Semiconductor User Information Service
Newsletters 1988-1989

Dataquest

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January–March Index

The following is a list of the newsletters in this section:

- **Japanese Semiconductor Industry Update: Will Industry Conditions Remain Strong?** (1989–01)—Dataquest is forecasting that consumer and nonconsumer electronic equipment production will grow at rates of 7.6 percent and 17.2 percent, respectively. Japanese suppliers enjoyed brisk business in 1988, especially the companies that manufacture memory products. Dataquest observes that in spite of the current DRAM shortage, overall there should be strong future growth in the Japanese semiconductor industry.

- **High–Definition TV: Is America Finally Waking Up?** (1989–02)—The United States Department of Defense (DOD) announced its intention to finance the development of an advanced, high–resolution video display screen. Dataquest concludes that with the recent announcements by U.S. government agencies regarding HDTV, the U.S. industry will move ahead, and potential suppliers of both equipment and semiconductors will be more willing to make the necessary investments in products for the HDTV application.

- **January Procurement Survey: Order Rates Remain Unchanged as Inventory Levels Decline** (1989–03)—Respondents to this month's survey noted that inventory levels were reduced and that targeted levels also declined. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest concludes that the overall electronics industry is relatively healthy, and the outlook is for a realistically steady growth year in 1989.

- **Northern Telecom: Strategy, Technology, and Semiconductors** (1989–04)—Northern Telecom has become one of the world's largest suppliers of telecommunications equipment. This newsletter focuses on the company's $260 million consumption, $140 million procurement, and $120 million production of semiconductors. Dataquest recommends that Northern Telecom (and the other participants in the industry) continue to tighten the links between design, manufacturing, and marketing in order to respond as quickly as possible to changing customer needs.

- **Unisys: Successful Merger, Bright Future** (1989–05)—Unisys, formed in 1986 by the merger of Sperry and Burroughs, is a fine example of the power of synergy. This newsletter discusses the company's directions product line, divisions and subsidiaries, and semiconductor procurement. Dataquest concludes that compatibility, leverage, and cost control are perhaps the best terms to describe the success of the Unisys merger.

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January–March Index

- **February Procurement Survey: Lead Times Fall while Order Rates Stabilize** (1989–06)—Lead times for semiconductors are improving and order rates are steady, yet overall inventory levels have increased since last month's survey. This bulletin discusses the current actual versus target semiconductors inventory levels for all OEMs and for computer OEMs. Dataquest concludes that the easing of lead times and coinciding increases of inventory levels may be an aberation that will smooth out as companies strive to achieve their targeted goals.

- **The Cost of Quality: Prevention versus Cure** (1089–07)—The total cost of a semiconductor component can be broken down into three main categories: unit price, inventory cost per unit, and rework costs due to component or system failure This bulletin discusses the break-even point where the preventative cost of quality and the remedial cost of quality are equal. Dataquest concludes that by analyzing quality cost, one can quantify where improvements are needed and prove the adage that "Quality is free."

- **Chips & Technologies Enters the Mass Storage Controller Business** (1989–08)—Chips & Technologies' newly formed Mass Storage Organization announced its first drive controller chip set, the Micro Channel Fixed Disk Adapter CHIPSet, on February 21. This bulletin analyzes the company's strategy and estimates the hard drive controller market. Dataquest concludes that the entry of a first-rate chip set vendor such as Chips & Technologies into this market will have a catalytic effect, enhancing competition and therefore innovation among all chip set manufacturers.

- **March Procurement Survey: Equipment Sales Up, Orders and Lead Times Down** (1989–09)—This month's respondents continued to see overall lead times fall as systems sales climbed relative to February. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest concludes that as the current business cycle rolls on, the specter of semiconductor supplies overshooting aggregate demand is rearing its disruptive head.

- **The Analog IC Market: A Barometer for the Semiconductor Industry** (1989–10)—A well-known fact is that the analog IC market neither grows as fast nor suffers the same severe downturns as the digital market. This newsletter provides a new look at analog IC market growth and how it relates to the total market. Dataquest concludes that the movement of the analog IC market should be of interest to more than the suppliers and users of analog ICs.

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- **Fourth Annual Procurement Survey: Old Issues Remain Hot; Accurate Forecasting is the Key** (1989–11)—The fourth annual Dataquest procurement survey results were announced at the Semiconductor User and Applications Conference that was held in San Francisco, California, in late February. This newsletter discusses the survey structure and findings. Dataquest concluded that the underlying thread that ran through this year's survey was that the availability of key components pervaded all areas of procurement.

- **Strategic Implications of Living in a DRAM Technology–Dependent World** (1989–12)—At Dataquest's recent Semiconductor User and Applications Group Conference, users and suppliers of cutting–edge semiconductors such as DRAMs and ASICs expressed deep concern about industry survival, given the challenge of technology dependence. This newsletter focuses on the serious strategic implications for systems manufacturers and chip suppliers in a technology–dependent world. Dataquest concludes that suppliers should make the necessary capital expenditure and strategic plans for their companies to survive profitably over the long term by dependably meeting user demand for cutting–edge semiconductors such as DRAMs and ASICs.

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Research Newsletter

SUIS Code: Newsletters 1989: January–March
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STRATEGIC IMPLICATIONS OF LIVING IN A DRAM TECHNOLOGY-DEPENDENT WORLD

SUMMARY

At Dataquest's recent Semiconductor User and Applications Group Conference, users and suppliers of cutting-edge semiconductors such as DRAMs and ASICs expressed deep concern about industry survival, given the challenge of technology dependence. As shown in Figure 1, long-term demand for DRAMs should remain competitive, with personal computer manufacturers expected to use 56.5 percent of the worldwide DRAM production during 1990. This newsletter focuses on the serious strategic implications for systems manufacturers and chip suppliers in a technology-dependent world.

IMPLICATIONS OF TECHNOLOGY DEPENDENCE FOR SYSTEMS MANUFACTURERS

Technology dependence is defined here as a state of reliance on other suppliers for leading-edge DRAMs, ASICs, and other related product technologies. For semiconductor users, the central issue surrounding technology dependence concerns the number and dependability of suppliers of critical components. Users are concerned about whether there is a single source or multiple sources, whether the source is located locally or overseas, and if a single source, if that source operates multiple worldwide fabs that provide the same advanced manufacturing process and quality standards for a required component. For semiconductor suppliers, the issue of concern is the source of the intellectual property (or technology process) needed to make the chip.

As shown recently, systems manufacturers' technology dependence periodically translates into critical spot shortages of cutting-edge semiconductors as well as higher average selling prices (ASPs) for these devices as compared with worldwide systems competitors. Spot shortages and higher ASPs mean a loss of revenue and profits for systems manufacturers. More precisely, spot shortages cut system unit sales immediately and narrow or kill the window of opportunity for planned new systems. Similarly, higher chip ASPs increase systems' cost of goods sold, reducing profit margins and/or pricing competitiveness.

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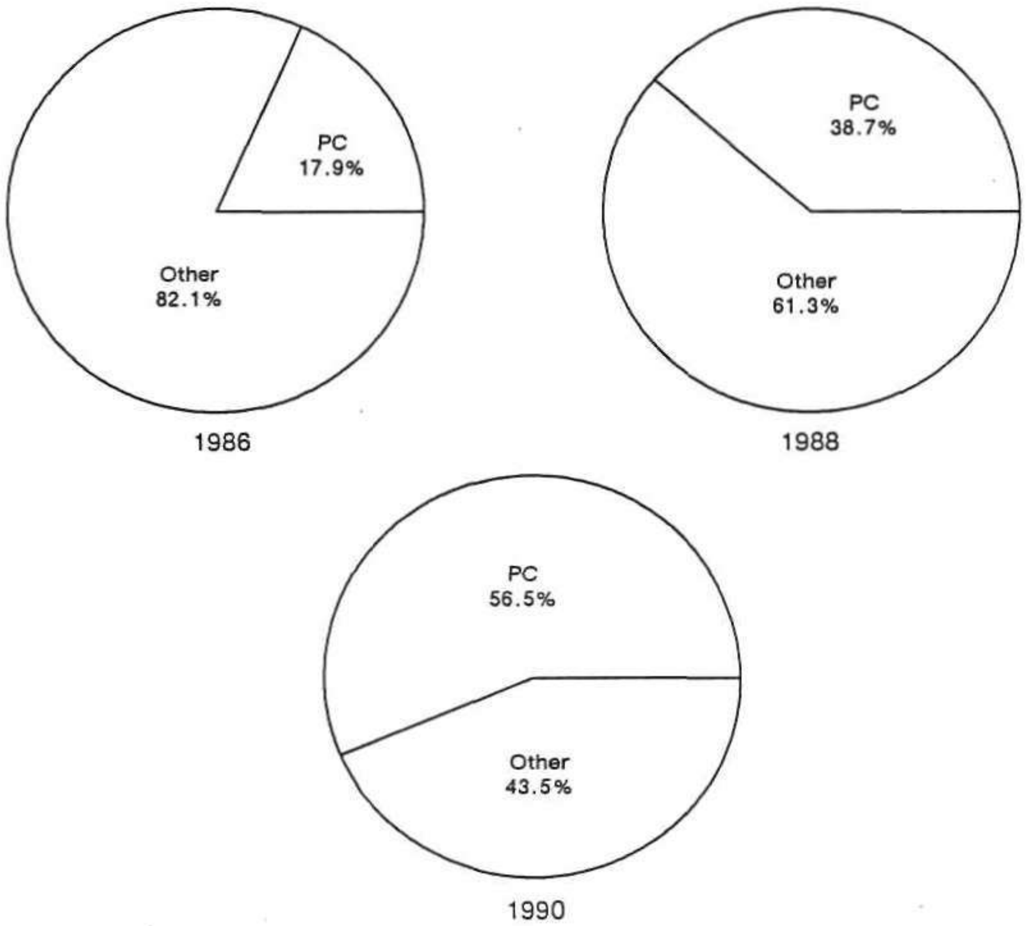
Figure 1

Estimated PC DRAM Consumption as a Percentage of Worldwide DRAM Production



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Source: Dataquest
March 1989

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THE LONG-TERM DRAM PROCUREMENT CHALLENGE

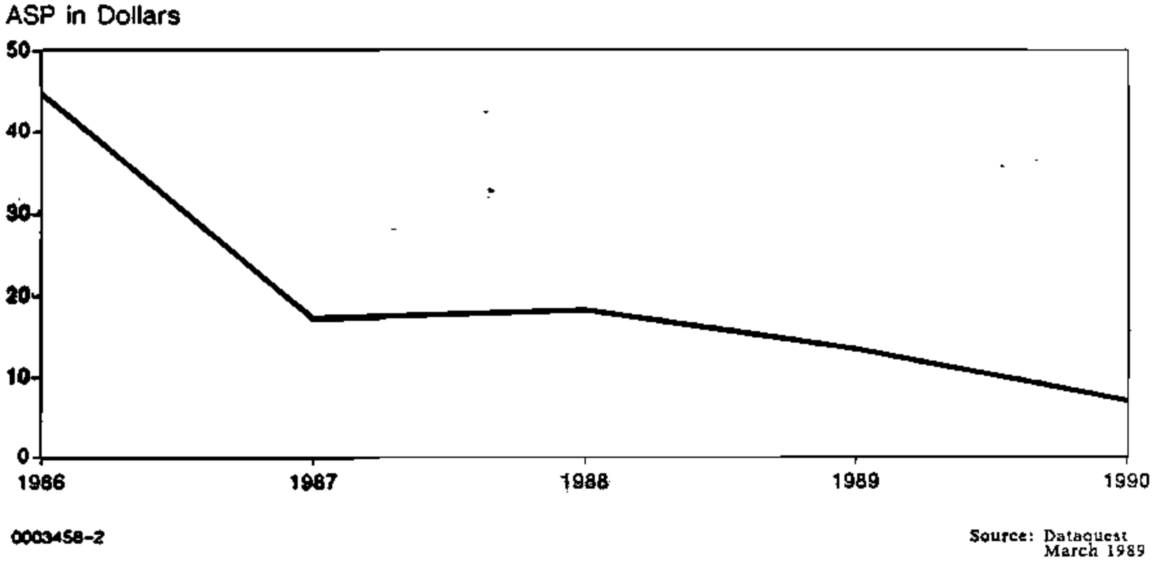
During our conference, users verbally conveyed the message that the procurement of DRAMs (especially specialty DRAMs) ranks as the number one procurement issue of 1989 and beyond.

DRAMs serve as prime examples of technology dependence for worldwide users of semiconductors. North American, European, and Rest of World DRAM users are dependent largely on Japanese suppliers for the DRAM product. During 1988, DRAM technology dependence translated into price disadvantages for North American and European buyers of DRAM vis-à-vis Japanese users.

There is some good news for users of 1Mb DRAMs this year, as shown in Figure 2.

Figure 2

Estimated North American 1Mb DRAM ASPs (100,000 Units)



Source: Dataquest March 1989

This figure shows a consistent long-term decline in the price for 1Mb DRAMs. The ramp in supply of 1Mb DRAMs should be balanced by demand by early third quarter. Even so, the dynamics of DRAM supply-demand remain quite complicated. In terms of the technology dependence issue, during 1989, North American, European, and Rest of World DRAM users can expect to pay premiums of 18 to 21 percent over Japanese pricing.

In addition, users at the conference consistently expressed dismay that the current ramp in 1Mb DRAM supply misses users' needs and will continue to do so for the foreseeable future.

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Unsatisfied DRAM Demand

From these users' perspectives, there will be plenty of 1Mb DRAMs for users at a declining price over the long term—but only regarding the 1Mbx1 device in plastic DIP with an access time of 100ns or greater. For many users, a crying need exists for supply-limited 1Mb DRAMs that operate at 80ns or less, and/or in the 256Kx4 configuration, and/or in a surface-mount SOJ package, as well as specialty products like video RAMs.

For current and prospective DRAM suppliers, production of these devices offers a significant profit opportunity. Premiums for faster speed, surface-mount packaging, and more complex configurations typically run in the range of 10 to 20 percent over the commodity-type counterpart, and as much as 40 to 60 percent during times of spot shortages, as now occurs with the 256Kx4 devices.

The Impact of the DRAM Crunch on the Supply of Other Semiconductors

Life in a DRAM-hungry world also means spot shortages and erratic pricing for other key semiconductor products. The DRAM-related impact on semiconductor supply and pricing is as follows:

- Slow SRAMs—direct and great
- High-speed MPUs—indirect but noticeable
- Fast SRAMs—little and unnoticeable

Users of slow SRAMs (especially the 8Kx8 devices) have experienced a supply crunch for the past year to year-and-a-half. The continuing shortage stems directly from events in the DRAM arena and clearly illustrates the pitfalls of technology dependence of North America and Europe on Japanese technology. From a strategic position, memory suppliers view slow SRAMs as "fab-fillers." During business slowdown periods, these suppliers increase output of slow SRAMs in order to keep their fabs moving, but cut slow SRAM supply (and increase output of DRAMs) when the more lucrative DRAM products are in strong demand. Dataquest expects some relief for users of 8Kx8 and 32Kx8 slow SRAMs by the third quarter of this year; however, the supply of slow SRAMs will remain a long-term function of events in the DRAM world.

For users of high-speed microprocessor components (MPCs), the DRAM supply constraint had an indirect but noticeable impact on their system production and profit targets during 1988. MPCs and DRAMs do not compete for fab space, but shortages of 256K and 1Mb DRAMs (as well as specialty devices now) resulted in system delivery delays, lost unit sales, and higher system prices. The DRAM specter has not disappeared.

