firming in the DRAM arena and should remain because of forecasting mechanisms now in place in the majority of large to medium-size system companies.

The end of the Gulf War may not mean an instant pickup in sales, but its absence is one less unknown in a uncertain economy. Dataquest continues to forecast steady growth in the semiconductor market in line with slow and steady sales in the aggregate systems arena. ■

By Mark Giudici

Product Analysis

Users' Long-Range PLD Price Outlook: CMOS PLD Pricing Premiums Erode As TTL Loses Share

Summary

CMOS PLD suppliers are engaged in a long-term battle to displace the declining but still-predominant bipolar TTL technology. As shown in Table 1, this article provides users with a strategic perspective on Dataquest's Semiconductor Procurement Service (SPS)—formerly the Semiconductor User Industry Service—forecast of North American bookings prices for TTL PLDs and CMOS PLDs through 1995. The forecast is based partly on the results of Dataquest's just-completed February-March 1991 quarterly price survey of users and suppliers (see Table 1). *The big news is that users can expect more aggressive pricing by CMOS device suppliers,* which should narrow—if not eliminate—the price premium typically charged for CMOS parts over equivalent high-density bipolar TTL versions. Users of 22V10 devices should watch out for the legal wild card.

Overview

In order to assess long-term price trends, this article focuses on three price points for select TTL PLDs and CMOS PLDs—the first-half 1991 price range from the survey, the survey's second-half 1992 price range, and the 1995 price forecast. The information on the PLD price ranges for the latter half of 1992 can serve as a window of insight into the industry's long-range price outlook.

The price analysis presented here correlates with the half-year and long-range price tables scheduled to be mailed to SPS clients on March 20, 1991. For clients that use the SPS on-line service, these prices correlate with the half-year and long-range price tables dated March 1991 in the on-line service. For additional product coverage and more detailed product specifications, please refer to those sources.

Table 1
Long-Range Programmable Logic Device (PLD) Price Trends
(North American Bookings, 10,000 Volume, PDIP or PLCC)

	Price Trends (Dollars)		
Specification	Estimated First-Half 1991 Price Range	Estimated Second-Half 1992 Price Range	Estimated 1995 Price
TTL, <20 pins, <6.0ns	6.55 to 8.45	4.95 to 7.55	5.50
6.1 to 7.5ns	3.54 to 3.60	2.94 to 2.96	2.40
7.6 to 10ns	1.70 to 1.97	1.50 to 1.50	1.32
TTL, 24 pins, 15 to <25ns	1.21 to 1.40	1.02 to 1.24	1.08
TTL, 24 pins, 22V10			
15 to <25ns	5.30 to 7.40	5.10 to 6.48	4.49
CMOS, <20 pins			
<6.0ns	NA	NA	NA
6.1 to 7.5ns	6.25 to 7.00	5.02 to 5.50	4.45
7.6 to 10ns	3.69 to 4.95	2.92 to 3.37	2.30
CMOS, 24 pins, 15 to <25ns	1.17 to 1.76	1.02 to 1.78	1.33
CMOS, 24 pins, 22V10			
15 to <25ns	7.27 to 8.60	5.70 to 7.06	4.91

NA = Not available
Source: Dataquest (March 1991)

This article compares price trends for the equivalent-version bipolar TTL (hereafter, TTL) and CMOS parts in order to highlight converging or diverging price trends.

PLD Market Trends

TTL technology should maintain a lead in terms of fastest PLDs; however, the market is shifting to CMOS devices. Typically, prices for a TTL device—which is the older technology—have been lower than for the equivalent CMOS version. Users can expect somewhat different long-term price trends for TTL PLDs and CMOS PLDs, although there should be long-term price *convergence* for some parts.

Table 2 shows Dataquest's preliminary 1990 CMOS PLD and TTL PLD market share ranking. During 1990, CMOS PLD market shipments as measured in dollars expanded robustly, while TTL PLD shipments contracted slightly.

In addition to user information, more than one-half of the suppliers listed in Table 2 participated in the SPS quarterly price survey.

TTL PLDs

TTL PLD Specifications: 7.5ns, 20 Pins or Fewer

Table 2 shows the four suppliers of TTL PLDs in order of market share ranking: Advanced Micro Devices, Texas Instruments, Philips Components (which owns Signetics Company), and National Semiconductor.

Table 1 reveals that, for the first half of 1991, users and suppliers that responded in the survey anticipate that the North American bookings prices for TTL devices that operate at 7.5ns (20 pins or fewer) will range *narrowly* in price from $3.54 to $3.60. Survey participants also expect tight pricing—hovering near $2.95—for the second half of 1992. Dataquest estimates a North American bookings price of $2.40 for 1995.

TTL PLD Price Trend

TTL PLD users can generally expect a *narrow*, but competitive, price range. The reason is that many TTL PLDs suppliers must remain

Table 2
Estimated Preliminary Worldwide 1990 CMOS and TTL PLD Market Share Ranking

	1990 Rank	Company	Market Share (%)
CMOS			
	1	Xilinx	20.9
	2	Altera	19.4
	3	Lattice Semiconductor	15.4
	4	Cypress Semiconductor	10.9
	5	Advanced Micro Devices	19.4
	6	Intel	7.5
	7	Actel	5.2
	8	Others	10.2
		Total	100.0
TTL			
	1	Advanced Micro Devices	57.9
	2	Texas Instruments	27.2
	3	Philips Components	9.8
	4	National Semiconductor	5.1
		Total	100.0

Source: Dataquest (March 1991)

price-competitive vis-à-vis CMOS device suppliers; however, TTL players will only *periodically* increase pricing pressure on *each other*. At first glance, the tight TTL price range might appear to be noncompetitive, but upon closer inspection, the prices actually are *quite* competitive versus prices of equivalent CMOS parts.

CMOS PLDs

CMOS PLD Specifications: 7.5ns, 20 Pins or Fewer

Table 2 shows the following ranked order of CMOS PLD suppliers: Xilinx, Altera, Lattice Semiconductor, Cypress Semiconductor, Advanced Micro Devices, Intel, and Actel. The "Others" segment includes Gould AMI, National Semiconductor, and Philips Components (Signetics Company).

The survey results shown in Table 1 show a *wide* range of bookings prices for CMOS PLDs that operate at 7.5ns (20 pins or fewer)—$6.25 to $7.00—during the first half of 1991. Survey participants estimate a price range of $5.02 to $5.50 for the second half of 1992. For 1995, Dataquest estimates a price of $4.45.

CMOS PLD Price Trend

Users of CMOS PLDs can plan for a trend of a *wide* but competitive price range. The reason is that many CMOS device suppliers are becoming increasingly price-competitive *not only* against other suppliers of CMOS devices *but also* against suppliers of TTL parts.

This competitive reality translates into very low prices on the bottom of the CMOS price range. Meanwhile, other suppliers will pursue a strategy that strives to avoid pricing battles by stressing performance, and still others will be unable to compete on price. This reality leads to high prices at the top of the price range. Collectively, these factors mean a wide range of CMOS PLD prices.

PLDs

PLD Specifications: 10ns, 20 Pins or Fewer

Table 1 reveals a wide range of North American bookings prices—from $3.69 to $4.95—during the first half of 1991 for CMOS devices that operate at 10ns (20 pins or fewer). By contrast, survey respondents expect a *narrower* and *lower* price range—$1.70 to $1.97—during this period for the equivalent TTL version.

Furthermore, survey participants consistently project a price of $1.50 for the TTL part during the second half of 1992. The survey results also indicate some narrowing of the price spread for the CMOS versions—to a range of $2.92 to $3.37—for the latter half of 1992. Even so, the price range for the TTL chip remains *narrower* and *lower* than for the CMOS counterpart.

PLD Specifications: 6ns, 20 Pins or Fewer

The information in Table 1 shows that survey respondents expect North American bookings prices for TTL devices that operate at 6.0ns (20 pins or fewer) should widely range in price from $6.55 to $8.45 for the first half of 1991. The participants also call for a very wide price range—$4.95 to $7.55—for the second half of 1992. For 1995, Dataquest currently forecasts a conservative North American bookings price of $5.50.

The reason for this wide range of TTL PLD prices is that this fast device still stands at an early stage of the product life cycle. Suppliers have entered this arena at different times (meaning they are at different points on the cost-learning curve), which translates into a wide price range.

CMOS PLD suppliers will continue to take market share from suppliers of the still-predominant bipolar TTL technology.

In addition, Table 1 reflects that there is as yet no CMOS equivalent—a reflection of the current performance edge of TTL technology over CMOS. Should a CMOS version be developed, prices for the TTL part could decrease more rapidly than is currently projected and reach below the $5 mark as early as 1993 or even the second half of 1992.

PLD Specifications: 7.5ns, 24 Pins

Users and suppliers that participated in the survey expect North American bookings prices for 24-pin TTL devices that operate at 7.5ns to range from $6.05 to $6.94 during the first half of 1991 . Again, survey participants anticipate a *narrow* price range of $5.02 to $5.11 for the second half of 1992. Dataquest estimates a $4.22 North American bookings price in 1995.

No CMOS part of this specification is yet available in the market. Some survey participants expect a CMOS version to appear by early 1992 and project a price of approximately $9.50 to $10 for this device in the second half of 1992. The TTL part is likely to maintain a price advantage vis-à-vis the anticipated CMOS device over the long term.

PLD Specifications: 15ns, 24 Pins

Table 1 shows that, during the first half of 1991, survey participants anticipate North American bookings prices for 24-pin TTL devices that operate at 15ns (which is a somewhat mature product) to range *narrowly* from $1.21 to $1.40. These users and suppliers also expect a slim range of prices—$1.02 to $1.24—for the devices in the latter half of 1992. Dataquest estimates a North American bookings price of $1.08 for this TTL device for 1995.

In contrast, the survey information calls for a *wide* range of North American bookings prices—$1.17 to $1.76—for the equivalent CMOS PLD during the first half of 1991. Survey participants project an even wider price range—$1.02 to $1.78—for the device in the second half of 1992. Dataquest estimates a price of $1.33 for this CMOS part for 1995.

For users and suppliers, this information signals the likelihood of aggressive long-term price declines. If competition intensifies, as is likely, prices for both the TTL and CMOS products should collapse to the lower end of the price range as early as the second half of 1992. Under this competitive scenario, CMOS prices could decline more rapidly than is currently forecast and approach parity with TTL prices by 1993.

22V10 PLDs

22V10 PLD Specifications: 15ns, 24 Pins

For the first half of 1991, survey participants expect North American bookings prices for 24-pin TTL 22V10 ICs that operate at 15ns to range *widely* in price from $5.30 to $7.40. Survey respondents expect a somewhat narrower price range—$5.10 to $6.48—for these devices in the second half of 1992. Dataquest estimates a 1995 North American bookings price of $4.49.

Long-Term Drop in Prices?

For the equivalent CMOS PLD, Table 1 shows that users and suppliers anticipate that bookings prices will range from $7.27 to $8.60 for the first half of 1991. The survey estimates call for a *wide spread* of prices—$5.70 to $7.06—for the device in the second half of 1992. Dataquest estimates a price of $4.91 for 1995. For users and suppliers, this information appears to signal sharp near-term and long-range drops in prices for TTL 22V10s and CMOS 22V10s.

22V10 Wild Card

A wild card exists regarding the price outlook for all 22V10 devices. Advanced Micro Devices has sued the following suppliers for alleged patent infringement: Atmel, Cypress Semiconductor, Gazelle Microelectronics, and Samsung Semiconductor. If this patent claim is upheld in court, prices would decline more slowly than is currently projected. The 22V10 price forecasts are based on the assumption that a settlement will be reached between Advanced Micro Devices and these suppliers. Samsung settled last year. At the time this article was written, Atmel had just settled, but Cypress had countersued.

Regardless, in line with earlier analyses, survey respondents consistently project that the price range for the TTL version of the 22V10 will be *lower* and *narrower* than for the CMOS part.

22V10 PLD Specifications: 25ns, 24 Pins

For the first half of 1991, survey respondents estimate that the North American bookings prices for 24-pin TTL 22V10 ICs that operate at 25ns will range *widely* from $2.55 to $3.88. Survey participants also expect a wide price range—$2.29 to $3.42—in these devices for the second half of 1992. Dataquest estimates a 1995 North American bookings price of $1.98.

For the equivalent CMOS 22V10, survey information estimates that the North American bookings price range will be nearly the same as for the TTL part—$2.53 to $3.90—in the first half of 1991. The survey estimates call for a *very* wide range of prices—$1.78 to $3.20—for these devices in the second half of 1992. Dataquest estimates a price of $2.00 for 1995.

The patent-claim wild card also clouds the price outlook for these 22V10 devices. Again, if Advanced Micro Devices' patent claim proves valid, prices would decline more slowly than is currently projected. If the claim is not valid or a settlement is reached, prices for the CMOS versions of these 22V10s are forecast to reach parity with TTL prices during the long term.

Dataquest Perspective

This article provides users with a strategic perspective on Dataquest's SPS forecast of North American bookings prices for TTL PLDs and CMOS PLDs through 1995. The article focuses on three price points for select TTL PLDs and CMOS PLDs. In particular, the results of Dataquest's just-completed quarterly price survey—which reveals a complete spectrum of PLD price ranges for the *second half of 1992*—offers a window of insight into the industry's long-range price outlook.

CMOS PLD suppliers will continue to take market share from suppliers of the still-predominant bipolar TTL technology. PLD users that require low-power CMOS parts can look forward to more competitive prices relative to TTL alternatives. The inherent speed advantage of the TTL technology, combined with the proven maturity of this process, however, keep TTL PLDs a cost-effective solution, especially in very fast (sub-ens) system applications. TTL products should maintain their edge in terms of performance speed.

The big news revealed by the survey results is that users should plan for more aggressive pricing by CMOS device suppliers, which will narrow if not eliminate the price premium typically commanded for CMOS parts vis-à-vis TTL versions.

In line with this trend, PLD users should also anticipate the following trends. First, CMOS PLD users can expect a wide but competitive price range. The main reason is that the approximately 17 suppliers of CMOS devices are becoming increasingly price-competitive against TTL parts suppliers *and also* against CMOS device suppliers. Laggards will continue to price their devices at the high end of the range, but the real pricing action will occur at the lower end.

Second, TTL PLD users can look for a narrow but competitive price range. Why? The four TTL PLD suppliers *must* be price-competitive against suppliers of CMOS devices, but these TTL houses will often be reluctant to place pricing pressure on each other. Nevertheless, tight TTL price ranges that appear noncompetitive in fact reflect very competitive pricing.

By Ronald Bohn

Merchant DRAM Suppliers: Another Shakeout Coming?

Summary

The prices of 1Mb and 4Mb DRAMs have been falling steadily. In the fourth quarter of 1989, the worldwide average billings price of a 1Mb DRAM was $9.45. Today, the billings price of a 1Mb DRAM ranges from $4.30 to $5.00. In the fourth quarter of 1989, the worldwide billings price of a 4Mb DRAM was $87.78. Today, the worldwide billings price of a 4Mb DRAM ranges from $18.00 to $23.00.