MPCs provide another illustration of the disadvantages associated with technology dependence. In this case, Japanese users of high-speed 16- and 32-bit microprocessors pay consistently higher ASPs than North American and European buyers. The explanation is that Japan has traditionally been dependent on North America for microprocessor technology. Even so, Japan is making a determined effort through The Real-time Operating Nucleus (TRON) project to break free from North American technology dependence.

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Fast SRAMs provide another example in which North American users (and to a lesser extent, Europeans) enjoy a price advantage over Japanese users. Because the fast SRAM business is a performance-driven marketplace, suppliers of fast SRAMs enjoy many opportunities for product differentiation and thus higher ASPs and profit margins. Because fast SRAMs can be more lucrative than DRAMs, fast SRAM supply is little affected by the DRAM crunch.

In terms of technology dependence and fast SRAM supply/pricing, the many profitable niches in the fast SRAM arena have drawn many suppliers, ranging from start-ups to major North American, Japanese, and European houses, to the North American region. By contrast, Japanese users are largely dependent on large Japan-based suppliers. The competitive fast SRAM environment in North America translates into a price advantage for North American users versus Japanese or European buyers.

TECHNOLOGY DEPENDENCE IN THE FUTURE: ASICs VERSUS DRAMs

For semiconductor manufacturers, memory production has served and continues to serve as the supplier's manufacturing process "technology driver." During the conference speech entitled "ASICs and the Graveyard of Overriding Considerations," Andrew M. Prophet discussed factors that indicate that there may be a parting of the ways in terms of any given semiconductor supplier's process technology into two separate streams--the familiar DRAM stream and the less familiar ASIC stream.

ASIC Technology Dependence

The key point for semiconductor users and suppliers is that a new form of technology dependence--ASIC technology dependence--could emerge. ASIC technology reliance will become an issue in applications that center on lower quantities, faster turnaround, and rapid yield. By contrast, DRAM technology dependence should remain a concern in applications that entail larger volumes, cyclical yield improvements, and cell design optimization.

1989 ASIC Pricing Trends

The long-term scenario of ASIC technology dependence becomes an immediate issue because right now ASIC suppliers, particularly suppliers of 1.5- to 2.0-micron CMOS gate arrays, cell-based ICs (CBICs), and programmable logic devices (PLDs), are waging a fierce pricing battle for ASIC design wins that go into system production during the 1990 to 1992 time frame.

During 1989, all ASIC solutions are declining in price, except for 3.0-micron gate arrays which are being phased out. Most important, gate arrays continue to hold a price advantage over CBICs in terms of price per gate and nonrecurring engineering (NRE) costs, but that edge is narrowing.

For users, total system cost-saving analysis requires users to closely weigh the long-term benefits of using 1.5- to 2.0-micron CMOS CBICs (in larger gate-count applications) versus 1.5- to 2.0-micron CMOS gate arrays. Similarly, CMOS PLDs should be examined for use in systems to be produced in low-unit volumes (approximately 2,000 systems or less) because the avoidance of gate array NRE costs achieved through the use of PLDs typically translates into lower total system cost.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

After careful consideration of this technology-dependent world, we recommend the following to users and suppliers.

For users to minimize the loss of revenue, profits, and overall systems competitiveness associated with technology dependence, systems manufacturers must do the following:

- Seek multiple sources of cutting-edge products like DRAMs, high-speed microprocessors, and ASICs. Ideally, establish both local and overseas sources for these devices.

- Regarding commodity-type products like standard logic, mature 8-bit MPCs, and nonexotic analog ICs, continue to narrow the supplier base. If there is only a sole source to supply your system's critical component, demand that the sole source maintain multiple worldwide fabs for the cutting-edge device, with each fab using an identical technology process, line geometries, and quality standards.

- Given the impending divergence in the semiconductor process technology stream into a DRAM stream and an ASIC stream and in view of your system's total semiconductor needs, search out suppliers on a local and worldwide basis whose fabs can produce both DRAMs and ASICs, including CMOS gate arrays and/or CBICs.

Suppliers should make the necessary capital expenditures and strategic plans so that their firms can profitably survive over the long term by dependably meeting user demand for the cutting-edge semiconductors like DRAMs and ASICs. Profitable opportunities include serving the following:

- North American and European users with DRAMs, especially noncommodity type, and commodity-grade slow SRAMs

- Japanese users with high-speed microprocessors, although the advance of Japan's TRON project will close that window of opportunity to late entrants in the Japanese market and also standard logic, ASICs, and analog ICs.

Ronald Bohn

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Research Newsletter

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FOURTH ANNUAL PROCUREMENT SURVEY: OLD ISSUES REMAIN HOT; ACCURATE FORECASTING IS THE KEY

SUMMARY

The fourth annual Dataquest procurement survey results were announced at the Semiconductor User and Applications Conference that was held in San Francisco, California, in late February. The top three issues of availability, pricing, and on-time delivery remained unchanged from last year's survey because of 1988's severe memory shortage. As a direct result of this memory shortage, U.S. semiconductor suppliers lost 20 percent of the business of respondent companies to the hands of Japanese suppliers.

Supplier of the Year

The procurement survey was used as a vehicle to allow users to vote for the Semiconductor Supplier of the Year. Suppliers were rated on the following five criteria:

- Quality
- On-time delivery
- Price
- Technical support
- Overall customer service

Based on input from 300 purchasing managers, Motorola Inc. was presented with the First Annual Semiconductor Supplier of the Year Award at the conference dinner.

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Offshore Production

Offshore production by system companies has peaked since most of all planned offshore production facilities have now been completed. Eighty-eight percent of those that have offshore production do not plan on bringing their offshore production back home. A regionally balanced production base now appears to be in place.

Purchasing Growth

Semiconductor users have been conservative regarding semiconductor purchasing growth for the past two years. In our last survey, users projected growth for the year at 13.3 percent; the actual growth totaled 24.7 percent. This year, the users project semiconductor purchasing growth to be 17.8 percent. Users are being fairly aggressive with their projections; this is in part due to last year's memory shortage that left many in the lurch combined with some pent-up system demand carryover. Dataquest forecasts that North American semiconductor consumption will grow by 8.4 percent this year due to an anticipated second-half slowdown in electronics semiconductor demand.

SURVEY STRUCTURE

As we have done for the past three years, Dataquest's Semiconductor User and Applications Group gathers procurement information regarding major customers and markets for semiconductor manufacturers and users. Semiconductor users utilize this information to check their status against the market, and semiconductor manufacturers glean information about their customer base.

The respondents to this year's survey came from the Electronic Business 200 (EB 200). The overall response rate of 36 percent of the 841 purchasing sites (48 percent response of the top 400 sites) indicates that buyers expect to increase their 1989 semiconductor purchases by close to 18 percent.

In order to ensure that the companies we questioned used semiconductors, we selected from the original 200 companies system companies that were not component, software, or component distribution firms. This resulted in a sample of 168 companies (EB 168). We then surveyed by telephone each of the 841 procurement sites of these 168 companies. The interviews were conducted with buyers, purchasing managers, or those involved with material or corporate contract management. The EB 200 represents $299 billion in electronics revenue. Our sample, the EB 168, represents 63 percent of North American semiconductor consumption. Figure 1 illustrates the geographic locations of these major customers.

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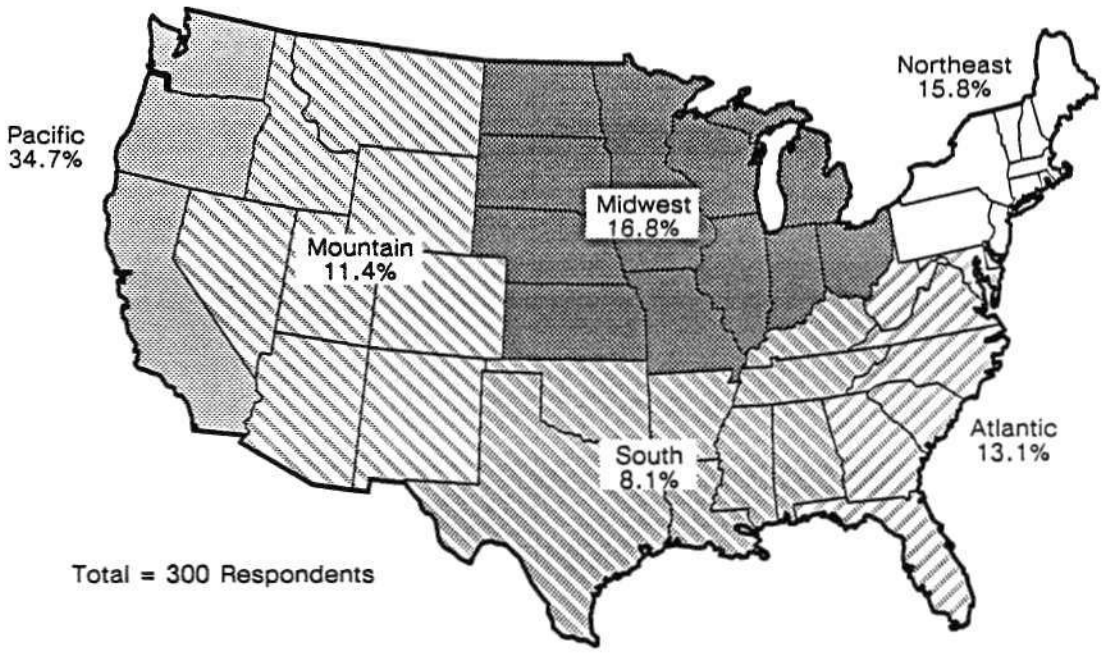
Figure 1

Procurement Survey Respondents' Geographic Locations



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Source: Dataquest
March 1989

The respondents to the survey closely match the overall industry distribution of the EB 168, as seen in Figure 2. All but two industry segments were within 2 percent of the overall EB 168 distribution (industrial, a negative 8.1 percent and military, 6.1 percent). The higher-than-actual military response minimally affected the survey, with the exception of inventories and ASIC nonuser responses, which were slightly higher as a result.

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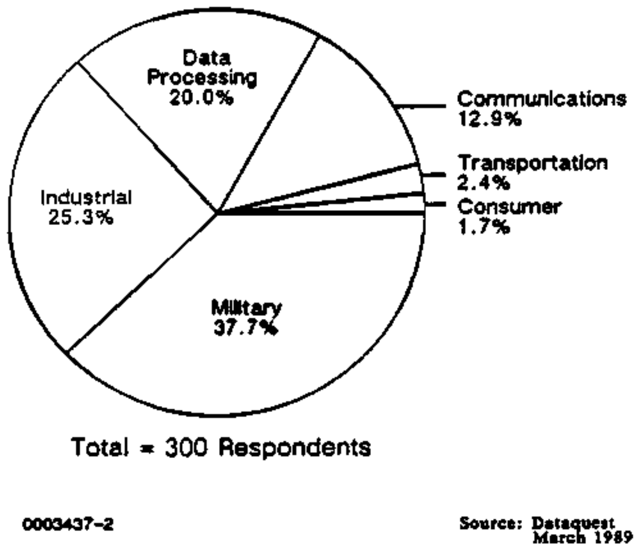
Figure 2

Survey Respondents by Major Line of Business



SURVEY FINDINGS

Regional Sourcing Trends

This year's respondents purchased 20.0 percent fewer semiconductors from U.S. suppliers (60.5 percent, down from 80.5 percent), while the Japanese doubled their market share (34.5 percent, up from 17.1 percent). Regional sourcing was the telltale response that clearly illustrated what last year's memory shortage did to the electronics industry. (We defined the regional base of semiconductors as the semiconductor company's country of origin.) This type of large loss of market share by one group of suppliers (in this case, U.S. suppliers) points out the dangers of having a regionally unbalanced supply of key components.

As an example of this imbalance, the data processing respondents who use a higher percentage of memory now buy nearly equal amounts of their semiconductors from U.S. and Japanese suppliers, as shown by Figure 3. This situation represents a drop for U.S. suppliers from 63.0 percent of the market to 47.3 percent and a corresponding rise for Japanese suppliers from 34.5 percent to 46.7 percent. Within the United States, distributors gained market share last year (14.6 percent versus 12.2 percent) as a result of the pervasive memory shortage that forced many buyers to source from distribution once their OEM contracts were exhausted. An interesting point is that European suppliers gained market share, rising from 1.1 percent to 4.6 percent, while Pacific Rim vendors maintained a 1.4 percent share.

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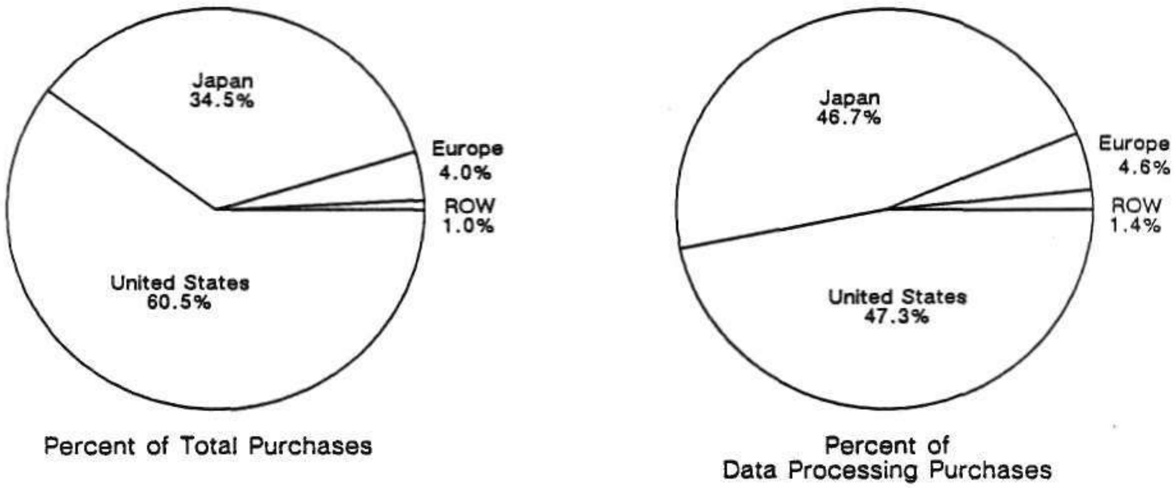
Figure 3

Regional Supplier Base



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Source: Dataquest
March 1989

ASIC Usage Trends

ASICs continue to be used as a design solution, while component counts per system and power consumption decline. More than one-half (56 percent) of the respondents now use ASICs. Of the 44 percent not now using ASICs, 23 percent plan to use them this year, 40 percent will not use ASICs, and 37 percent do not know their ASIC plans. The types of ASICs that will be bought by those that use or plan to use ASICs in 1989 are shown in Figure 4. The 37 percent of nonusers that are undecided about this technology present both an opportunity and a potential stumbling block as ASICs vendors try to remove the mystique that continues to surround this technology for some users.

The industry breakdown of the 44 percent of ASIC nonusers is shown in Table 1. The higher-than-average military segment and lower-than-average industrial responses have affected this breakdown somewhat. Another reason that the military use of ASICs is low is the long life cycles of typical military systems and the relatively short life cycle of an ASIC technology. With ASICs, the typical 10 to 20 year life cycle of a military system could go through as many as three costly technology/redesign iterations.

The trend to shift production offshore has peaked (see Table 2). For 1989, 80.0 percent of the respondents say that they do not plan to move production offshore at all. Of those that have offshore facilities, 87.7 percent do not plan to bring production back to the United States. The reason given for not changing the status quo is that all plans for offshore production are now completed. Because the major proportion of production cost is no longer labor but material, it appears that the worldwide regional production base is now becoming balanced.

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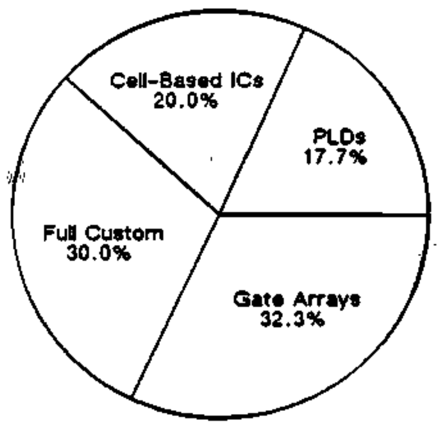
Figure 4

Type of ASICs Planned for in 1989



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Source: Dataquest
March 1989

Table 1

Profiles of ASIC Nonusers
Percent of Total

	1986	1987	1988
Data Processing	18%	13%	13%
Communications	11	15	11
Industrial	49	55	35
Consumer	6	2	2
Military	14	15	35
Transportation	2	0	4
Total	100%	100%	100%

Source: Dataquest
March 1989

Table 2

Anticipated Shift to Offshore Production

	1986	1987	1988	1989
A Great Deal	8.4%	10.1%	3.3%	2.7%
Some	35.9%	33.2%	34.0%	17.3%
Not at All	55.7%	56.7%	62.7%	80.0%

Source: Dataquest
March 1989

Offshore purchasing of semiconductors has also peaked with 14.9 percent of all respondents' buying coming from offshore sites compared with 14.2 percent from last year's survey. This response correlates with the production plans of companies that have now expanded operations offshore and are also increasing their purchases of foreign parts onshore.

Inventory Trends

The ongoing trend to reduce inventories is growing as semiconductor users strive to cut overhead costs and improve quality. The vendor reduction programs that have been put in place over the past years are now bearing fruit as inventory levels continue to decline. The average inventory level from the respondents for 1988 was 36.5 days. Only 37.0 percent of the respondents were at targeted inventory levels, 46.0 percent surveyed were over the target levels by an average of 22.5 percent, and 17.0 percent were under target by an average of 16.0 percent. The fact that 63.0 percent of the respondents were missing their inventory goals points out the need for improved forecasting and communications between buyers and sellers. Improvement in inventory control is being planned by 45.0 percent of the respondents who plan on reducing their inventory levels. This is the highest percentage recorded for those planning to lower inventories since we started taking this survey. The improved buyer-supplier communications environment was cited as the main reason buyers felt comfortable with lowering their inventory levels.

Major Issues

Every year we ask users what the most vexing problems are that they expect to face in the coming year. Table 3 shows the historical and future issues that procurement managers have faced and expect to face. Pricing, quality, on-time delivery, and availability changed positions but remained the top four issues in 1986 and 1987, while availability, pricing, and on-time delivery remain unchanged in the top three positions for 1988 and 1989. The scramble to acquire DRAMs and SRAMs last year kept availability, in large part, the key issue foreseen in 1989. Pricing and delivery remain key issues even in the current seller's market.

Table 3

Major Procurement Issues

1987		1986
1	Pricing	1
2	Availability/Lead Times	
3	Quality/Reliability	2
4	On-Time Delivery	3
5	FMVs/Trade Agreement	-
6	Cost Control	-
7	JIT/Inventory Control	5
8	Surface Mount	-
9	New Products/Obsolescence	-
10	ASICs	-
11	Offshore Manufacturing and Procurement	-
-	Reducing Vendor Base	6
-	Product Obsolescence	7
-	Second-Sourcing	8
-	Forecasting	9
-	Supply/Availability/Shortages	4

1989		1988
1	Availability	1
2	Pricing	2
3	On-Time Delivery	3
4	Quality/reliability	6
5	Memories	5
6	JIT/Inventory Control	9
7	Cost Control	4
8	New Products/Obsolescence	8
9	Surface-Mount Technology	-
10	Second-Sourcing	-
-	Reducing Vendor Base	7
-	Fluctuating Yen/Currency Exchange	10

Source: Dataquest
March 1989

What has changed is the higher focus on quality as buyers are passing on to their suppliers the market's demand for ever higher quality. The higher ranking of quality reflects this emphasis to meet customer demand, and also indicates some dissatisfaction with suppliers that fail to keep pace with quality improvement. Inventory control/JIT also has risen as a concern as companies continue to work at squeezing out all excess costs. Two new issues reemerging into the top ten are surface mount technology (SMT) and second sourcing. The prevalence and increased technical support needed by SMT has made this package technology again an issue. Second sourcing again is an issue again primarily because of the memory shortages experienced last year that left many buyers high and dry, searching for parts.

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DATAQUEST CONCLUSIONS

The underlying thread that ran through this year's survey was that the availability of key components pervaded all areas of procurement. The following were all affected by last year's shortages:

- Pricing
- Delivery
- Forecasting
- Second sourcing

Companies that coped best through last year's supply difficulties were those that had in place good working relationships with their suppliers and informed the suppliers as soon as possible of any foreseen change in component need. Although not the whole solution, close communication between buyer and seller is much better than little or no communication.

Many of today's leading-edge technology companies are continuing to integrate the following:

- Design
- Purchasing
- Manufacturing

Good internal communications are a prerequisite to good external communications. The strong outlook in semiconductor purchases foreseen by this year's respondents may be an instinctive reaction to prevent last year's memory scramble. The combination of expected availability problems and high purchase rates points out the need for an improvement in forecasting that can only come from improved communication.

The current three key issues of availability, price, and on-time delivery all focus on how well a company copes with the uncertainties of the volatile electronics market. Accurate forecasting of both increases and decreases is the key that top companies use to remain competitive and maintain leadership in their fields.

Mark Giudici

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Research Newsletter

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0003410

THE ANALOG IC MARKET: A BAROMETER FOR THE SEMICONDUCTOR INDUSTRY

SUMMARY

It is well known that the analog IC market neither grows as fast nor suffers the same severe downturns as the digital market. Less well known is that the difference in growth rates between the total monolithic IC market and the analog market 1) is periodic and tracks the IC industry ups and downs, and 2) has provided a leading indicator for every downturn over the past 16 years.

Over the past 16 years, most IC market forecasts have predicted the decline of the analog segment of the semiconductor market. In reality, the analog IC market not only has kept pace with the semiconductor market in general, but it has offered a stable benchmark by which the state of the IC industry can be measured.

This newsletter provides a new look at analog IC market growth and how it relates to the total market.

THE ANALOG BENCHMARK

The line graph in Figure 1 shows both total monolithic IC consumption and analog IC consumption over the past 16 years. The curves are similar in shape, differing mainly in magnitude, which suggests that the analog market tracks the total IC market. By using the World Semiconductor Trade Statistics (WSTS) data shown in Figure 1, a bar chart can be constructed (see Figure 2) that shows monolithic analog IC sales as a percentage of the total monolithic IC sales. The important point shown by this bar chart is that analog sales have consistently remained at about 20 percent of the total monolithic IC market. This is a surprising result because, despite significant changes in both analog and digital products, the analog proportion of 20 percent has remained virtually unchanged over the 16-year period. Using the fact that the analog portion of the market has remained at approximately one-fifth of total sales suggests that the consumption curve of Figure 1 can be redrawn, multiplying analog sales five times for comparison. This has been done in Figure 3.

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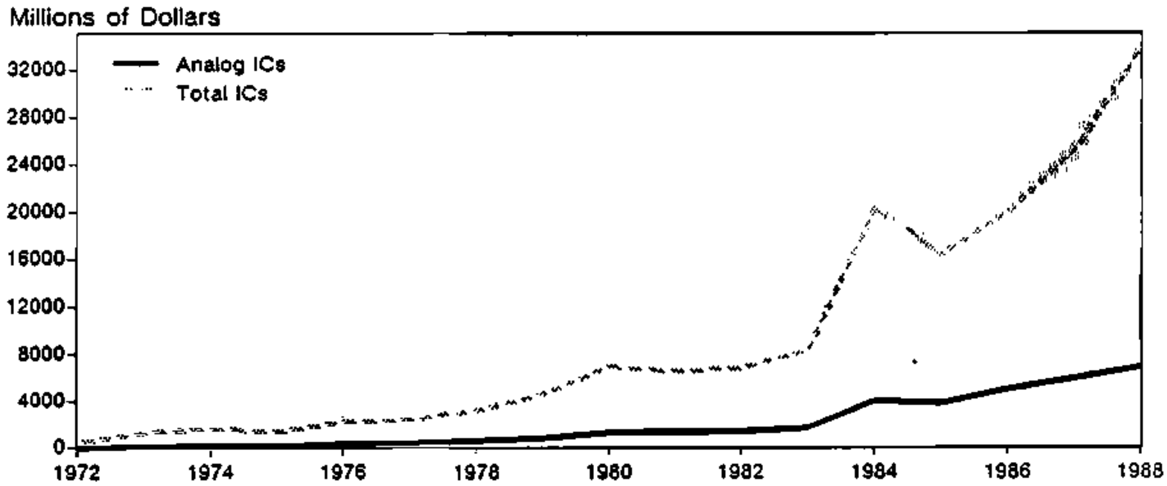
Figure 1

Analog IC Sales versus Total Monolithic IC Sales



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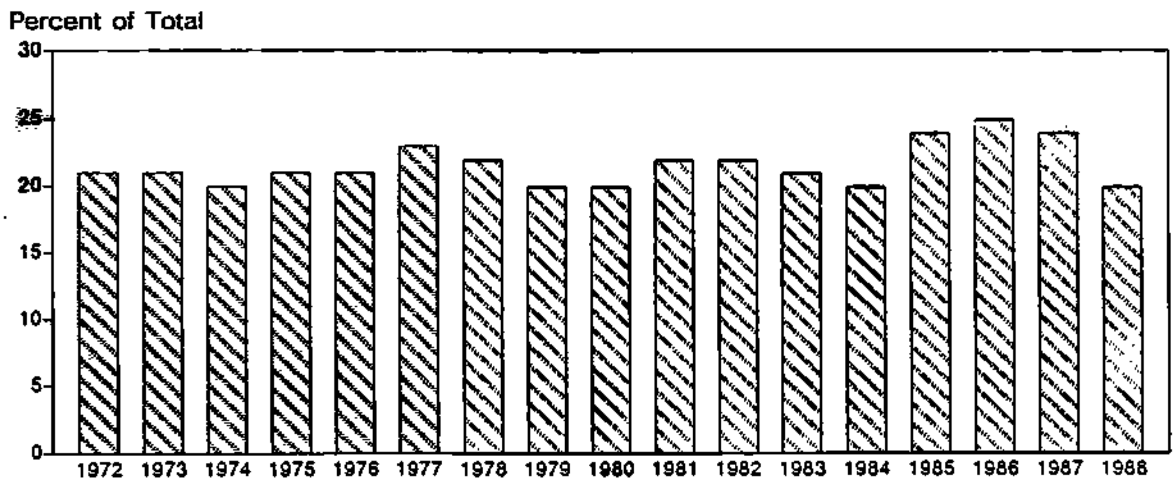
Source: Dataquest
March 1989

Figure 2

Analog IC Sales As a Percentage of Total Monolithic ICs



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Source: Dataquest
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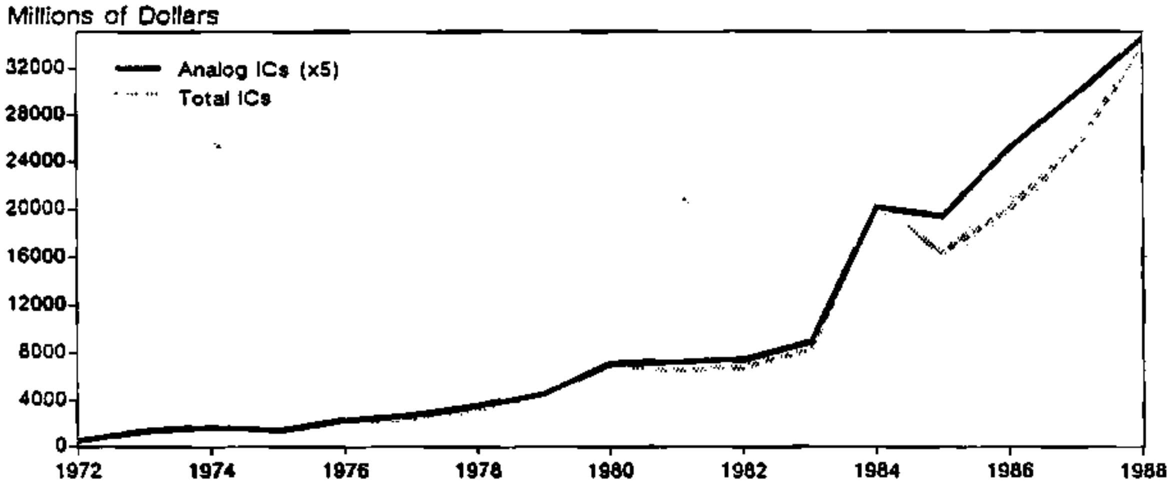
Figure 3

Total IC Sales versus Five Times Analog Sales



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Source: Dataquest March 1989

Figure 3 shows how closely the analog market tracks the total IC market. The analog curve is not only similar in shape, but it is a smoother curve that more closely defines the long-term market trends. These curves diverge greatly at two important periods—strong growth (boom) periods and weak market (bust) periods.

Please note that Figures 1, 2, and 3 use WSTS data to isolate monolithic ICs. This WSTS data represents only the reported sales of SIA participants, so the year-to-year growth rates can be distorted. Japanese companies joined this trade association in 1984, which is why the growth is so large in this year (although it was an exceptional year). WSTS data are used to establish the relationship of analog to total ICs in monolithic form only and not for absolute numbers or growth rates.

Taking sales data and plotting it as growth rates over 16 years, as illustrated in Figure 4, shows these growth characteristics more graphically. While it is well understood that the analog market shows smaller growth rates and declines than the total market, the less obvious long-term result of this pattern is that the analog market growth during the bust period compensates for the lower growth during the boom period. This is why analog IC sales remain at a nearly constant 20 percent of total IC sales.

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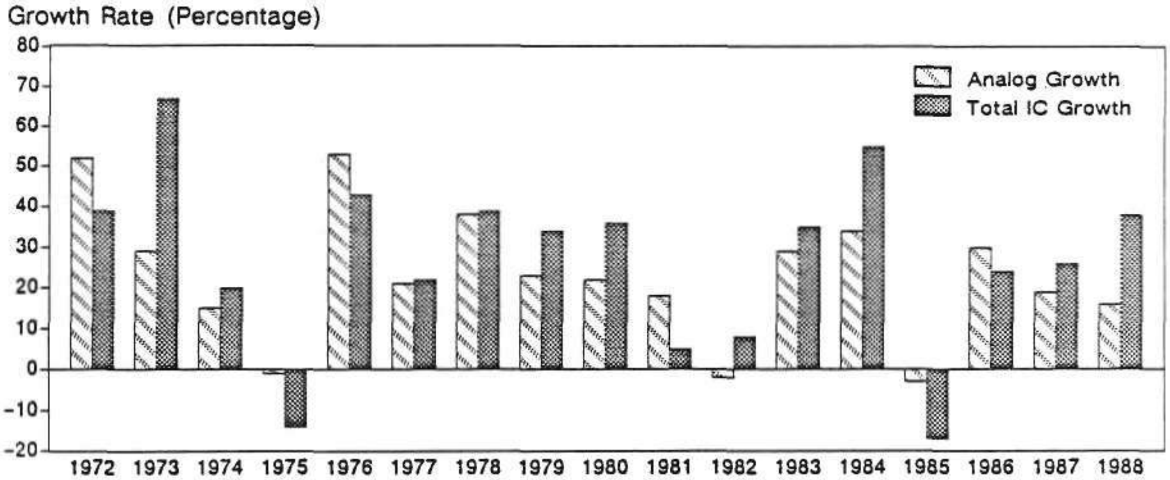
Figure 4

Growth Rate Comparison
(Total ICs versus Analog ICs)



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GROWTH RATES COMPARED

The fact that analog IC growth lags the total growth in periods of strong growth and leads in periods of slow (or negative) growth suggests a periodic nature to these comparative growth rates. By plotting the total IC sales growth minus the analog growth by year over the same 16 years, the periodic nature of their relative growth is dramatically illustrated (Figure 5). This graph defines normal boom periods as being above the zero axis and bust periods as being below. The slow markets of 1975, 1981, and 1985 are clearly defined, as are the strong years of 1973, 1979, and 1984.