Part of this decline is normal. Learning-curve price declines are a part of each DRAM generation. These declines stimulate demand and allow buyers to economically cross over to the next DRAM generation. However, in the fourth quarter of 1990, 1Mb DRAM price declines seemed much sharper than would be expected from learning-curve experience only. Prices were squeezing profits. Japanese DRAM manufacturers responded with production cutbacks of 1Mb DRAMs.

These recent and larger-than-expected 1Mb DRAM price declines are due to a simple economic fact: oversupply. Based on Dataquest's analysis of existing merchant capacity and planned, publicly announced capacity additions, we believe that an oversupply of 1Mb and 4Mb DRAMs exists. We believe that this condition is likely to continue.

DRAM Supply and Demand

Dataquest maintains a worldwide fab database that contains wafer-start capacity for individual semiconductor companies. From our fab database, we determine current DRAM capacity in wafer starts and add to it all the announced plans for building future DRAM capacity. This DRAM wafer-start capacity is converted to DRAM unit capacity by applying the set of assumptions for die size and yield shown in Table 1. Unit DRAM capacity is then compared with Dataquest's forecast of DRAM demand to determine if there is or will be an imbalance of DRAM supply and demand.

We believe that our capacity assumptions are on the conservative side. For example, all fab

TABLE 1
Assumptions for DRAM Die Size, Probe Yields, and Good Die Per Wafer

	Die Size (mm^2)	Probe Yield (%)	Good Die per 6-Inch Wafer
1Mb DRAM	40	79	293
4Mb DRAM	96	48	66
4Mb DRAM (Shrink)	71	65	128

Source: Dataquest (March 1991)

lines that produce non-DRAM devices in addition to DRAMs were excluded from the analysis. If these fabs and some appropriate fraction of their capacity were included in the analysis, the resulting DRAM capacity numbers would be much higher.

Many fabs in our database are listed as capable of producing either 1Mb or 4Mb DRAMs. Thus, this study is based on an aggregate analysis of 1Mb and 4Mb DRAM capacity. In this article, we provide three scenarios regarding the mix of fabs capable of either 1Mb or 4Mb DRAM production. These scenarios reflect assumptions for low capacity, high capacity, and intermediate capacity for 1Mb and 4Mb DRAMs.

The low-capacity scenario assumes that all 1Mb DRAM fabs that are also capable of 4Mb DRAM production will indeed shift their production to 4Mb DRAMs. This scenario is low capacity because fewer 4Mb DRAM die can be fabricated from a wafer than 1Mb DRAMs. (The die for 4Mb DRAMs are larger than the die for 1Mb DRAMs.)

The high-capacity scenario assumes that none of the fabs listed as capable of either 1Mb or 4Mb DRAMs will shift production to 4Mb DRAMs. This scenario is high capacity because more 1Mb DRAM die than 4Mb DRAM die can be fabricated from a wafer.

The intermediate-capacity scenario assumes that 50 percent of the fabs listed as capable of producing both 1Mb and 4Mb DRAMs will actually shift production to 4Mb DRAMs.

DRAM demand and our estimated DRAM capacity for the three scenarios are shown in Figure 1. What is striking about this figure is that the combined capacity of 1Mb and 4Mb DRAMs—under all three of our capacity scenarios—exceeds the projected combined demand for these devices by a substantial margin. For example, in 1994, the low-capacity scenario projects a capacity of slightly over 2,500 million units and a demand of just under 2,000 million units, an excess of over 25 percent.

Table 2 evaluates the supply-and-demand estimates in Figure 1 in terms of percentages. For example, in 1994, demand will be only 66 percent of the potential supply under the high-capacity scenario and 74 percent of supply under the low-capacity scenario.

Dataquest Perspective

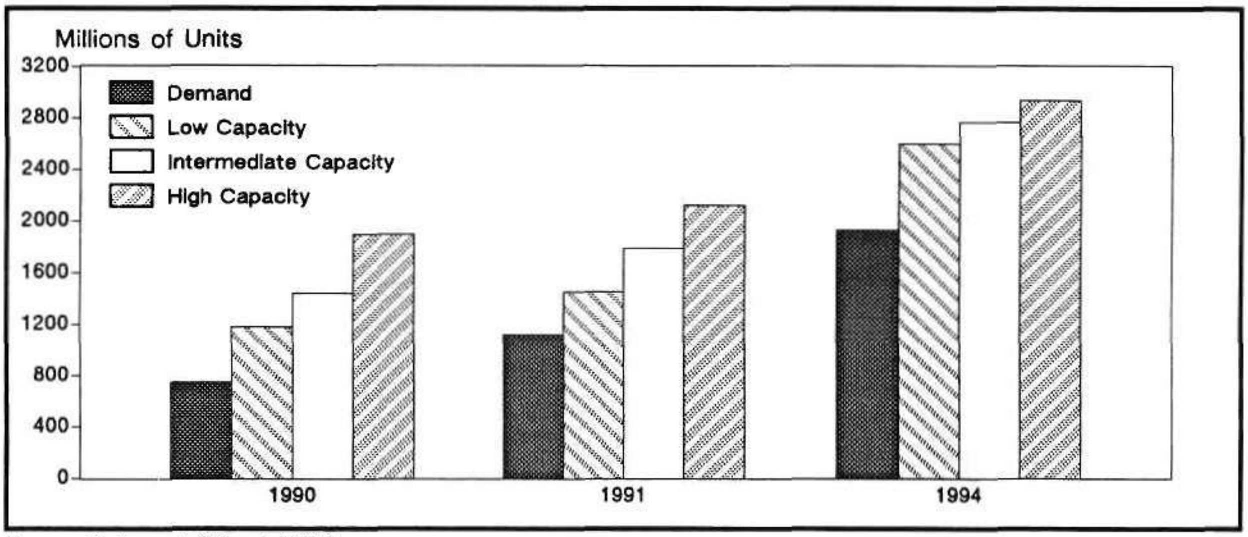
A multiple set of assumptions guides the Dataquest megabit-density DRAM price forecast. This article focuses on *one* key assumption--that global DRAM capacity will exceed market DRAM demand during the first half of this decade.

It should be emphasized that this large DRAM capacity has to be utilized for oversupply to occur. In the short term, DRAM producers could very well choose not to use their full-production capacity. This happened in fall 1990 when Japanese producers announced cutbacks in production of 1Mb DRAMs.

A longer-term strategy to reduce overcapacity is to switch some DRAM capacity to other products such as SRAMs or ASICs. An example of this strategy would be Motorola's recent announcement that its MOS 11 fab in Oak Hill, Texas, will be used to produce SRAMs rather than 4Mb DRAMs as originally planned. A third alternative strategy is that a DRAM fab facing overcapacity could aggressively pursue foundry relationships to fill unused capacity.

In the early and mid-1980s, the industry faced a similar, although not identical, situation. There were too many DRAM manufacturers, and oversupply resulted. Many DRAM producers decided to leave the DRAM business for what they

FIGURE 1
Estimated Aggregate of 1Mb and 4Mb DRAM Supply and Demand



Source: Dataquest (March 1991)

TABLE 2
Estimated Merchant Demand as a Percentage of Worldwide Merchant Capacity for 1Mb and 4Mb DRAMs Combined

	Low Capacity	Intermediate Capacity	High Capacity
1990	63	52	40
1991	77	63	53
1994	74	70	66

Source: Dataquest (March 1991)

hoped were more profitable product lines. Capital spending fell more sharply than ever before. Equipment companies folded, merged, restructured, laid off staff, and some even cut back on R&D.