This graph may lead to the conclusion that an industry downturn can be predicted when the total-to-analog growth rates get too far apart. An analog lag of more than 10 percent seems to signal an approaching downturn as it did in 1974, 1980, and 1984 (and again in 1988).

Note that Figures 4 and 5 are derived from Dataquest information that includes worldwide data but does not identify monolithic ICs separately from total ICs. These curves are essentially the same as those derived from the WSTS data used in Figures 1 through 3 but are used to prevent concern about the growth rate distortions that could result from the WSTS data.

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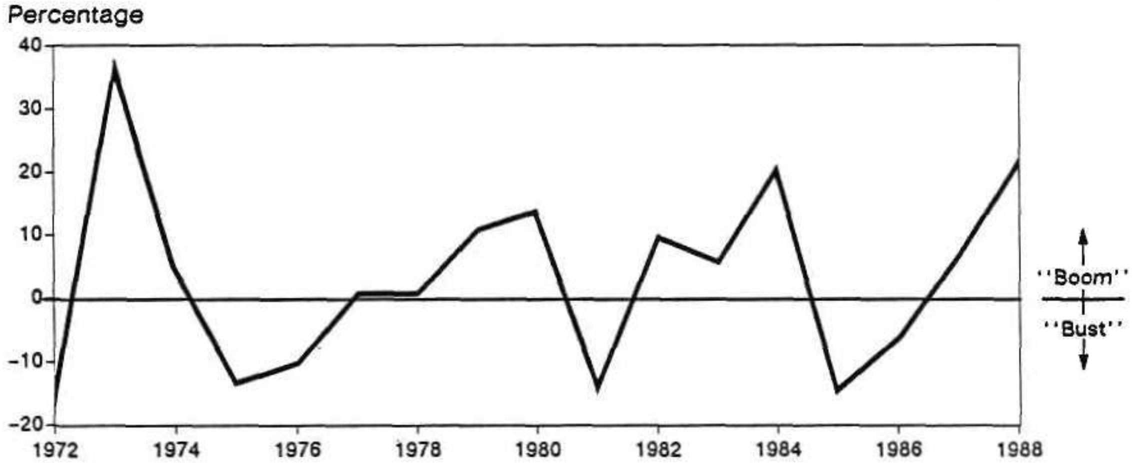
Figure 5

Growth Rate Difference by Year
(Total IC Growth Minus Analog IC Growth)



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How can the different growth rates forecast a change? By showing when the total IC market is growing faster than the analog market, the graph defines a period of an imbalance in market demand (a boom period) and the following adjustment (a downturn). Analog components do not exist in a vacuum. They provide interface, conversion, and signal-processing functions found in all electronic equipment. Even products considered to be digital can contain analog ICs in the power supply and output functions. Any product handling electronic signals such as audio, radio, TV, and telephone equipment must have analog ICs. In addition to this broad market application, analog ICs have shorter lead times, less pricing volatility, many suppliers, and few high-demand glamour circuits.

In an ideal IC market, one in which supply equals demand, prices remain relatively constant, and end-product markets have little variability, both the total and analog growth curves should track. However, distorted buying patterns caused by chip shortages, long lead times, and "hot" electronic products can lead to the total-to-analog growth rate difference shown in Figure 5. Past occurrences of this large growth rate difference have led industry observers to conclude that the analog IC market was declining. In fact, as we have seen, the large difference in growth rates was not signaling the decline of analog as much as it was indicating a forthcoming market downturn.

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FORECAST

Dataquest has forecast a slowdown in the second half of 1989, using other forecasting techniques. The same conclusion may be drawn by interpreting the growth rate difference curve of Figure 5 as a leading industry indicator. The fundamental assumption for this interpretation is that analog will remain at a constant 20 percent of IC sales (as it has over the past 16 years). This leads to the conclusion that the average value of the difference curve of Figure 5 must remain constant (at zero) over time. When a demand difference as large as we saw in 1988 occurs, a correction (total industry slowdown) can be expected within the next one to two years to maintain this zero value.

DATAQUEST CONCLUSIONS

The movement of the analog IC market should be of interest to more than the suppliers and users of analog ICs. Analog IC products are important to all areas of electronics. It is this broad functional utility that ties analog so significantly to the whole IC market. But it is the analog market's unique pattern of stability that makes it a suitable benchmark to measure the changes in the total IC market. While the periodic pattern that shows up in Figure 5 may not always remain a viable forecasting method, it does fit the past patterns of industry changes. The analysis of analog IC growth patterns can provide a useful leading indicator of the general health of the IC market.

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Mark Giudici
Gary Grandbois

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Research *Bulletin*

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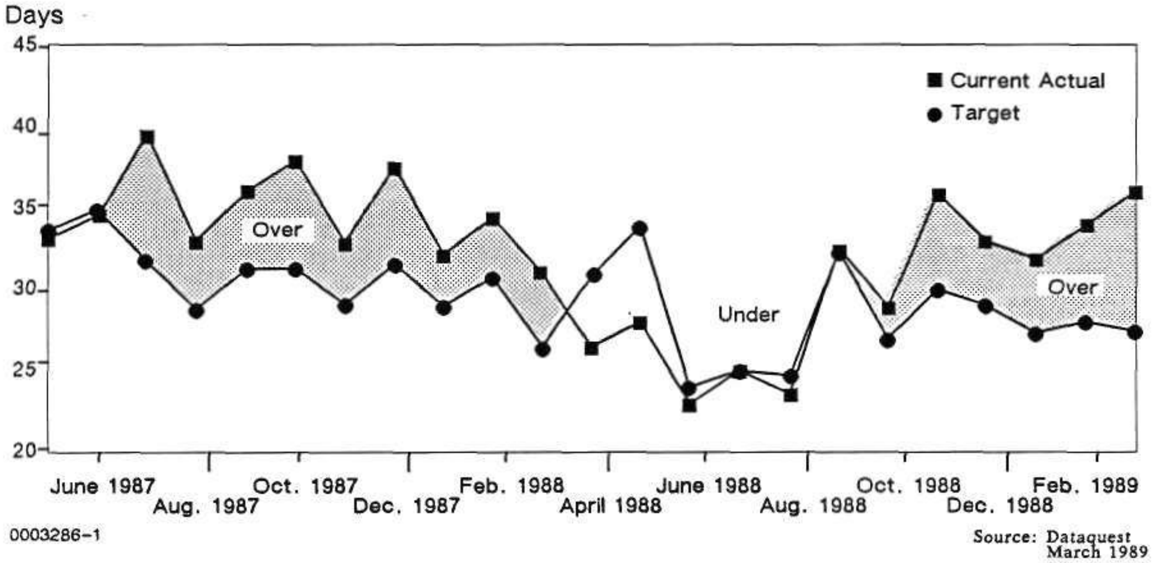
MARCH PROCUREMENT SURVEY: EQUIPMENT SALES UP, ORDERS AND LEAD TIMES DOWN

This month's respondents continued to see overall lead times fall as system sales climbed relative to last month. Bookings of semiconductors remained constant with last month's input, as reflected in the flat to slightly higher inventory levels seen. Total OEM inventory targets remained flat at 27.4 days, while actual inventories rose to 36.1 days; this was higher than last month's figure of 33.9 days (see Figure 1). Although order levels were lower than last month, actual inventories grew at a faster pace. It is possible that next month's semiconductor order rate may also decline as buyers struggle to meet inventory targets.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0003286-1

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March 1989

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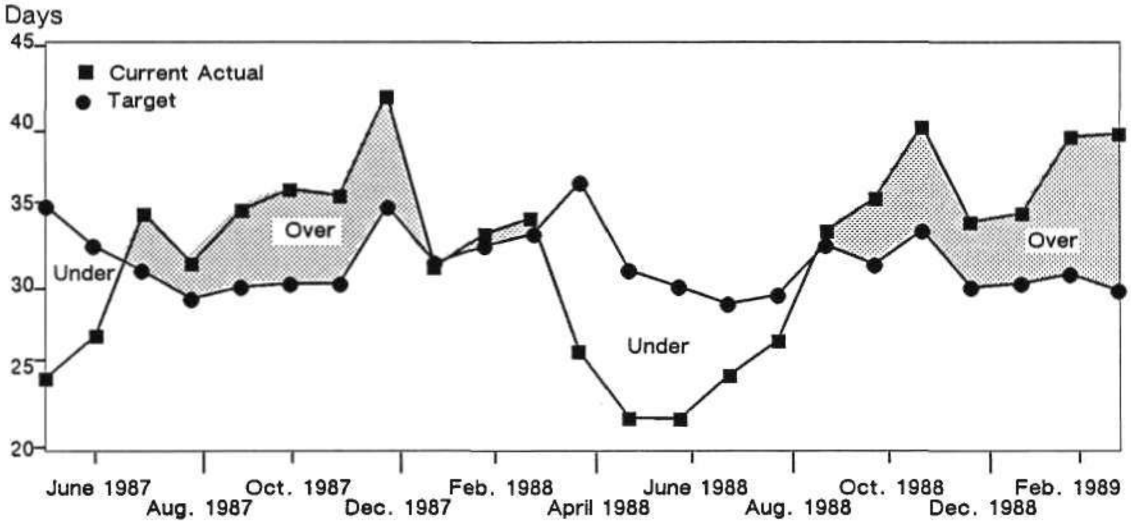
The target inventory level of the computer OEM respondents declined by a day to 29.8 days, while the actual level remained at a flat 39.4 days (see Figure 2). The result is an increase in the difference between actual and targeted inventories. This gap continues to highlight how increased availability of 1Mb DRAMs is affecting the juggling act now going on in semiconductor procurement.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



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Source: Dataquest
March 1989

Overall pricing continues to decline gradually in the wake of slower bookings and simultaneous increases in supply. Although allocations still exist for video RAMs, some slow SRAMs, 256K DRAMs, and x4-type DRAMs, the overall availability of product (i.e., standard logic, microprocessors in general, nonvolatile memory, and ASICs) is keeping lead times and prices in line. As availability improves, on-time delivery is becoming an issue; surface-mount packaging continues to be a problem for some users.

DATAQUEST ANALYSIS

As the current business cycle rolls on, the specter of semiconductor supplies overshooting aggregate demand is rearing its disruptive head. Accurate forecasting by system buyers combined with close communication between buyers and suppliers can improve the balancing act now under way. Even though system sales continue to grow at a fair clip, once the freight train of semiconductor supply picks up momentum (primarily based on last year's sales rate), the only guide beneficial to both users and suppliers is accuracy in forecasting.

Mark Giudici

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Research Bulletin

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CHIPS AND TECHNOLOGIES ENTERS THE MASS STORAGE CONTROLLER BUSINESS

Chips and Technologies' newly formed Mass Storage Organization announced its first drive controller chip set, the Micro Channel Fixed Disk Adapter CHIPSet, on February 21. Targeted toward OEM suppliers of PS/2-compatible computers, this chip set is capable of supporting ST506/412 (both MFM and RLL versions) and Enhanced Small Device Interface (ESDI) type drives using a single controller.

Consistent with Chips' general product strategy of combining high-level integration with an intelligent, systems-level architectural approach, the Disk Adapter CHIPSet will allow for a significant reduction in chip count, while imposing minimal architectural constraints upon system designers.

In entering this segment of the PC chip set market, Chips will not only be competing against established rivals Cirrus Logic and Western Digital, but also against former ally Adaptec. If successful, Chips is likely to become, by reputation as well as by market presence, a major player in setting future controller interface architectures as well.

Consisting of the 82C780 Micro Channel Hard Disk Controller and the 82C784 Data Separator, this new chip set represents the first step toward a complete line of chip set products aimed at integrating hard and floppy disk drives into AT-, PS/2-, and EISA-compatible personal computers that use AT and ST506/412 interfaces, the Small Computer Systems Interface, and the Enhanced Small Device Interface.

These chip sets will function as host adapters, controllers, and interfaces, not only in systems, but also in the embedded control portion of "smart" disk drives. This capability will expand Chips' current customer base of controller board houses, system houses, and OEMs to include drive manufacturers as well.

DATAQUEST ANALYSIS

Dataquest views this announcement as a broadening of product and market scope for Chips, rather than a radical departure in corporate strategy. While the move will broaden Chips' customer base within the PC and peripherals industries, the company's fate remains inextricably tied to the health of the PC industry.

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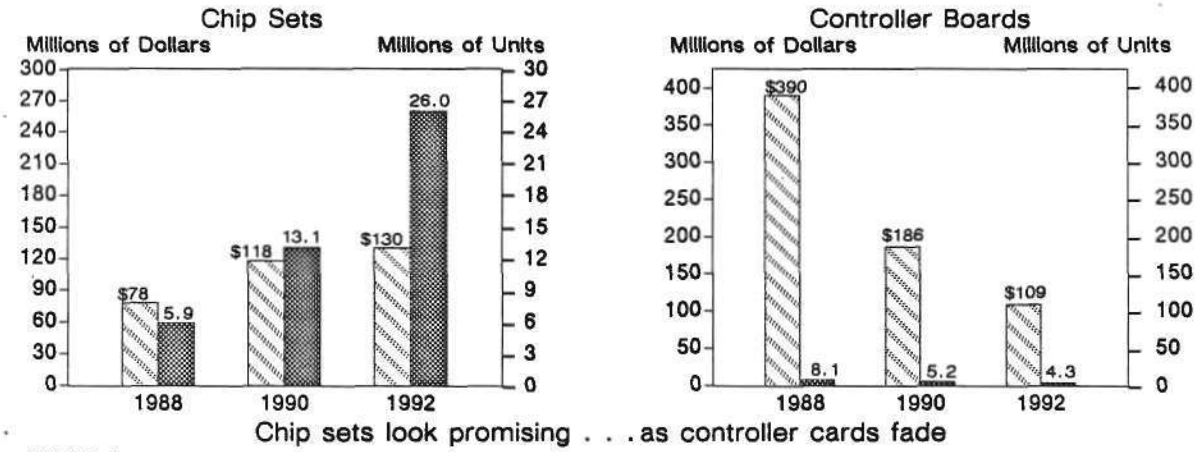
As it has in other markets, Chips can be expected to continue applying its strategy of offering system design flexibility through intelligent product architecture while lowering chip count, and therefore total system cost, through high-level integration. This may well serve as a wake-up call to those who still view peripheral control as a board-level industry and expect subsystem-level pricing and revenue.

Dataquest forecasts that by 1992, the percentage of hard drives qualifying as "smart" (i.e., containing embedded controllers and therefore not requiring controller cards) will grow from the present 42 percent to 85 percent. At the same time, we expect that the confusion surrounding the various versions of SCSI (a major roadblock in the transition of controller cards to chip sets) will soon be ironed out, accelerating the trend toward low-cost, standardized, chip set-implemented solutions. Figure 1 shows Dataquest's estimate of the controller chip set market and the controller board market through 1992.