Since the mid-1980s, the industry has been much more circumspect about adding capacity. The growth rate of capital spending was much less in the second half of the 1980s than in the first half. Inventories, because of just-in-time deliveries and closer supplier/vendor relationships, are much better managed than in 1985. Since the shakeout in the mid-1980s, the industry has matured.

However, new DRAM players have emerged since the mid-1980s. These companies (Motorola, Asia/Pacific companies, and second-tier Japanese companies) have added capacity in order to gain market share. The capacity from the new players, plus the capacity from the established players, today adds up to overcapacity. Clearly, the industry faces a challenge: how to manage overcapacity without the correction of another shakeout.

DRAM users can expect long-range competitive price trends to continue partly because of this capacity situation. Other issues that will affect prices, such as cost/yield trends, individual supplier strategies, and government intervention (e.g., FMUs, reference prices) are being closely watched by Dataquest and will be analyzed in future issues of *Dataquest Perspective.*

By Ione Ishii

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Company Analysis

Another Giant in a World of Start-Ups: Toshiba Enters the PC Chip Set Market

Background

In January 1991, Toshiba introduced an 80486-based Micro Channel Architecture (MCA) chip set for applications in high-end desktop computer systems. The new chip set is the product of a strategic alliance between Toshiba and Micral, an independent affiliate of Groupe Bull. The 4-chip family is designed by Micral and will be manufactured and marketed by Toshiba.

Toshiba is among the first manufacturers to announce a 486 MCA chip set, although Dataquest expects the 486 MCA market to achieve the most significant growth of any segment in the PC chip set market over the next two years. Toshiba's market entry is a very significant development, indeed. What we are observing is a first-tier semiconductor manufacturer teaming with a leading MCA design house to compete with its own customers in the merchant arena of a most significant emerging market.

Competitive Issues

One of the more interesting issues surrounds Toshiba's foundry customers. Toshiba provides manufacturing services for a large number of PC chip set suppliers. Of particular note is Chips & Technologies, the market leader. Although Chips has foundry relationships with several other manufacturers including Fujitsu, LSI Logic, National Semiconductor, NEC, Oki, Seiko, Ricoh, and Yamaha, the company is in the unenviable position in which one of its major competitors controls its cost of silicon.

Chips & Technologies is not alone. Many fabless chip set suppliers that rely on foundry services from Toshiba and other semiconductor manufacturers are faced with an interesting predicament: As the level of complexity and integration in systems logic chip sets increases, the number of silicon suppliers with adequate processes to produce the chips decreases. In previous generations of AT-bus products, the level of design complexity was such that silicon was virtually a commodity product and much of a chip set company's added value resided in the chip design. With dozens of qualified silicon suppliers, the technological barriers to entry were relatively low for any design house with a reasonable amount of systems expertise. However, as design complexity increases, the number of designers and silicon vendors qualified to supply the product shrinks. Much of the added value in a high-end chip set will reside in the fabrication process technology. This situation poses a significant challenge to the league of fabless chip set design houses.

Dataquest believes that broad-line suppliers have a greater chance for success in this cutthroat market, financially and technologically, as manufacturing capability becomes the determining factor.

Toshiba is the second broad-line semiconductor manufacturer to enter the chip set market in the past four months. The first was National Semiconductor in October 1990 with AT-bus chip sets for 286- and 386SX-based systems. Other large semiconductor manufacturers in this market include Texas Instruments, Intel, and Motorola (through its relationship with ACC Microelectronics).

The critical competitive advantage is becoming low-cost manufacturing. At the same time, the determining factor for added value is quickly becoming manufacturing process technology.

Dataquest believes that broad-line suppliers have a greater chance for success in this cutthroat market, financially and technologically, as manufacturing capability becomes the determining factor. Many niche chip set suppliers eventually will be squeezed out of the market or acquired by larger semiconductor companies. Those that do survive will focus on leading-edge and enabling products such as data/voice compression and multimedia/DVI. These features and functions will reside within the PC in future generations.

Dataquest believes that the 486 MCA-based chip set market will experience significant growth in the next two years as the industry continues to progress along the MPU performance path. Intel has stated that shipments of the 80386DX peaked in 1990 because it was being "squeezed at both ends" of the performance spectrum by the 486 and the 80386SX. Now that AMD has introduced its Am386 clone of the 80386, Intel has still further reason to make the 386DX obsolete. Intel's goal is to establish the image of performance and desirability for the 486 products. The achievement of this goal likely will mean substantial price reductions in 1991 for the 486, particularly the 486-25. As a result, Dataquest expects to see a marked increase in the number of 486 shipments and resultant shipments of 486-based chip sets in 1991. Furthermore, although the number of 486-based chip set vendors currently is limited, we expect to see regular introductions of new 486-based products throughout 1991.

Dataquest Perspective

As expected, the PC chip set business is maturing quite rapidly. No longer the high-margin niche market with low entry barriers, the highly competitive chip set arena has quickly become an overpopulated market with intense competition. As more companies have entered the market, product differentiation has become more difficult to achieve and vendors are facing increased competition on the basis of price. The critical competitive advantage is becoming low-cost manufacturing. At the same time, the determining factor for added value is quickly becoming manufacturing process technology. For these reasons, Dataquest believes that the balance of power in this market is shifting to the large, well-diversified manufacturers with leading-edge processes. In the next two years, we expect a shakeout to occur in this market, with the survivors being the well-established broad-line suppliers and other companies that have the design expertise and the agility to pursue other leading-edge niche opportunities.

For buyers of chip sets, it is becoming more important to know whether a supplier is a downstream competitor. Close scrutiny of corporate alignments is now also necessary for both chip set and semiconductor suppliers. The Dataquest Company Backgrounders list the major alignments and agreements for the top 25 worldwide semiconductor suppliers. ■

By Ken Pearlman
Phil Mosakowski

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Technology Analysis

Semiconductor Cost Trends

Introduction

Applications of Cost Model Analysis

Cost model use falls into two broad areas: near-term cost/price optimization planning and long-range system cost analysis. A usable model allows for both applications. The Dataquest semiconductor cost model uses 17 key variables of semiconductor manufacture after raw silicon wafers have been processed.