Figure 1

Estimated Hard Drive Controller Markets



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As a pioneer in the chip set industry, Chips and Technologies has run up an impressive track record by being first out of the gate. By offering unique, systems-level solutions, Chips has enjoyed the luxury of sole-source pricing while offering a reduction in system cost. In this respect, it faces a new set of challenges in playing catch-up with both Cirrus Logic and Western Digital. Many of the advantages that Chips usually enjoys could evaporate in this new market. We look for Chips to establish credibility early and to attempt to establish premium pricing in order to protect the comfortable margins it has enjoyed to date.

While most observers view this card-to-chip-set transition as inevitable and the process of PC consolidation as inexorable, Dataquest believes that the entry of a first-rate chip set vendor like Chips and Technologies into this market will have a catalytic effect, enhancing competition and therefore innovation among all of the chip set players. We expect this heightened competitiveness to accelerate the trend toward intelligent peripherals and subsystems of all kinds, opening the door a little wider for tomorrow's more sophisticated machines and more powerful applications.

Kevin Landis

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Research *Bulletin*

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THE COST OF QUALITY: PREVENTION VERSUS CURE

The total cost of a semiconductor component can be broken down into three main categories: unit price, inventory cost per unit, and rework costs due to component or system failure. There is a break–even point that determines where rework costs can be offset by improvements in incoming quality (i.e., price + quality adder). To determine the break–even point, the following variables need to be identified:

- Unit price
- Inventory cost per unit
- Units per board
- Boards per month
- Incoming inspection cost per unit
- Component burn–in cost per unit
- System burn–in cost
- Average rework cost per board
- Average cost to repair a field failure

Once the above costs are known, it is relatively straightforward to determine the break–even point where a quality price adder at the component level balances with repair costs at the board rework or field repair level. Table 1 shows the cost structure with and without the preventative cost of quality. However, without any of these preventative costs, there are generally remedial costs that far outweigh the up–front expenditures.

Looking at Table 2, the average rework cost per board is $350 and the average field repair cost is $2,000. Assuming that 10 percent of the boards require rework due to a lack of burn–in or incoming QA, and that an additional 5 percent of the boards require field repair, quality costs at the component level become more justifiable. Comparing the bottom lines of Tables 1 and 2 shows that the preventative cost of quality totals less than the remedial cost ($1,092,500 compared with $1,085,000).

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Table 1

Preventative Cost of Quality

Unit Price	$20.00
Inventory Cost/Unit	$0.50
Burn-In Cost/Unit	$0.75
Incoming QA Cost/Unit	$0.45
Units/Board	100
Boards/Month	500

Total Cost with Burn-In & QA:
(($20.00 + $0.50 + $0.75 + $0.45) x 100) x 500 = $1,085,000

Total Cost without Burn-In & QA:
(($20.00 + $0.50) x 100) x 500 = $1,025,000

Source: Dataquest
February 1989

Table 2

Remedial Cost of Quality

Unit Price	$20.00
Inventory Cost/Unit	$0.50
Units/Board	100
Boards/Month	500
10% Board Failure/Month	50 Boards
Rework Cost/Board	$350.00
5% System Failure/Month	25 Systems
Field Repair Cost	$2,000

Total Cost:
(($20.00 + $0.50) x 100) x 500 + ($350 x 50) +
(25 x $2,000) = $1,092,500

Source: Dataquest
February 1989

DATAQUEST CONCLUSIONS

The cost of quality must be looked at closely from both a preventative and a remedial perspective. Customer satisfaction with end products demands that the products work right from the start. The incremental up-front costs of quality more than make up for the ill will and potential lost business earned by poor quality that surfaces after a product is in the field. Fortunately, the preventative costs of quality have declined for users, due mainly to the increased quality levels of semiconductor components. Dataquest's annual procurement survey continues to show that quality is of key importance both in controlling costs and in improving performance. By analyzing quality costs, one can quantify where improvements are needed and prove the adage that "Quality is free."

Mark Giudici

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Research *Bulletin*

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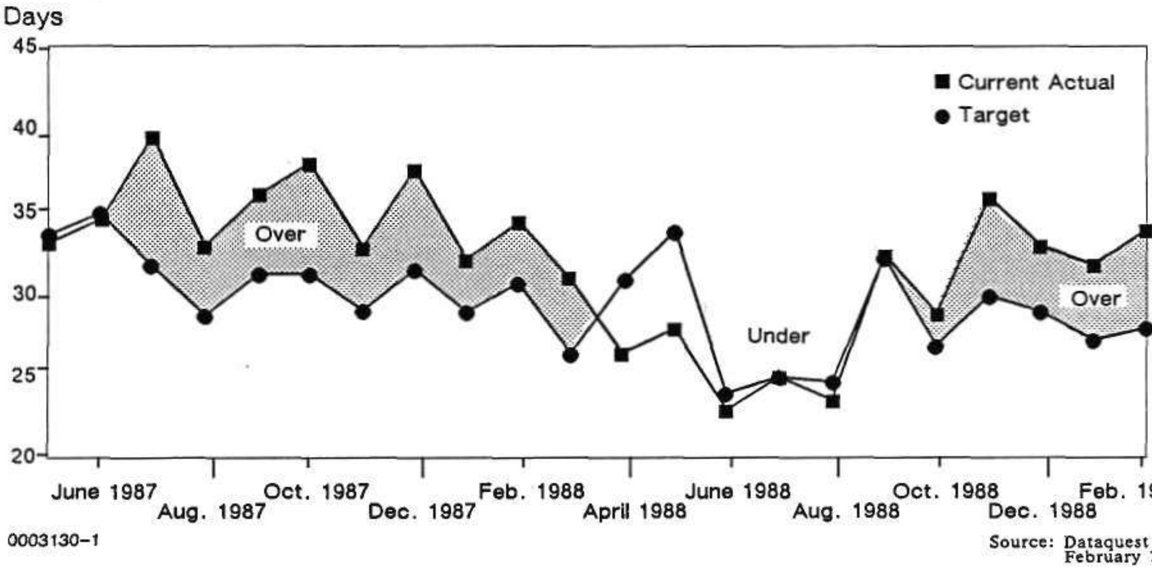
FEBRUARY PROCUREMENT SURVEY: LEAD TIMES FALL WHILE ORDER RATES STABILIZE

Lead times for semiconductors are improving and order rates are steady, yet overall inventory levels have increased since last month's survey. Total OEM inventories, both targeted and actual, rose slightly as users continue to experience fast DRAM and slow, low-density SRAM availability problems. As seen in Figure 1, the inventory target of 27.8 days was exceeded by the current level of 33.9 days. Although this is an incremental increase, these levels still are below targeted and actual inventory levels of a year ago (30.8 and 34.5 days, respectively).

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



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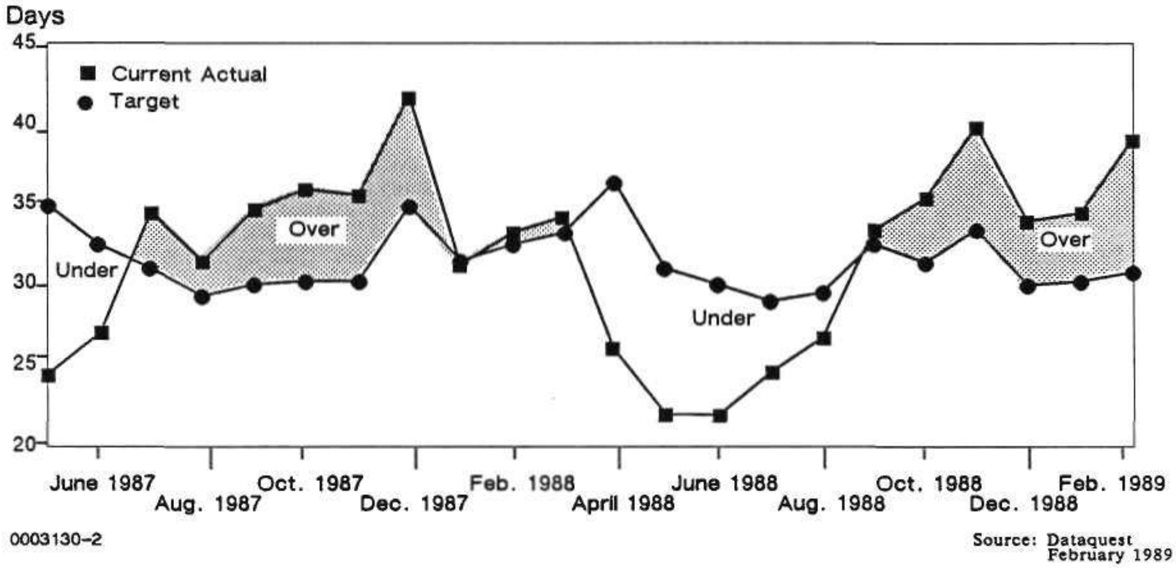
While the average target level hovered at 30.8 days, the actual inventory level of 39.2 days for the computer OEM respondents jumped almost 5 days over last month's level (see Figure 2). This is primarily due to the increasing availability of commodity DRAMs and a relative flattening of end-use demand compared with last year's record growth. Some insurance ordering of DRAMs still is going on by some smaller companies. It is well understood that, as volumes of 1Mb DRAMs increase, it is a matter of time before associated memories will become more available.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



Overall pricing continues to decline gradually, largely at the hands of improved availability of 1Mb DRAM and some microprocessors. Allocations still exist for some video and x4 configuration memory parts; this will continue, as reported earlier, until the market for the predominant 1Mb part is saturated. Overall pricing, including memories, is slightly lower than in our last survey. Surface-mount packaging continues to be a problem for the minority of users, with problems arising in the ceramic packaged parts.

DATAQUEST ANALYSIS

The easing of lead times and coinciding increases of inventory levels may be an aberration that will smooth out as companies strive to achieve their targeted goals. As the overall availability of semiconductors improves, balancing of inventory needs and system shipment rates will take precedence. As the market approaches supply-demand equilibrium, it is paramount that open communication between users and suppliers continues in order to maintain low inventory levels and constant shipment schedules.

Mark Giudici

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Research Newsletter

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UNISYS: SUCCESSFUL MERGER, BRIGHT FUTURE

COMPANY OVERVIEW

Unisys, formed in 1986 by the merger of Sperry and Burroughs, is a fine example of the power of synergy. Unisys' total revenue in 1988 was $9.9 billion, an increase of 3.0 percent from 1987; earnings were $218 million, roughly flat from year to year. The company manufactures computers ranging from networked workstations through mainframes and is a major supplier of defense electronics including embedded computers, radar control, and navigation systems. The compatibility of product lines, organizational skills, and an ongoing focus on cost control have helped this merger to be uniquely successful as it enters its third year. Although the company is not without challenges still from global and focused competition, it already has hurdled many of the financial problems encountered by joined operations.

Cost savings accrued from the structural changes made since the merger are being transformed into opportunities for long-term growth through research and development (R&D), with a budget that increased by 20 percent in 1988. In fiscal year 1987, Unisys ranked fifth among electronics vendors in R&D expenditures, having invested $597 million in R&D.

One of the important reasons behind the company's success at managing its cost structure is an emphasis on cost-effective sourcing of materials—in particular, semiconductors. Total semiconductor use at Unisys in 1988 is estimated at $360 million, with $40 million in commercial grade produced captively (see Figure 1).

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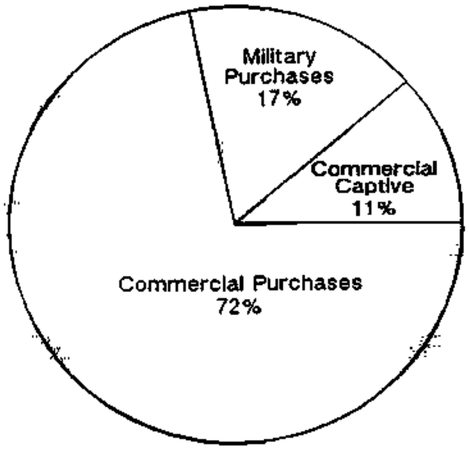
Figure 1

Unisys Semiconductor Use



COMPANY DIRECTIONS

Unisys expects to double its revenue to $20 billion by the early 1990s. Internal expansion and acquisitions in selected high-growth areas are paving the way for Unisys' growth. In 1988, Unisys acquired Timeplex and Convergent Inc. and entered into a joint venture with Mitsui & Co. to form Nihon Unisys Ltd. (NUL). Timeplex now forms the core of Unisys Networks, uniting all communications engineering and placing Unisys at the forefront of industry-standard networks that provide whole business solutions. Convergent will provide Unisys with strategically important engineering, development, and marketing expertise and will be an anchor for a $2 billion distributed systems business that includes Unisys' UNIX systems, BTOS workstations, and personal computers. NUL will increase opportunities for Unisys in one of the fastest-growing computer markets in the world; NUL is Japan's fifth-largest computer company.

Unisys plans to be the leader in opening and unifying mixed-system environments, and the company expects to revolutionize the practical use of information technology. A new Unisys "solutions environment" will permit use of software across multiple system families. Drawing on its expertise in fourth-generation languages and artificial intelligence, Unisys intends to streamline the entire process for creating applications software.

After a decade of investment in the development of common module technology, Unisys continues to play its key role of developing modularly designed avionic information-processing systems for the future. Unisys has significantly expanded its role in developing navigation, radar, and communications systems as well as electronic warfare systems by securing significant contracts in 1987.

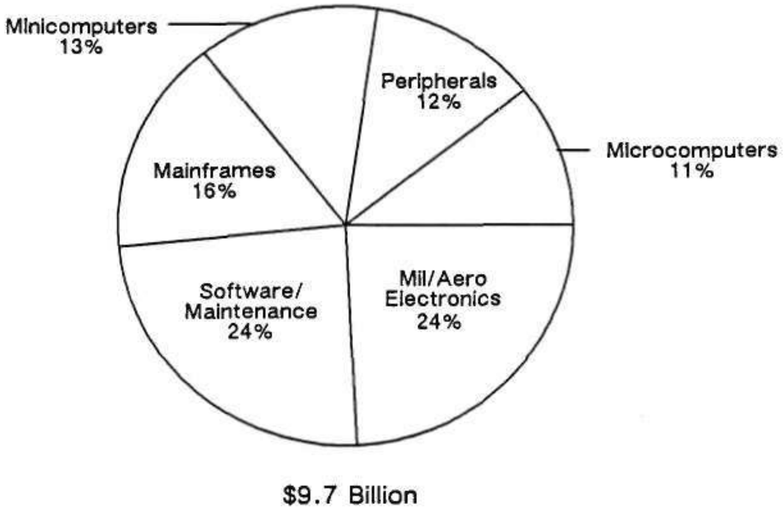
The company is gearing its focus toward entering into larger network projects and improving and upgrading its mainframe and workstation offerings including architectural continuity, connectable open systems, embedded computing systems for military and aerospace, intelligent workstations, and fourth-generation languages.

PRODUCT LINE

Unisys' product portfolio is divided into two main segments: Commercial Information Systems (75 percent of total revenue) and Defense Systems (25 percent of total revenue). Percentage of revenue by product line can be seen in Figure 2.

Figure 2

Unisys Revenue by Product Line



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Source: Dataquest
February 1989

Commercial Information Systems

The Commercial Information Systems group focuses on the following five business areas:

- Industrial and Commercial
- Financial
- Public Sector
- Communications and Airlines
- Federal Information Systems

In 1987, Unisys made a significant move toward providing the total business solution. The company expanded its BTOS II family of networked workstations and introduced Cluster Share, through which IBM-compatible PCs can be readily integrated into a BTOS network. The company also introduced the Unisys PW^2 Family, the first Personal Workstation to run all three of the popular industry-standard operating environments: MS-DOS, OS/2, and UNIX.

The company also entered into an important arrangement with AT&T in 1988. This arrangement will allow Unisys to play a strategically valuable role in enhancing the functionality of the UNIX operating system environment for the rapidly growing commercial market.