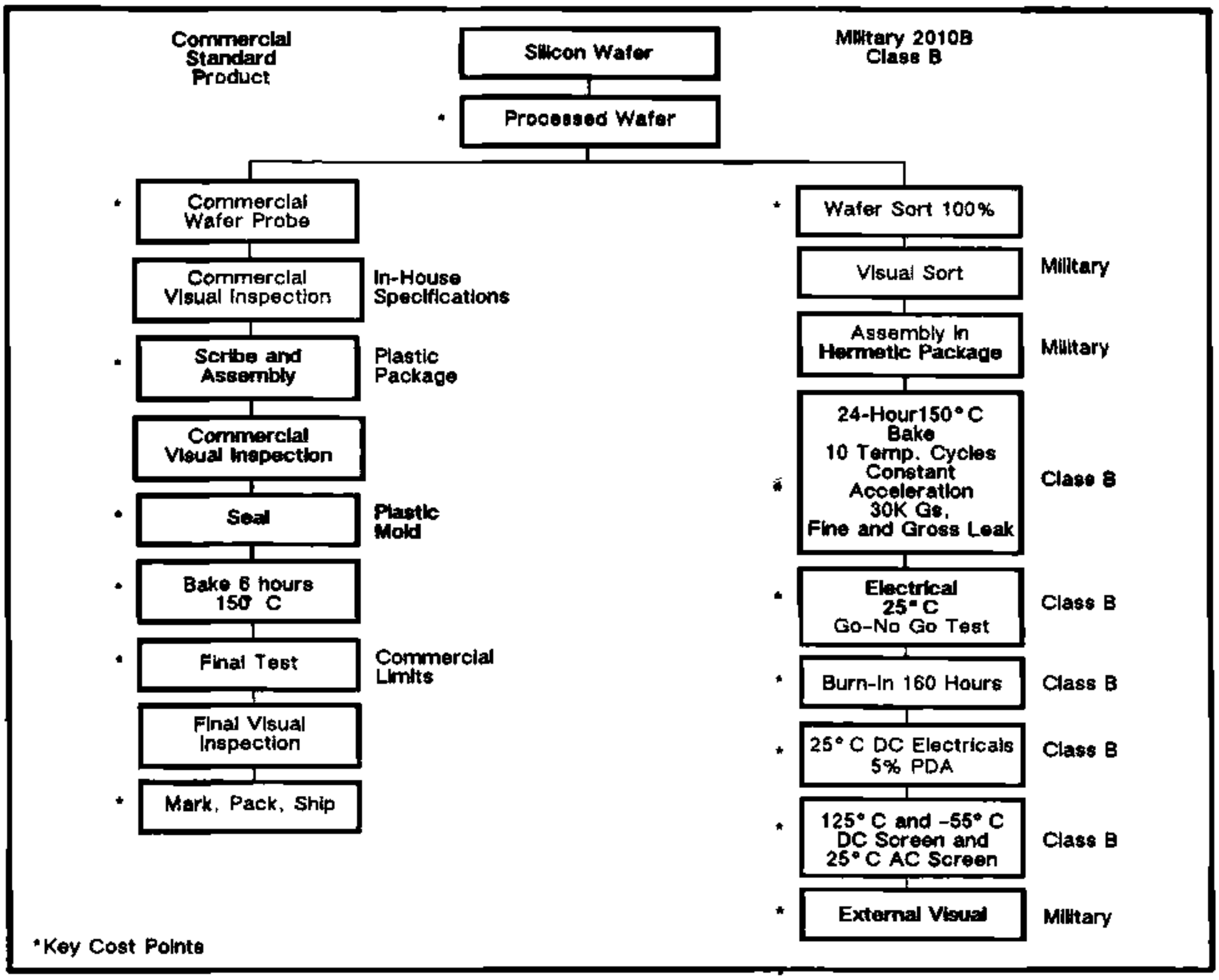
Semiconductor cost models are predominantly used to compile costs for use in near-term contract negotiations. By identifying areas where costs can be reduced, price negotiation results often benefit the parts buyer. Applying experience-curve theory to cost model applications can give both short- and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

Strategic use of cost models in long-range planning has been underutilized mainly because long-range variables are perceived as too erratic to model, let alone base plans on. By utilizing different learning curves to individual variables in the model and then modeling these derived inputs, one can better understand future trends and have alternative strategies at hand if any variable actually differs from its expected trend line. This method of cost model use can easily be made part, or the basis, of a proactive strategic plan.

The cost/price relationship for semiconductor products varies from product to product, from company to company, and with time as a function of business conditions.

The high rate of technological change in the semiconductor industry has caused the cost per function to decrease at an average rate of 35 percent per year for the last 20 years. This high rate of change is expected to continue in the future.

Figure 1
Commercial and MIL-STD Manufacturing Flow



Source: Dataquest (March 1991)

Cost Analysis

Cost versus Price

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

The cost/price relationship for semiconductor products varies from product to product, from company to company, and with time as a function of business conditions. A good way to perform cost/price analysis is to monitor prices and costs over a period of several years for selected product types and identify the average gross margin for these types. By using this procedure, semiconductor users can develop a good feel for the cost/price relationship for the semiconductor products they buy. Buyers can use the cost/price data provided here to estimate the cost of purchased materials and determine target prices for future price negotiations.

This article provides semiconductor users with the cost data necessary for cost/price analyses of specific semiconductor products.

Cost Factors

The cost of a semiconductor device is developed by adding the cost of each step in the manufacturing process. Figure 1 shows the manufacturing process flow for semiconductor devices and identifies the important cost steps in the process.

Our cost model categorizes costs into the following four areas:

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

Screening and qualification tests include burn-in and MIL-STD quality and reliability assurance processing requirements.

In our analyses, we have assumed that the product being modeled is being manufactured with technology that has passed the start-up phase. For example, shifts to 6-inch wafers will be indicated at a time when most manufacturers have made the change, rather than when the first manufacturer begins production.

The manufacturing process starts with an unprocessed silicon wafer that costs from $15 to $25. After completing more than 100 processing steps, the cost of a processed wafer is 10 to 30 times the initial cost of the unprocessed wafer. The wafer cost is a function of the following:

- The number of mask layers required
- The photolithographic requirements
- The quality of chemicals and purchased wafers
- The clean room environment

A complex relationship exists among each of these elements, the processed wafer cost, and the end cost of the product.

Number of Mask Layers

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

Photolithographic Requirements

Wafer costs increase as device features become smaller. However, smaller features result in more die or more functions per wafer. Although the wafer cost will be higher, the cost per function will often be lower.

Table 1
Number of IC Process Mask Layers

Process	Single-Layer Metal	Multilayer Metal
Schottky TTL	7	9
ECL	8	10
NMOS	8	10
HMOS	9	11
CMOS	10	12-15
HCMOS	11	13-16
Bipolar Linear	7-9	9-11
BiMOS	14	16-18

Source: Dataquest (March 1991)

Quality of Materials and Clean Room Environment

As device features become smaller, semiconductor circuits become more susceptible to defects in the semiconductor material. These defects result in lower yields. Defects occur in the purchased silicon wafers and masks; the defects are introduced during processing by chemicals and particles in the air.

Increasing the quality of materials and improving the clean room environment increases the cost of processed wafers. However, the resulting lower-defect material produces higher yields and lower unit costs. This is especially true for VLSI products.

Finished wafers are then tested and electrically sorted to separate the good die from the bad. The primary cost factors at wafer sort are the yield (percent) of good die on the wafer and the testing costs, which are a function of the cost per hour of using the test equipment and the time required to test each die. Increased wafer sort yield is the single most important factor in reducing the cost of VLSI products.

Package Costs

Electrically sorted die are then assembled into packages. Packaging costs vary from pennies to several dollars, depending on the type of packages needed. Table 2 provides cost estimates for representative packages used for integrated circuit products. As automation increases, labor content per device decreases.

Assembled units then receive their final tests. The most important final test costs are the equipment operating cost, test time, and yield. The cost of performing tests over time is assumed to increase moderately, while yields increase as test methods and manufacturing methods are improved.

Table 2
1991 Package Cost Estimates—Total Assembled Cost (Die-Free)

No. of Pins (Vol.)	Plastic DIP (500K)	CERDIP/ QUAD (100K)	Side-Braze (25K)	SOIC/ SOJ (500K)	PLCC (500K)	LDCC (25K)	CLCC (100K)	Ceramic PGA (25K)	Plastic PGA (25K)	QFP (EIAJ) (100K)	PQFP-JEDEC (100K)	TSOP (50K)	TAB (TAPE) (per site)
8	0.06	0.29	1.95	0.08									
14	0.10	0.32	2.05	0.13									
16	0.10	0.35	2.15	0.15									
18	0.12	0.54	2.35	0.18	0.16		1.00						
20	0.14	0.59	2.48	0.18	0.19	2.55	1.02						
22	0.15	0.62	2.72	0.19									
24	0.17	0.65	3.26	0.20		3.10	1.21						
28	0.22	0.85	3.80	0.24	0.26		1.60						
32	0.38	0.97	4.28	0.33	0.32	4.12	1.72					1.10	
40	0.32	1.30	5.34	0.35			2.35			0.38		1.10	
44	0.52				0.38	5.70	2.40						
48	0.44		6.50				2.60			0.48			
52					0.51		3.84			0.52			
64	0.70						4.12			0.68			1.35
68		3.00			0.60		4.65	8.25	3.10	0.70			1.35
84		3.97			0.75		5.60	9.75	3.90	0.7 (80ld)			1.35
100								10.24	5.00	0.95	1.20		1.35
128								13.50	6.00	1.40	1.60 (132ld)		1.35
144								16.30	7.04	2.10			1.35
160								18.50	8.10	2.60	2.60 (164ld)		2.47
208								25.25		3.65			2.47
244									10.40	4.70			2.47
256									13.10				3.95
308								43.10	15.60				3.95

(Continued)

Table 2 (Continued)
1991 Package Cost Estimates—Total Assembled Cost (Die-Free)

No. of Pins (Vol.)	Plastic DIP (500K)	CERDIP/ QUAD (100K)	Side-Braze (25K)	SOIC/ SOJ (500K)	PLCC (500K)	LDCC (25K)	CLCC (100K)	Ceramic PGA (25K)	Plastic PGA (25K)	QFP (EIAJ) (100K)	PQFP-JEDEC (100K)	TSOP (50K)	TAB (TAPE) (per site)
Material Consideration:													
Ld Frame Mat'l	C194	A42	A42	C194	C151	A42	None	A42	Cu	A42	C194	A42	Cu w/Sn plate
Ld Form	TH	TH	TH	Gull/J	J	Gull	None	TH	TH	Gull	Gull	Gull	Gull
Wire	Au	Al	Al	Au	Au	Al	Al	Al	Au	Au	Au	Au	NA
Lid	Epoxy	Ceramic	Au/Kovar	Epoxy	Epoxy	Au/Kovar	Au/Kovar	Au/Kovar	Au/Epoxy	Epoxy	Epoxy	Epoxy	NA
Preform	NA	Glass	Au/Sn	NA	NA	Au/Sn	Au/Sn	Au/Sn	NA	NA	NA	NA	NA

Note: Costs reflect offshore assembly. Plated metal not included in lead-frame cost (except TAB).
NA = Not available
Source: Dataquest (March 1991)

The final mark, pack, and ship step has only a minimal effect on the total product cost. Labor, shipping containers, and a 1 percent yield loss are the primary cost factors at this stage of manufacturing.

Cost Model

This cost model determines the variable cost for the device modeled. The variable cost includes the cost of direct labor and materials for each product modeled.

Processed wafer cost, number of die per wafer, test cost per hour, and assembly cost are all empirical data; so are the yield percentages used in each step. The following outline shows how each line of the cost model is developed.

Understanding Yields

Only a portion of die on a given wafer will meet the electrical test specifications to which 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

Wafer Sort	
Wafer size (diameter in inches)	= A
Capacity utilization (%)	= B
Geometry (microns)	= C
Processed wafer cost ($)	= D
Die area (square mils)	= E
Active area factor	= F
Number of masks	= G
Defect density per square inch per mask	= H
Gross die per wafer	= I = (0.9 *11*(A/2)x10^6/E
Processed wafer cost per gross die ($)	= D/I = J
Test cost per hour ($)	= K
Wafers tested per hour	= L
Wafer sort cost per gross die ($) (K/L)/I	= M
Cost per gross die at wafer sort ($) J + M	= N
Wafer sort yield (%)=(((E/F/10^6)*GxH)*100)	= O
Cost per sorted die ($)=Nx100/0	= P
Assembly	
Material cost/sorted die-SOJ pkg. ($)	= Q
Number of Pins	= R
Assembly yield (%)	= S
Cost per assembled die ($)=(P + Q)/S*100	= T
Final Test	
Test time per die (sec.)	= U
Cost per hour of testing ($)	= V
Test cost per die ($) U * V/3600	= W
Final test yield (%)	= X
Cost per final tested unit ($)	= Y = (T + W)/X*100
Mark, Pack, and Ship	
Cost at 99% yield (%) = 0.01*Y	= Z
Total fabrication cost per unit ($)	= AA = Y+Z
Foreign Market Value (FMV) Formula Adders	
R&D expense (15%) = 0.15*AA	= AB
SG&A expense (10%) = (AA + AB)*0.10	= AC
Profit (8%) (AA + AB + AC)*0.08	= AD
Constructed FMV = AA + AB + AC + AD	

uses an exponential equation called Murphy's formula to approximate yield:

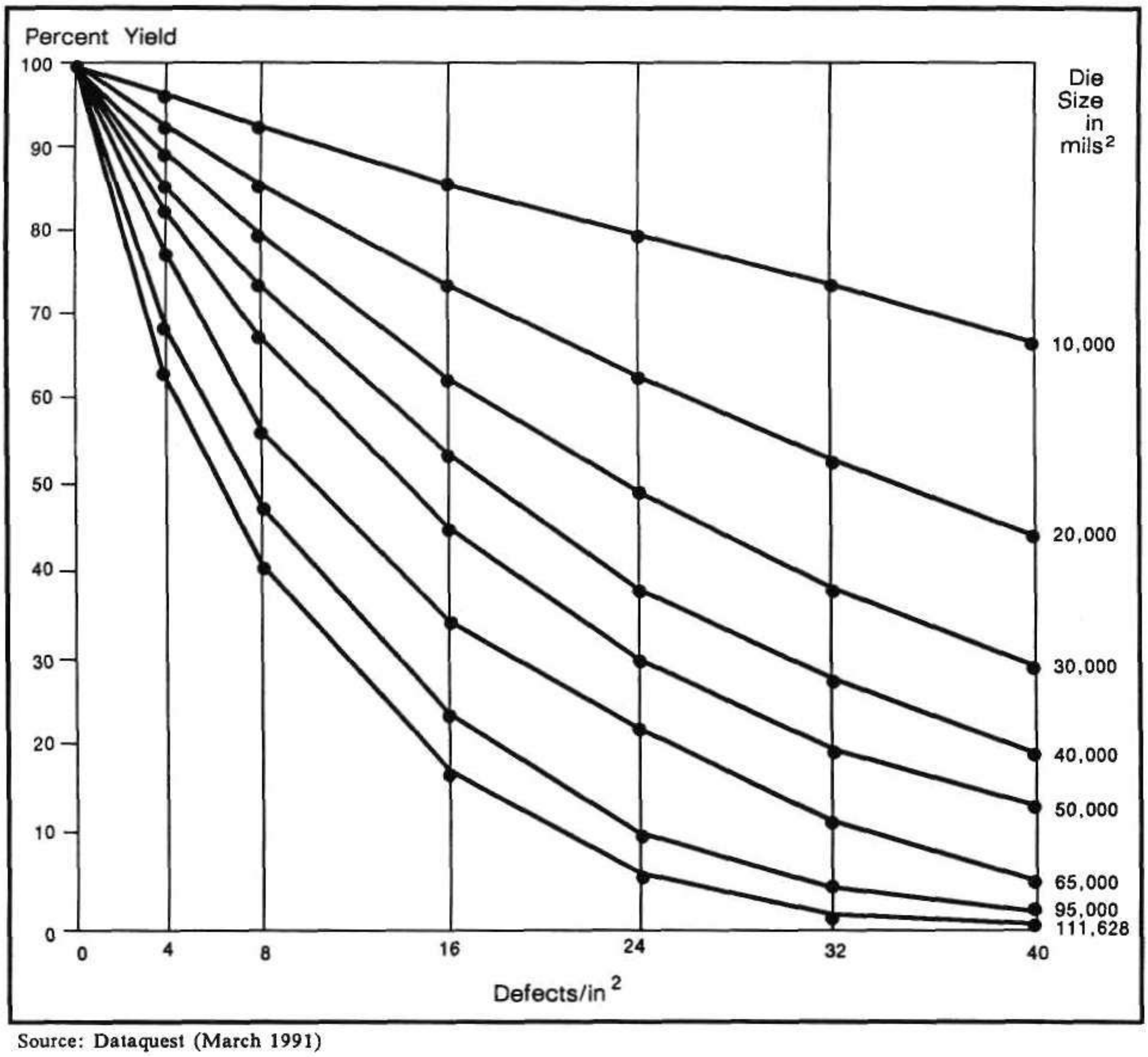
$$\text{Yield} = e^{(-DA)};$$

where e is the constant 2.72, D is the defect density in defects per square inch, and A is the area of the chip in square inches. This mathematical formula is useful for analyzing the key factors that affect semiconductor yields: the number of defects on the wafer and the number of chips on the wafer. The number of chips per wafer is determined by the area of each chip. Defects on a wafer are caused by particles in the air falling on the wafer during semiconductor manufacture. The number of defects on a wafer is determined by the number of particles in the air and the number of mask steps required in the processing of the wafer. An increase in mask levels requires more time in the fab area, thus increasing the chances of particles falling on the wafer and causing a reduction in yield.

Yield Trade-Offs

Figure 2 describes graphically the effect of defects on wafer electrical test yield. Each line represents the yield curve size for a given defect density. Many facilities presently in

Figure 2
Semiconductor Yield Defect-Density Effect



Source: Dataquest (March 1991)

production produce 8 to 20 defects per square inch, while state-of-the-art VLSI facilities will produce only from 1 to 5 defects per square inch. As the size of a die continues to increase, the effects of defects per square inch become increasingly detrimental to yield. In response to this necessity, Class 10 and lower clean rooms are becoming the norm for competitive semiconductor manufacturers. (Class refers to the amount of particulates of a certain size per square foot that exist in a clean room. For example, a Class 10 clean room has no more than 10 particulates per square foot.)

By taking a typical 4Mb DRAM with two different die sizes (approximately 112K square mils and 142K square mils) in two different manufacturing areas, one with 8 defects per square inch and the other with 4 defects per square inch, one can easily see in Table 3 the advantages of utilizing a clean room with less particulates. This points out why it is more economical to ship larger die if the fabrication area is cleaner, because more die per wafer are shippable.

Yield and Related Costs

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

Electrical Wafer Sort

The first test, electrical wafer sort, is done on processed wafers by a computer-based tester at a test station specifically designed for that device. The tester automatically tests each die on the wafer by contracting each pad on each chip and marking with a dot of ink those die that do not pass the test. Test costs consist of equipment operating costs, direct operator costs, and the amount of time required to test each wafer.

Table 3
4Mb DRAM Yield Loss to Defects
(Percent Good Die/Number of Good Chips per Wafer)

Chip Size	Fab Area	
(Mils^2)	8 Defects/In.^{2}	4 Defects/In.^{2}
142,000	32.1—57 die	56.6—101 die
111,628	40.9—93 die	63.9—145 die

Note: A cleaner fabrication area allows for more shippable product even if the die size is larger than in a "dirtier" area.
Source: Dataquest (March 1991)

Equipment operating costs are dominated by the depreciation of the test equipment. Semiconductor test equipment is generally depreciated over five years and can range in price from $250,000 to $1,000,000, depending on test requirements. Dataquest uses estimates of test costs per hour ranging from $25 to $100 per hour. The most complex integrated circuit test costs range from $50 to $100 per hour.

Dataquest assumes that a test operator supports each piece of test equipment and estimates the labor cost per hour to be $17. The total test cost, including labor, then ranges from $40 to $115 per hour.

The time to test a wafer is determined by the circuit complexity, the number of chips per wafer, and the yield. Good die take about five times as long to test as bad die. Test programs are formulated and used to minimize test time by testing functions of the device statistically proven to most likely fail first. Test times for good die are kept to a minimum by performing only those tests that assure 85 to 90 percent test yield when packaged. Wafer sort test times for full-production VLSI chips takes no longer than 9 seconds for each chip.

Applying the above to a 4Mb DRAM example results in the following: there are 228 gross die per 6-inch wafer, and 118 (52 percent) are good. The test time for each wafer is about 51 minutes. For this example, we use a test cost per hour of $58 ($41 for equipment, $17 for the operator). Total test cost per wafer is $49.30, with the test cost per die totaling $0.239.

Assembly and Packaging

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

Packaging technology has continuously improved, but the basic assembly steps have not changed significantly during the past

20 years. The three main areas of assembly are as follows:

- Die separation
- Die attach and lead bond
- Encapsulation

Die Separation. This step refers to the method of separating the individual die on a wafer. One technique is very similar to the method of cutting and breaking glass. A diamond stylus automatically scratches the wafer in the areas between the die, called scribe lines. Once the total wafer has been scribed, the wafer is placed on a machine that fractures the wafer along the scribe lines. Some manufacturers use laser scribe machines to etch a line along the scribe line. Thick wafers require diamond sawing along the scribe lines.

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

Die Attach and Lead Bond. Assuming the use of a standard plastic small outline J-lead (SOJ), good die are attached to metal lead frames with a small amount of molten gold or low-cost epoxy. It is imperative that a die be securely attached to the lead frame in order for it to withstand later testing requirements made of the finished device. The next step is bonding the pads of the chip to individual leads of the package with either gold or aluminum wire that is between 1.0 and 1.5 thousandths of an inch in diameter. Thermocompression bonding involves heating the lead frame and attached die to about 340° C. The bonding wire is automatically pressed against the bonding pad on the heated die, fusing the wire to the die. The wire is then drawn to its respective bonding pad on the lead frame, which is also fused. Automated bonding machines are capable of bonding more than 1,000 packages per hour. Once the die is attached with bonded leads, another visual inspection is performed to eliminate devices that were damaged or bonded incorrectly.

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

Final Test

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

Each unit is stringently tested at this step, across "worst case" conditions. The circuits are tested for maximum and minimum speeds, for power dissipation, and for many combinations of inputs and outputs—that is, they are tested to ensure that they will meet all of the manufacturer's specifications and guarantees. The automatic test equipment performs thousands of separate tests in seconds. A typical final test by the manufacturer runs from less than one second on a TTL logic device to up to 15 seconds or more on some 4Mb DRAMs.