Unisys reaffirmed its commitment to the mainframe base with a series of significant introductions and announcements in 1988. The company introduced the B38 workstation based on the INTEL 80386. It extended both the high and low ends of the A Series, providing it with one of the widest performance spectrums in the industry. Unisys also extended the 110 and 2200/200 systems and the V Series, and made the first deliveries of the new System 80 Models 10 and 20.

Defense Systems

The Defense Systems group provides defense electronics through these five major lines:

- Shipboard and Ground Systems
- Systems Development
- Communication Systems
- System Support
- Computer Systems

The following paragraphs describe some of Unisys' key military and aerospace programs.

Government Agency Contracts

Unisys is instrumental in the FAA's air traffic control automation and modernization program and supplies all of the FAA's terminal automation systems. Culminating a 10-year cooperative effort by four government agencies, NEXRAD (Next Generation Weather Radar) is now entering production under a $450 million, multiyear contract. By the mid-1990s, 175 NEXRAD systems will be installed for commercial use and in military sites worldwide.

Navy Contracts

The navy accounts for a major percentage of Unisys' defense revenue. In 1988, Unisys won the latest sole-source contract for the AN/AYK-14(V) navy airborne computer. Under this contract, Unisys will provide 65 16-bit computers with options for 365 more units. Unisys is also an alternate supplier for the Aegis combat system. The system will be used aboard more than 50 guided-missile cruisers and destroyers. In April of 1988, a Unisys/Westinghouse team won a $10 million qualification contract leading to becoming second-source producers for the Aegis SPY-1D electronic radar. Unisys, a leading supplier of shipborne computers, is replacing the navy's old, small, general-purpose computers with embedded computer system families—the UYK43 and UYK44. Unisys also has won a $280 million contract to supply microcomputers throughout the U.S. Department of Defense.

Other major navy contracts awarded in 1988 include a $509 million contract in March for the initial production of navigation systems for D-5 Trident II missile-firing submarines and a $101 million award to provide MK 99 fire-control systems for which Unisys is a second-source supplier. In 1988, installation of the first navigation system on the Trident submarine, the USS Tennessee, was completed and integration tests started.

Air Force Contracts

Unisys is also a contractor on major air force programs. Selected to develop the YF-23 advanced tactical fighter (ATF) avionics processor, Unisys is at the leading edge of new technologies for the future generation of military aircraft. The company has expanded its role in advanced modular avionics and very high speed integrated circuit (VHSIC) central computers for U.S. combat aircraft during the last year. The Unisys Common Module family that includes various standard modules currently consists of 16-bit 1750 MPU modules; 32-bit MPU modules planned; communication modules (1553B, high-speed, dual-speed); and memory (EEPROM, CMOS) and power modules.

The air force also selected Unisys to be one of two major suppliers to the air force's rapid-deployment, high-capacity voice communications project: the AN/TRC-170 Troposcatter Digital Microwave Communication System.

Unisys is developing a third-generation airborne battlefield command and control center (ABCCC3) in a capsule for specially modified Air Force EC-130s to provide contingency command control for forward areas of the battlefield. The center serves as an airborne extension of several ground-based control agencies.

Foreign Government Contracts

Unisys is working on several contracts for foreign governments. At the end of 1987, the Royal Thai Air Defense System (RTADS) which Unisys is designing, integrating and installing, was more than half complete. Unisys is also working on a nearly $1.1 billion contract covering electronic combat systems for six Canadian frigates assigned to Unisys Canadian subsidiary-Paramax Electronics Inc.; the initial contract was extended by $1 billion to supply systems for six more frigates.

DIVISIONS/SUBSIDIARIES

Table 1 presents a summary of Unisys' commercial and defense divisions and subsidiaries. This list represents a combination of Sperry and Burroughs units minus the divisions sold to Honeywell.

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Table 1

Unisys Divisions and Subsidiaries

Location	Equipment
Unisys Corporation Detroit, MI (Parent Company)	
Commercial Systems Group	
Foundation Computer Systems Cary, NC	Utility software
GRAFTEK, Inc. Boulder, CO	Peripherals, computer services, engineering/ technical software
Memorex Santa Clara, CA	Peripherals, accessories, components
Pasadena Plant Pasadena, CA	Computers
Sperry Corp. Saint Paul, MN	Electronics services, computers, peripherals, AI software
Timeplex, Inc. Woodcliff Lake, NJ	Utility software, data communications equipment
Unisys Knowledge Systems Organization Paoli, PA	Artificial intelligence
Defense Systems Group	
Communication Systems Group Salt Lake City, UT	Telecommunications, intelligence, data communications, computers
Computer Systems Division Eagan, MN	Information processing systems, militarized computer products and displays
Shipboard & Ground Systems Group Great Neck, NY	Sonar equipment, EW communication systems, sonar countermeasures equipment, ground defense radar systems, shipboard navigation equipment, shipboard radar equipment
System Development Group Camarillo, CA	Command and control, custom services microcomputers
System Support Group McLean, VA	Technical services, facilities management, integrated systems
Semiconductor Facilities	
Unisys Components Group Rancho Bernardo, CA	ASICs

Source: Various Industrial Sources

SEMICONDUCTOR PROCUREMENT

The impact of Unisys' new leverage after the merger was felt directly in purchasing. Greater volume allowed Unisys to renegotiate supplier contracts, significantly reducing procurement costs. It also created a critical mass to successfully execute vendor quality-improvement programs. In 1987, Unisys cut 21 percent off its purchasing bill. Suppliers' rosters were dramatically cut also; for instance, the number of connector suppliers was reduced from 88 to 20.

The purchasing operation is done through central procurement units as well as through the divisions themselves. The Materials Management Center (MMC) in Pueblo, Colorado, is in charge of semiconductor procurement for the Computer Systems Division units in Pueblo and in Saint Paul, Minnesota, as well as for the Shipboard and Ground Systems Group in Clearwater, Florida. The Communication Systems Division in Salt Lake City, Utah, and the Shipboard and Ground Systems Group in Great Neck, New York, do their own purchasing. Central procurement for commercial semiconductors is done by the Component Engineering and Procurement Organization (CEPO) in San Diego, California. CEPO is responsible for supplier qualification, component engineering, quality verification, contracts, and executing procurement.

Figure 3 shows a percentage breakout of semiconductor purchases. In-house capabilities, recently consolidated into the Rancho Bernardo, California, facility, supply an estimated 11 percent of commercial semiconductor use. This facility produces primarily gate arrays and cell-based ICs. These products are manufactured both on bipolar process technology as supplied by Motorola and on CMOS from Intel. Along with internal CAD and packaging technology, the purpose of this captive capability is to produce volume proprietary logic ICs as well as quick-turn engineering prototypes. Standard products are almost entirely purchased directly from outside vendors.

Military semiconductor purchases accounted for approximately 19 percent or $60 million of total external purchases. All of the military semiconductor sourcing is done externally, both directly and with distributors.

After the merger, Unisys reorganized its purchasing operations, creating the following seven procurement task forces:

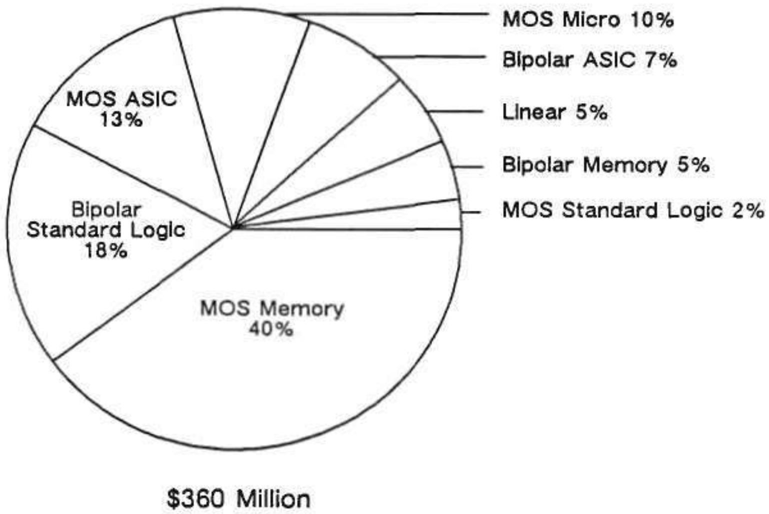
- Electronics
- OEM
- Foreign
- Mechanical
- Semiconductor
- MRO
- Government

These task forces are responsible for determining corporate needs, setting price targets, and conducting negotiations. Four of the task forces deal primarily with electronics. The semiconductor group coordinates contracts for both defense and commercial divisions; the OEM group coordinates personal computers and small systems; the electronic group coordinates all passive devices, connectors, electromechanicals, and printed circuit boards; and the international procurement group executes purchases with offshore suppliers mostly in the Far East. Offshore suppliers, account for roughly $350 million annually—mostly for systems, peripherals, and components. The role these offshore suppliers play is increasing as they represent a growing portion of Unisys' purchases.

Strategic programs that facilitate and improve operations efficiency are also being set in place. Currently Unisys has certification, just-in-time (JIT), and electronic data interchange (EDI) programs with selected component vendors.

Figure 3

Unisys Semiconductor Purchases 1988



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Source: Dataquest February 1989

DATAQUEST CONCLUSIONS

Compatibility, leverage, and cost control are perhaps the best terms to describe the success of the Unisys merger. Similar yet somewhat complementary product lines and corporate organizations have helped Unisys in achieving leverage in both the markets it serves and the purchases it makes. Although 1988 was a relatively flat year for revenue and earnings growth, the company is faring much better than most mergers and probably much better than either Burroughs or Sperry could have alone.

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Unisys has been able to maintain a high level of R&D investment principally because of aggressive cost control and economies of scale achieved during the past two years. By applying the principle of centralized leveraged contracting and working closely together with its suppliers and internal engineering organizations, the component procurement groups at Unisys have contributed greatly toward maintaining cost control.

Unisys' ability to increase R&D efforts because of reduced overall costs is a key competitive advantage, putting the company in an enviable position of decoupling its new product-development funding from moderate swings in revenue. This could prove to be an advantage in both the commercial computer market, where many economists are predicting a downturn in 1990, and in the defense electronics market, where funding is flat and efficiencies will be mandated.

Greg Sheppard
Najoo Wadia

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Research Newsletter

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1989–4
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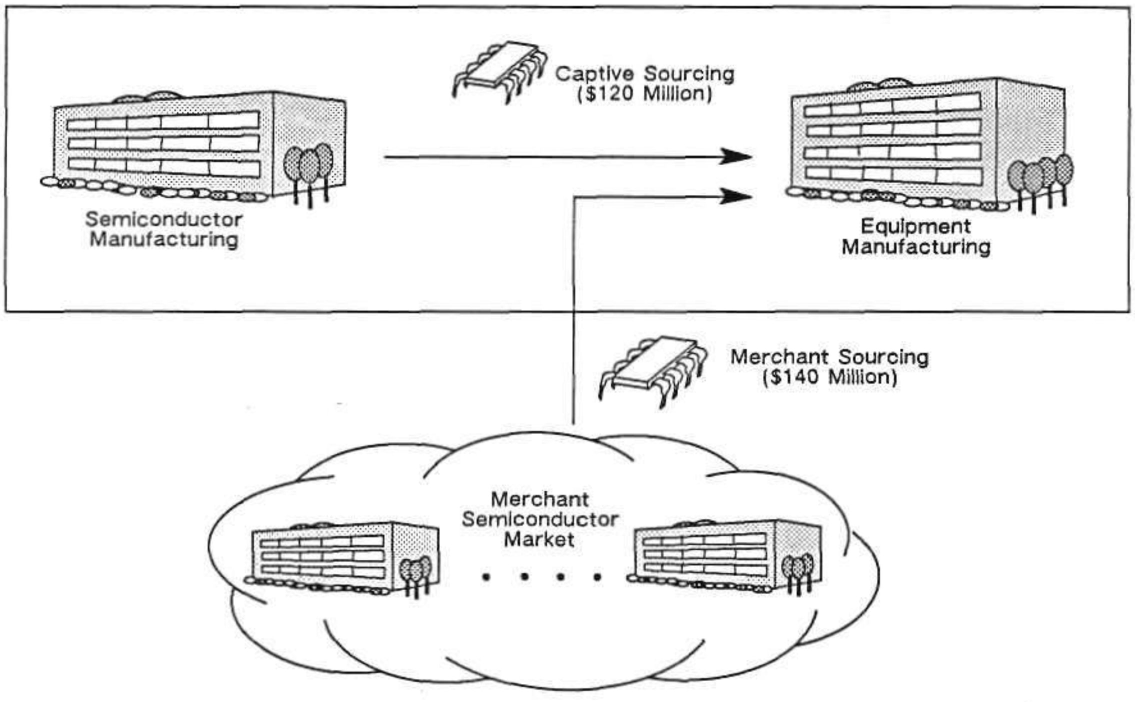
NORTHERN TELECOM: STRATEGY, TECHNOLOGY, AND SEMICONDUCTORS

SUMMARY

Northern Telecom has become one of the world's largest suppliers of telecommunications equipment. The company also has an integrated strategy of manufacturing 40 to 50 percent of the semiconductor components it needs, as illustrated in Figure 1. This newsletter focuses on Northern's $260 million consumption, $140 million procurement, and $120 million production of semiconductors.

Figure 1

Semiconductor Consumption and Production at Northern Telecom



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Source: Dataquest
February 1989

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COMPANY PROFILE

Northern Telecom had sales of $4.9 billion in 1987, as presented in Table 1. The company's revenue grew at a compound annual growth rate (CAGR) of 12.9 percent between 1984 and 1987, or 50 percent faster than the estimated CAGR of 8.2 percent of the overall telecommunications market during the same period.

Table 1

Northern Telecom's Performance Results

	1984	1985	1986	1987	CAGR 1984-1987
Revenue ($M)	$3,374	$4,263	$4,384	$4,854	12.9%
Income ($M)	$ 256	$ 299	$ 313	$ 347	10.7%
Employees	47,000	47,000	46,000	49,000	1.4%

Source: Northern Telecom
Dataquest
February 1989

Northern's manufacturing facilities in North America are listed in Table 2. The company's research and development activities are conducted by Bell-Northern Research, a subsidiary of Northern (70 percent ownership). Northern Telecom spent $588 million on research and development in 1987; this amount represents 12 percent of the company's revenue.

Table 2

Northern Telecom's Manufacturing Facilities in North America

Location	Products
Canada	
Aylmer, Quebec	Transmission equipment
Belleville, Ontario	Business telephones
Brampton, Ontario	Central office switches
Calgary, Alberta	Key telephones
London, Ontario	Residential telephones
Montreal, Quebec	Wire and cable
Ottawa, Ontario	Semiconductors
Saskatoon, Saskatchewan	Optical fibers
Winnipeg, Manitoba	Transmission equipment

(Continued)

Table 2 (Continued)

Northern Telecom's Manufacturing Facilities in North America

Location	Products
United States	
San Diego, CA	Semiconductors
Santa Clara, CA	Private branch exchanges
W. Palm Beach, FL	Datacom equipment & phones
Atlanta, GA	Transmission equipment
Morton Grove, IL	Datacom equipment
Ann Arbor, MI	Private branch exchanges
Minneapolis, MN	Datacom equipment
Minnetonka, MN	Business systems
Marlton, NJ	Datacom equipment & phones
Moorestown, NJ	Network monitoring equipment
Concord, NH	Network monitoring equipment
Raleigh-Durham, NC	Central office switches
Nashville, TN	Telephones
Dallas, TX	Private branch exchanges

Source: Northern Telecom
Dataquest
February 1989

In 1987, Northern earned 65 percent of its revenue from sales made in the United States, 30 percent from sales made in Canada, and 5 percent from sales made outside North America. In the United States, the company manufactures most of the products that it markets there. Northern's stated goal is to expand its business in Europe and Japan.

Semiconductor Consumption

Dataquest's estimate of Northern Telecom's 1987 semiconductor consumption is presented in Table 3. The company earned 63 percent of its revenue from the sale of public network equipment; 29 percent from the sale of customer premises equipment; and the remaining 8 percent from the sale of cable, outside plant, and R&D services. In addition, Dataquest estimates that 39 percent of Northern's 1987 semiconductor consumption of $260 million was for logic products, 34 percent was for memories and microcomponents, 19 percent was for linear, and 8 percent was for discretes and optoelectronics.

Table 3

Northern Telecom's Estimated 1987 Equipment Sales and Semiconductor Content (Millions of Dollars)

Equipment Type	Market Share	Revenue	Semiconductor Content
U.S. Totals	N/A	$2,894	$169
Central Office Switches	34%	936	60
Private Branch Exchanges	19%	599	39
Carrier Systems	6%	65	4
Microwave Radio	9%	43	2
Automatic Call Distributors	29%	36	2
Multiplexers	4%	30	2
Network Diagnostics	33%	25	1
Packet Switches	9%	24	1
Integrated Voice/Data Workstations	33%	22	1
Other	N/A	1,114	57
Canadian Totals	N/A	$1,335	$ 79
International Totals	N/A	$ 222	$ 12
Cable, Outside Plant, R&D	N/A	$ 403	N/A
Worldwide Totals	N/A	$4,854	$260

N/A = Not Applicable

Source: Dataquest
February 1989

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Semiconductor Procurement

Northern's component and manufacturing technologies are key to its overall competitive strategy. Semiconductor procurement is a function of the corporate operations staff and includes both tactical and strategic elements. Northern also has an external business group to manage foundry and semiconductor technology agreements. Vice presidents head these procurement and external business groups.

The company's component purchasing organization is headed by a purchasing operations director at the company's U.S. headquarters in Nashville, Tennessee. Northern negotiates annual contracts with its key semiconductor suppliers from this central location every fall. The actual purchases of semiconductors, however, are made throughout the year by the purchasing managers at each manufacturing location. Dataquest estimates that 55 percent of Northern's 1987 merchant semiconductor purchases of $140 million was for memories and microcomponents, 22 percent for logic, 15 percent for discretes and optoelectronics, and 8 percent for linear. The company has standardized on Motorola's microprocessor architectures.

Northern Telecom establishes the strategic relationships it needs with suppliers for ISDN and advanced semiconductor technology from both Nashville, Tennessee, in the United States and Ottawa, Ontario, in Canada. The company has been reducing its supplier base in recent years to just a few companies. (Dataquest believes that Northern's major suppliers include Intel, LSI Logic, Mitsubishi, Motorola, National, and Texas Instruments.) Northern works very closely with its partners to establish realistic requirements regarding pricing, delivery, quality, reliability, and technology. For example, the company is investigating a just-in-time delivery system for raw materials, and this will require very close relationships with Northern's suppliers in order for it to be practical. These long-term programs are headed by a strategic procurement practices director.

Semiconductor Production

Northern Telecom has CMOS fab facilities located in Ottawa, Ontario and in San Diego, California, to make custom digital and mixed analog/digital semiconductors for its telecommunications equipment. Dataquest estimates that Northern's 1987 semiconductor production was $120 million. None of Northern's semiconductor production is available on the merchant market.

Northern has just installed a $100 million submicron fab in its Ottawa plant, and one of the company's greatest concerns is the capital investment required to keep its production facilities current in the future. Based on historical trends, Dataquest estimates that the cost of a new fab doubles every 4 years. (Thus, a fab that costs $100 million in 1988 can be expected to cost $200 million in 1992 and $400 million in 1996.) The company is participating in the Captive Manufacturers Subgroup of the Semiconductor Industry Association to share its concerns with other organizations in similar situations.

DATAQUEST CONCLUSIONS

Competition

Competition in the telecommunications equipment market is becoming global and is increasing in intensity. One of Northern's competitors (i.e., AT&T) recently complained that companies in Japan, South Korea, and Taiwan are selling some of their equipment in the United States at unfair prices. Regardless of the final legal decision regarding pricing, however, Dataquest believes that Northern (and AT&T and all other suppliers to North America) will experience severe downward pricing pressures in this crowded market.

Strategy

Northern Telecom originally established its captive component operations to obtain the efficient use of silicon that comes from custom circuits. This strategy allowed the company to sell equipment with higher performance and more features at prices that were still competitive. A side benefit of this approach was the creation of entry barriers because the relatively high cost of a custom circuit design discouraged competitors from participating in the market. Today, however, application-specific IC (ASIC) technology makes customized silicon available to all equipment manufacturers as a result of the lower costs required to design a circuit. Dataquest believes that Northern must consider new ways to differentiate its equipment in the marketplace now that clonemakers have these tools at their disposal.

Leadership

Northern was one of the first companies to develop and market a digital central office switch, and this innovation has become the practice of the industry today. As competition in the telecommunications equipment industry increases and ASICs give all suppliers a common capability in semiconductor technology, Dataquest believes that the next strategic battleground in this market will be the accelerated time to market with new generations of products. Dataquest recommends that Northern Telecom (and the other participants in the industry) continue to tighten the links between design, manufacturing, and marketing to be able to respond as quickly as possible to changing customer needs.

Roger Steciak

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Research *Bulletin*

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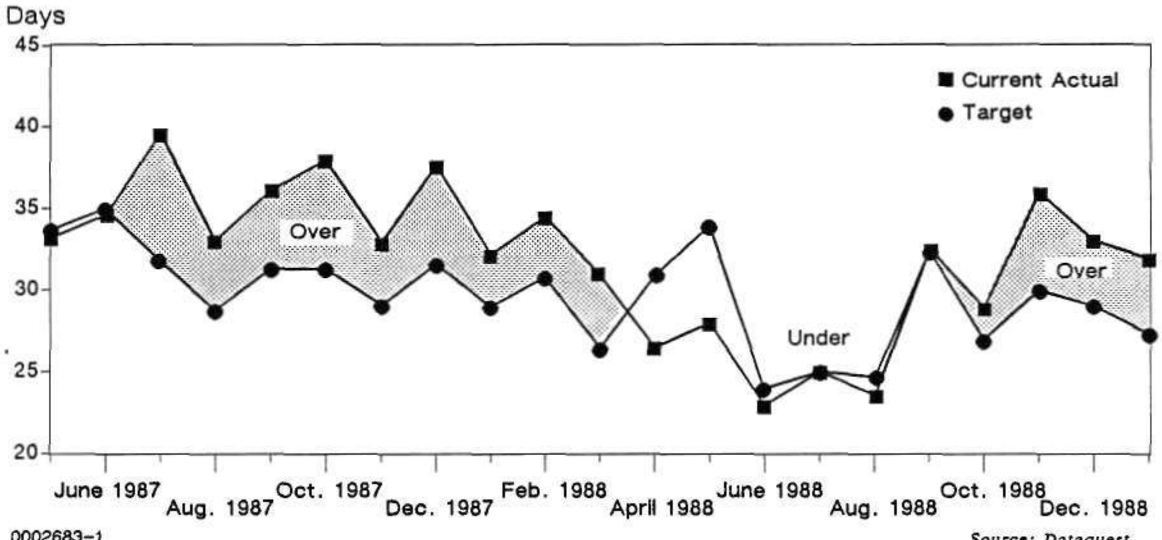
JANUARY PROCUREMENT SURVEY: ORDER RATES REMAIN UNCHANGED AS INVENTORY LEVELS DECLINE

Respondents to this month's survey noted that overall inventory levels were reduced and that the targeted levels also declined. Now that the holidays are past, order rates are expected to remain firm in relation to last month's slight decline, adding another stabilizing factor to the inventory situation. For the year, overall system sales ranged from 2 to 40 percent higher than last year's levels. During this time, inventory levels fluctuated by approximately 6.5 days around the 1988 mean of 29.5 actual inventory days, as seen in Figure 1. The January targeted and actual inventory levels of 27.3 and 31.9 days, respectively, continue to reflect the close inventory controls that have hallmarked the past two years.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



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Source: Dataquest January 1989

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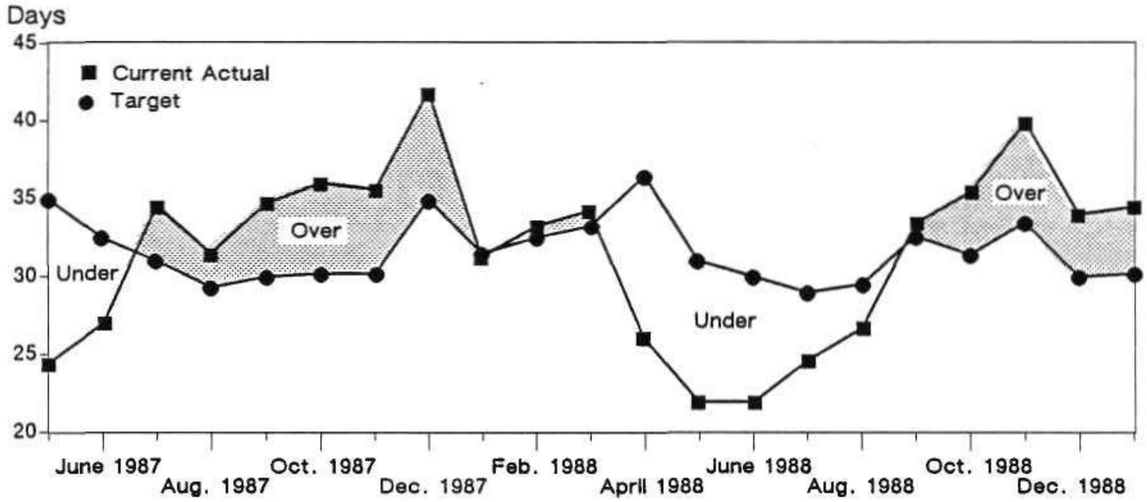
Inventory levels for computer OEMs have remained remarkably constant since our last survey, holding at 30.3 targeted days and 34.5 actual inventory days. Although the gap between the actual and targeted inventories (see Figure 2) still remains at slightly more than four (4.2) days, order rates for semiconductors have stayed at the same level if not slightly higher. The continued improved availability of 1Mb DRAMs has kept average actual inventory levels slightly higher as buyers continue to order memory to meet past demand.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



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Source: Dataquest January 1989

Overall, pricing of semiconductors has declined, largely in part due to the increased availability of 1Mb DRAMs and the softening of some logic and microprocessor prices. SRAM and 256K DRAM pricing remains firm and is expected to continue so through the next six months. Lead times have increased slightly up to 12 weeks as the mix of SRAM and lower-density DRAM shipments keeps lead times relatively high. Surface-mount package availability is becoming a critical problem for one-half of the respondents who use these parts.

DATAQUEST ANALYSIS

Inventory levels continue to decline as key components become more available and begin to catch up with order rates. As mentioned in earlier surveys, this inventory correction is expected and should continue through the next few months. Pricing should also continue its downward trend, with some exceptions in video RAMs and SRAMs. The overall electronics industry is relatively healthy, and the outlook is for a realistically steady growth year in 1989.

Mark Giudici

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Research Bulletin

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HIGH–DEFINITION TV: IS AMERICA FINALLY WAKING UP?

The United States Department of Defense (DOD) has announced its intention to finance the development of an advanced, high–resolution video display screen. The immediate purpose is to make a compact, low–cost unit for military systems (such as helicopters, tanks, planes, ships, and training simulators) that can display detailed images of battlefield conditions. In the coming months, the Defense Advanced Research Projects Agency (DARPA) is expected to provide further details of the specific projects to be funded. Dataquest believes that this action is an attempt by the United States to reclaim the high ground lost to foreign competition as the international economic landscape has shifted over the past two decades.

NATIONAL SECURITY

We believe that the broader purpose of this project is to restore vitality to the U.S. consumer electronics industry, while at the same time, bolster the country's national security. This twofold intent is an example of the interrelationship of today's end–use markets; for example, the focusing system of the 35mm camera has become the focusing system of the VCR, and the automatic electronic system of the VCR has become the automatic electronic system of the 35mm camera. Thus, the technology for one product can improve the performance or convenience of other products. A high–resolution display screen is an example of a strategic technology with potential applications in television sets, video games, military systems, automobile dashboards, computer monitors, medical scanners, and any systems where the display of detailed images would make the systems easier to use. We believe that a nation that ignores these types of end–use market interrelationships and the corresponding leverageability of these strategic technologies can put itself in danger on both economic and military fronts.

The mass production of equipment for the home creates demand for semiconductor components and helps to reduce the cost of the technology used by achieving scale economies. Without domestic production of consumer electronics equipment, technology costs will remain high for other domestic equipment industries. Although the United States pioneered almost all of the consumer electronics equipment in use today, Dataquest estimates that imported products have taken about half of the U.S. consumer electronics equipment market in the last 10 years. In addition, Dataquest estimates that products exported from the United States have only about a 10 percent share of the worldwide consumer electronics equipment market. VCRs, for example, are estimated

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to use almost 5 percent of the world semiconductor output, yet more than 98 percent of the world market is served by non-U.S. producers. As another example, there is now only one remaining U.S. TV set producer. By not participating in such key industries, we foresee that the United States is in danger in the long run of losing its leadership position in technology.

LAUNCHING HDTV IN THE UNITED STATES

Dataquest notes that estimates of the U.S. market potential of HDTV vary because this is an emerging industry with hundreds of variables between the initial idea and ultimate commercial success. We do believe, however, that an annual potential of 5 million HDTV sets at an average price of $750 in the year 2000 is a good estimate. With the installed base of conventional TV sets in the U.S. currently at about 160 million units, the potential for sales of HDTV sets over the next two to three decades is very large indeed as consumers eventually upgrade to the newer models.

However, HDTV is too expensive for any one company to develop alone. Dataquest sees as positive moves for the domestic HDTV industry the Defense Department's announcement to sponsor development of a high-definition display and an announcement earlier last year by the United States Federal Communications Commission requiring any HDTV standard to be backwards-compatible with conventional TV sets. It will require many years for HDTV sets to penetrate the market even under the best conditions because Dataquest believes that most consumers will not obsolete their conventional TV sets for HDTV until there is an ample supply of HDTV programs to watch. But Dataquest notes that investors might be more willing to fund HDTV programming ventures during the start-up years of the HDTV industry when they know that these programs can also be received on conventional TV sets.

DATAQUEST CONCLUSIONS

The world of the 1990s will be different from the past; as we approach the new decade, the United States no longer has a monopoly on high technology, and the competition is now both global and brutal. To survive, we believe that the United States must make changes in the way it does business in the world economy. Dataquest sees these HDTV announcements as the beginnings of a U.S. version of the industry-government consortiums that are common in both Europe and Japan to coordinate economic activity. It remains to be seen whether the result will be a wall of protectionism leading to another worldwide Great Depression or an environment where the U.S. economy can flourish as part of the larger world economy.

The standards for HDTV must still be defined before any HDTV products can be developed. Dataquest believes that with the recent announcements by U.S. government agencies regarding HDTV, the U.S. industry will move ahead, and potential suppliers of both equipment and semiconductors will be more willing to make the necessary investments in products for the HDTV application. End-use markets today are interrelated, and with the United States already losing ground to imports in the consumer electronics segment, there is the possibility that it could also begin to lose ground in other segments (such as military electronics). Dataquest concludes that the United States <u>must</u> become involved with the development and manufacturing of HDTV products to preserve its economic and military health.