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

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

The first approach is obviously the safer method, but it is also much more expensive. As a result, many semiconductor manufacturers will correlate the room temperature characteristics with the characteristics at temperature extremes, add a safety guard band to the room temperature test parameters, and then test at room temperature. Samples are regularly taken from the production lots and tested across the full range

Table 4
Semiconductor Cost Model—4Mb DRAM

Wafer Sort	1990	1991	1991	1991	1991	1992
Wafer Sort						
Wafer Size (Inches Diameter)	6	6	6	6	6	6
Capacity Utilization (%)	100.00	100.00	75.00	50.00	25.00	100.00
Geometry (Microns)	1.00	0.80	0.80	0.80	0.80	0.80
Processed Wafer Cost ($)	550	520	650	813	1016	450
Die Area (Square Mils)	142,000	111,628	111,628	111,628	111,628	111,628
Active Area Factor	1.00	1.00	1.00	1.00	1.00	1.00
Number of Masks	14	14	14	14	14	14
Defect Density per Square Inch	0.420	0.420	0.420	0.420	0.420	0.260
Gross Die per Wafer	179	228	228	228	228	228
Processed Wafer Cost per Gross Die ($)	3.0691	2.2811	2.8514	3.5642	4.4552	1.9740
Test Cost per Hour ($)	90.00	90.00	171.90	214.88	302.97	90.00
Wafers Tested per Hour	3.61	2.79	2.79	2.79	2.79	2.79
Wafer-Sort Cost per Gross Die ($)	1.8130	1.1015	2.1039	2.6298	3.7081	1.1015
Cost per Gross Die at Wafer Sort ($)	4.8822	3.3826	4.9552	6.1940	8.1633	3.0755
Wafer-Sort Yield (%)	43	52	39	26	13	67
Cost per Sorted Die ($)	11.2520	6.5209	12.7368	23.8815	62.9485	4.6172
Assembly						
Material Cost/Sorted Die—SOJ Package($)	0.1600	0.1400	0.1414	0.1428	0.1442	0.1400
Number of Pins	20	20	20	20	20	20
Assembly Yield (%)	90	92	92	92	92	93
Cost per Assembled Die ($)	12.6800	7.2401	13.9981	26.1134	68.5791	5.1153
Final Test						
Test Time per Die (Seconds)	12.00	12.00	12.00	12.00	12.00	10.00
Cost per Hour of Testing ($)	90.00	90.00	171.90	214.88	302.97	90.00
Test Cost per Die ($)	0.3000	0.3000	0.5730	0.7163	1.0099	0.2500
Final Test Yield (%)	90	90	88	86	82	93
Cost per Final Tested Unit ($)	14.4222	8.3779	16.5205	31.0399	84.7466	5.7692
Mark, Pack, and Ship						
Cost at 99% Yield (%)	0.1442	0.0838	0.1652	0.3104	0.8475	0.0577
Total Fabricated Cost per Net Unit ($)	14.5665	8.4617	16.6857	31.3503	85.5940	5.8269
FMV Formula Adders						
R&D Expense (15%)	2.18	1.27	2.50	4.70	12.84	0.87
SG&A Expense (10%)	1.68	0.97	1.92	3.61	9.84	0.67
Profit (8%)	1.47	0.86	1.69	3.17	8.66	0.59
Constructed Foreign Market Value (FMV)	19.90	11.56	22.80	42.83	116.94	7.96

Source: Dataquest (March 1991)

of environmental conditions to ensure that the correlation parameters are accurate.

The functions of wafer sort and final test correlate very closely. Often both tests are performed in the same room and/or on the same test machine; the chief difference is the test program. One of the main functions of the wafer sort program is to minimize the amount of additional labor and materials that would be assigned in producing bad circuits. This is especially important to devices with low die costs and higher assembly costs.

Wafer sort cannot eliminate all potentially defective die, however, for the following reasons:

- Most sophisticated circuits such as 4Mb DRAMs cannot completely be tested in wafer form due to parasitic effects resulting from the probes and wiring, incident room light, and other factors involved with physically sorting the die.
- Some of the die may be damaged during the assembly process.
- The die cannot be tested across the temperature range in wafer form because the wafer and probes cannot be easily maintained at temperatures below the ambient.

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

Cost Model Usage

As shown in Table 4, we expect improvements in yield to be made over time as specific product processes become better understood. Yield improvements result directly in lower costs. The more existing capacity (for example, plant and machinery) utilized, the lower the per-unit cost, because fixed costs are spread over more units. High capacity utilization combined with higher yields results in lower costs per unit that are directly reflected in lower prices under normal circumstances. This characteristic of the semiconductor industry can be used to knowledgeably estimate current and future price trends for product planning or price negotiation decisions.

The 4Mb DRAM

The 4Mb DRAM cost model shown in Table 4 reflects both yield improvement trends (1990, 1991, and 1992) and capacity use effects (1991; 100 percent to 25 percent utilization). Capacity utilization greatly affects unit cost even as yields improve. At a certain point, low utilization of capacity results in lower yields as process control procedures become difficult to monitor because of the lower volumes manufactured. This compound effect (higher fixed costs plus lower yields) in down markets is often cited in antidumping rhetoric as market prices temporarily dip below costs. The opposite occurs in growing markets under normal situations as shown in the 1990 and 1991 cost/price trends.

Dataquest Perspective

Individual unit costs of semiconductors form the most tangible variable in the total cost of a semiconductor device. The understanding of cost modeling and the variables that go into that model allows for more efficient allocation of resources both in planning and in the execution of those plans. By applying different assumptions to different variables in the model, one can uncover areas of cost not previously considered important. Many different "what if" scenarios are often required to utilize cost modeling fully in long-range system analysis.

Modeling is inherently flexible and can be updated if proven historical data basically differ from calculated model results. Checking and updating a model against known data ensures that the model is correct and current. Revisions to existing algorithms to better match reality are made when basic changes occur, not for perturbations that deviate from the norm.

Those in procurement can use cost modeling and experience curve analysis for both short- and long-term contract negotiations. Periodic "reality checks" of the model ensure that, when cost and price trends track in the same or different directions, plans can be made with confidence that the best information was available at that time. Cost modeling can also be used as an internal audit to note where actual costs compare with model costs. Traditional use of cost models in price negotiations combined with experience curve trends can fine-tune the final outcome of these important agreements. ■

By Mark Giudici

News and Views

DRAM Bookings Price Ranges

An upturn in the North American bookings price for 1Mbx1 DRAMs sent users scrambling in the first quarter; 4Mb DRAMs continue to decline in line with prior expectations. Table 1 shows the range of estimated North American bookings DRAM prices garnered during the just-completed February-March 1991 quarterly price survey.

Dataquest Perspective

The survey results show that the 1991 high price for 1Mbx1 DRAMs should increase from $5 during the first quarter to $5.25 during the fourth quarter—a clear signal that some suppliers are leaving this segment. By contrast, the survey also estimates that the 1991 low price for 4Mbx1 DRAMs should decrease from $19 during the first quarter to as low as $11 for the fourth quarter—an indication that suppliers are successfully ramping up. The wide range of prices reflects the volatility of the megabit-density DRAM business.

Table 1
DRAM Price Ranges—North American Bookings
(Contract Volume; Dollars)*

	First Quarter 1991			Fourth Quarter 1991		
	High	Low	Average	High	Low	Average
1Mbx1 DRAM DIP/SOJ (80ns)	5.00	4.10	4.45	5.25	4.00	4.49
4Mbx1 DRAM SOJ 300 mil (80ns)	29.00	19.00	20.76	17.00	11.00	14.52

*Contract volume is at least 100,000 per order.
Note: This information correlates with Dataquest's quarterly forecast for 1991-1992 dated March 1991.
Source: Dataquest (March 1991)

In the Next Issue

The following topics will be featured in the next issue of *Dataquest Perspective:*

- The latest DQ Monday Report regional pricing update
- Highlights and results of the latest Quarterly Price Survey
- The Semiconductor Capital Spending Update
- The Monthly Procurement Pulse

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