Roger Steciak

Dataquest
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Research Newsletter

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JAPANESE SEMICONDUCTOR INDUSTRY UPDATE: WILL INDUSTRY CONDITIONS REMAIN STRONG?

SUMMARY

(NOTE: Unless otherwise specified, all numbers referenced in the text of this newsletter refer to yen-based growth.)

Our updated forecast for the Japanese semiconductor industry shows Japanese semiconductor consumption up 23.7 percent in 1988 over 1987. This growth rate is up from our previous forecast for the following reasons:

- End-equipment production in 1988 was still strong.
- Memory shortages are expected to continue into 1989.

The growth rates for 1989, 1990, and 1991 are 12.3 percent, 0.7 percent, and 17.3 percent, respectively.

Tables 1 through 4 show our quarterly forecast in both yen and dollars. Tables 5 and 6 show the major regional market size with the percentage change in U.S. dollars.

ELECTRONIC EQUIPMENT PRODUCTION

Dataquest has increased its 1988 forecast growth rate for Japanese end-equipment production. Previously, we predicted a 10.2 percent growth rate over 1987; however, we have increased this to 13.7 percent. Dataquest is forecasting that consumer and nonconsumer electronic equipment production will grow at rates of 7.6 percent and 17.2 percent, respectively. The high yen appreciation and the resulting loss of competition in exports has not hurt the Japanese semiconductor industry because domestic demand has remained high.

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INDUSTRY

Japanese suppliers enjoyed brisk business in 1988, especially the companies that manufacture memory products. The demand remains strong from both domestic and international customers. Dataquest believes that the shortage of DRAMs and other high-density memories will continue into the first half of 1989 for the following reasons:

- Inventory levels remain low compared with 1987. Total semiconductor inventory is down 6.9 percent. Memory devices were down 34.9 percent in June compared with June of 1987.

- Although several suppliers were facing cancellations of memory device orders from personal computer manufacturers in the fourth quarter of 1988, this will have little effect on the suppliers due to existing large backlogs.

- It is our observation that prices will have declined in the fourth quarter of 1988; however, we believe that the demand will continue to grow and supplies will remain low. There is little possibility of more than a 15 percent price erosion in 1988.

DATAQUEST CONCLUSIONS

Dataquest observes that the following factors could adversely affect the Japanese semiconductor market:

- If the memory shortages continue past the first half of 1989, the situation may stir action among memory customers and non-Japanese memory manufacturers, especially in Korea. For example, the big users may decide to manufacture memory devices internally. The non-Japanese memory manufacturers could seize the opportunity to increase their world market shares.

- The memory industry could become highly competitive, as it did in 1985 and 1986, causing a decline in demand. However, if the semiconductor manufacturers maintain reasonable levels of capital spending and continue to develop advanced products, such as 4Mb DRAMs and 1Mb SRAMs, they could remain strong in the face of increased competition.

- If the memory manufacturers continue to have delivery problems because of high demand, they could damage their credibility as good suppliers. This would be particularly damaging if competition increases.

In spite of the current DRAM shortage, Dataquest concludes that overall, there will be strong future growth in the Japanese semiconductor industry for the following reasons:

- Japanese suppliers will continue to dominate the memory market with advances into 1Mb SRAMs and 4Mb DRAMs.

- Japanese end markets are developing products that generate new semiconductor demands in the world market. These products include digital/ audio disk players, facsimiles, camcorders, and laser printers, all of which consume tremendous numbers of chips. In addition, these products are forcing development of next-generation semiconductors such as high-end micros, DSPs, and high-resolution sensors.

Japanese manufacturing and consumption both enjoyed steady growth in 1988; however, the uncertain ramifications of a possible long-term memory shortage make us cautious in our extended forecast.

(Portions of this document were originally published by Dataquest's Japanese Semiconductor Industry Service and are reprinted with its permission.)

Mark Giudici
Bridget O'Brian

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Table 1

Estimated Semiconductor Shipments to Japan
(Percent Change in Yen)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	3.6%	0.9%	9.0%	11.2%	1.8%	23.7%
Total IC	6.3%	(1.4%)	10.2%	11.3%	2.1%	22.5%
Bipolar Digital	(3.7%)	(1.9%)	7.4%	14.4%	3.7%	21.9%
Memory	(7.4%)	19.1%	3.7%	9.5%	2.2%	33.5%
Logic	(3.2%)	(4.7%)	8.0%	15.2%	3.9%	20.3%
MOS Digital	13.2%	2.3%	14.8%	12.8%	1.7%	32.2%
Memory	13.1%	9.0%	22.5%	10.5%	3.0%	45.3%
Micro	8.2%	5.0%	11.9%	11.4%	0.8%	28.2%
Logic	17.4%	(6.2%)	8.6%	16.7%	0.9%	21.8%
Linear	(0.9%)	(8.3%)	1.2%	6.1%	2.0%	3.7%
Discrete	(4.1%)	(2.2%)	4.5%	9.9%	0.4%	14.1%
Optoelectronic	(5.3%)	38.5%	6.8%	12.6%	2.1%	63.3%

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989
Total Semiconductor	23.7%	1.4%	2.4%	0.9%	(1.6%)	12.3%
Total IC	22.5%	1.1%	2.0%	0.6%	(1.7%)	12.1%
Bipolar Digital	21.9%	1.8%	0	(2.4%)	(4.0%)	10.9%
Memory	33.5%	0	(6.4%)	(5.7%)	(3.6%)	(1.7%)
Logic	20.3%	2.1%	0.9%	(2.0%)	(4.1%)	12.8%
MOS Digital	32.2%	0.7%	2.0%	1.1%	(1.4%)	13.4%
Memory	45.3%	0.5%	2.6%	1.2%	(1.3%)	15.3%
Micro	28.2%	0.7%	2.2%	1.7%	(1.7%)	11.8%
Logic	21.8%	0.9%	1.2%	0.6%	(1.4%)	12.4%
Linear	3.7%	1.9%	3.1%	1.1%	(1.1%)	9.6%
Discrete	14.1%	1.0%	2.8%	2.0%	(0.8%)	10.3%
Optoelectronic	63.3%	4.0%	4.8%	1.1%	(1.9%)	17.8%

Source: Dataquest
January 1989

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Table 2

Estimated Semiconductor Shipments to Japan
(Billions of Yen)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	2,055.4	560.5	610.8	679.2	691.5	2,542.0
Total IC	1,578.8	422.4	465.4	518.1	528.8	1,934.7
Bipolar Digital	213.9	57.0	61.2	70.0	72.6	260.8
Memory	26.3	8.1	8.4	9.2	9.4	35.1
Logic	187.6	48.9	52.8	60.8	63.2	225.7
MOS Digital	907.8	252.0	289.4	326.3	332.0	1,199.7
Memory	332.0	97.0	118.8	131.3	135.3	482.4
Micro	248.5	68.9	77.1	85.9	86.6	318.5
Logic	327.3	86.1	93.5	109.1	110.1	398.8
Linear	457.1	113.4	114.8	121.8	124.2	474.2
Discrete	347.6	91.3	95.4	104.8	105.2	396.7
Optoelectronic	129.0	46.8	50.0	56.3	57.5	210.6
Exchange Rate Yen/$	144.0	128.0	125.0	134.0	134.0	130.0

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989
Total Semiconductor	2,542.0	700.9	717.4	723.8	712.5	2,854.6
Total IC	1,934.7	534.8	545.4	548.9	539.7	2,168.8
Bipolar Digital	260.8	73.9	73.9	72.1	69.2	289.1
Memory	35.1	9.4	8.8	8.3	8.0	34.5
Logic	225.7	64.5	65.1	63.8	61.2	254.6
MOS Digital	1,199.7	334.3	341.0	344.9	340.0	1,360.2
Memory	482.4	136.0	139.5	141.2	139.4	556.1
Micro	318.5	87.2	89.1	90.6	89.1	356.0
Logic	398.8	111.1	112.4	113.1	111.5	448.1
Linear	474.2	126.6	130.5	131.9	130.5	519.5
Discrete	396.7	106.3	109.3	111.5	110.6	437.7
Optoelectronic	210.6	59.8	62.7	63.4	62.2	248.1
Exchange Rate Yen/$	130.0	134.0	134.0	134.0	134.0	134.0

Source: Dataquest
January 1989

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Table 3

Estimated Semiconductor Shipments to Japan
(Percent Change in U.S. Dollars)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	20.9%	6.5%	11.6%	3.8%	1.8%	36.0%
Total IC	24.0%	4.1%	12.8%	3.9%	2.1%	34.8%
Bipolar Digital	12.3%	3.5%	9.9%	7.0%	3.6%	34.1%
Memory	7.6%	26.0%	6.3%	3.0%	1.4%	47.0%
Logic	13.0%	0.5%	10.5%	7.6%	4.0%	32.3%
MOS Digital	31.9%	7.9%	17.6%	5.2%	1.8%	45.4%
Memory	31.7%	15.0%	25.3%	3.2%	3.1%	60.0%
Micro	26.3%	10.7%	14.7%	3.9%	0.8%	41.0%
Logic	36.6%	(1.0%)	11.1%	8.8%	1.0%	33.8%
Linear	15.8%	(3.3%)	3.6%	(1.0%)	2.0%	14.2%
Discrete	12.0%	3.0%	7.0%	2.5%	0.4%	25.5%
Optoelectronic	11.1%	46.4%	9.3%	5.0%	2.1%	79.6%

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989
Total Semiconductor	36.0%	1.3%	2.4%	0.9%	(1.6%)	14.6%
Total IC	34.8%	1.1%	2.0%	0.6%	(1.7%)	9.1%
Bipolar Digital	34.1%	1.7%	0.2%	(2.5%)	(3.9%)	8.0%
Memory	47.0%	0	(5.7%)	(6.1%)	(3.2%)	(4.1%)
Logic	32.3%	1.9%	1.0%	(2.1%)	(4.0%)	9.8%
MOS Digital	45.4%	0.7%	2.0%	1.1%	(1.4%)	10.4%
Memory	60.0%	0.5%	2.6%	1.2%	(1.3%)	12.2%
Micro	41.0%	0.8%	2.2%	1.7%	(1.6%)	8.8%
Logic	33.8%	0.9%	1.2%	0.6%	(1.4%)	9.4%
Linear	14.2%	1.9%	3.1%	1.0%	(1.0%)	6.5%
Discrete	25.5%	1.0%	2.9%	2.0%	(0.8%)	7.3%
Optoelectronic	79.6%	4.0%	4.9%	1.1%	(1.9%)	158.5%

Source: Dataquest
January 1989

Table 4

Estimated Semiconductor Shipments to Japan
(Millions of U.S. Dollars)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	14,329	4,379	4,885	5,069	5,161	19,494
Total IC	11,006	3,300	3,722	3,867	3,947	14,836
Bipolar Digital	1,491	445	489	523	542	1,999
Memory	183	63	67	69	70	269
Logic	1,308	382	422	454	472	1,730
MOS Digital	6,327	1,969	2,315	2,435	2,478	9,197
Memory	2,311	758	950	980	1,010	3,698
Micro	1,732	538	617	641	646	2,442
Logic	2,284	673	748	814	822	3,057
Linear	3,188	886	918	909	927	3,640
Discrete	2,424	713	763	782	785	3,043
Optoelectronic	899	366	400	420	429	1,615
Exchange Rate Yen/$	144	128	125	134	134	130

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989
Total Semiconductor	19,494	5,230	5,355	5,401	5,317	21,303
Total IC	14,836	3,991	4,071	4,096	4,028	16,186
Bipolar Digital	1,999	551	552	538	517	2,158
Memory	269	70	66	62	60	258
Logic	1,730	481	486	476	457	1,900
MOS Digital	9,197	2,495	2,545	2,574	2,537	10,151
Memory	3,698	1,015	1,041	1,054	1,040	4,150
Micro	2,442	651	665	676	665	2,657
Logic	3,057	829	839	844	832	3,344
Linear	3,640	945	974	984	974	3,877
Discrete	3,043	793	816	832	825	3,266
Optoelectronic	1,615	446	468	473	464	1,851
Exchange Rate Yen/$	130	134	134	134	134	134

Source: Dataquest
January 1989

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Table 5

Estimated Worldwide Semiconductor Market (Billions of U.S. Dollars)

	1988	1989	1990	1991	1992	1993	CAGR 1988-1993
North America	15.7	17.2	17.5	20.4	24.8	26.7	11.2%
Japan	19.5	21.3	21.5	25.2	30.5	33.3	11.3%
Europe	8.2	8.8	8.8	9.8	11.3	12.5	8.8%
Rest of World	6.1	7.3	7.9	9.9	12.7	14.3	18.4%
Total World	49.5	54.6	55.7	65.3	79.3	86.8	11.9%

Source: Dataquest
January 1989

Table 6

Estimated Worldwide Semiconductor Market (Percent Change, U.S. Dollars)

	1988	1989	1990	1991	1992	1993
North America	32%	10%	1%	17%	22%	8%
Japan	36%	9%	1%	17%	21%	9%
Europe	29%	7%	0	12%	15%	11%
Rest of World	57%	19%	9%	25%	28%	13%
Total World	36%	10%	2%	17%	22%	10%

Source: Dataquest
January 1989

X

SUIS April–June Index

The following is a list of newsletters in this section:

- **A Sampling of Sub-1.5-Micron Devices: July through December 1988** (1989-13)—The intent of this newsletter is to provide our clients with a barometer of the changes occurring in fabrication technology along with an idea of the types of leading-edge products entering production. This newsletter lists new microprocessor, microcontroller, and peripheral products that were introduced between July and December 1988. Dataquest believes that the listing represents a fair cross section of sub-1.5-micron products during the six-month period.

- **Semiconductor Price Survey: Spotlight on 1Mb DRAM Price Declines** (1989-14)—The year 1989 marks an overall downward trend in North America semiconductor pricing, with prices continuing to decline in commodity areas such as standard logic and nonvolatile memory. This newsletter highlights the key points of Dataquest's latest North America-based price survey and forecast. Dataquest recommends that, during 1989, semiconductor users should structure their supply-based activities by wearing a commodity products hat as well as a higher-performance products hat.

- **1989 Semiconductor User and Applications Conference: Business Remains Steady; Motorola Wins Supplier of the Year Award** (1989-15)—The annual Semiconductor User and Applications Conference once again provided both users and suppliers of semiconductors with a forum to discuss industry issues in both a formal and an informal setting. This newsletter summarizes the information presented at the conference, discusses how current issues are being addressed, and elaborates on the first annual Dataquest Semiconductor Supplier of the Year Award. Overall, the strategies and tactics presented at this year's conference, if carefully implemented, should help smooth the ruts in the anticipated bumpy road that lies ahead for the electronics industry.

- **April Procurement Survey: Order Rates Steady, Overall Availability Drought Over!** (1989-16)—The Semiconductor availability bubble has burst, according to this month's procurement survey respondents. This bulletin discusses the current actual versus target semiconductor inventory levels for all OEMs and for computer OEMs. Dataquest recommends that users should write into their contracts (if they have not done so already) clauses that allow for quarterly price reviews.

- **Distributors: Will They Adapt or Will They Die?** (1989-17)—The semiconductor industry is changing, and semiconductor distributors must change with it. This newsletter examines the needs of component buyers and semiconductor suppliers in relationship to innovative distributors. Dataquest believes that those distributors who adapt to and meet these needs will both survive and thrive in the 1990s.

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SUIS April–June Index

- **The ASIC Package Proliferation** (1989–18)—Surface-mount technology now is mainstream. This newsletter discusses the packages currently being used or under development for ASICs, and it also reviews the issues and choices pertaining to standards involved in ASIC packaging. Dataquest believes that package proliferation will continue as the ASIC market develops.

- **North American Market Watch, April 1989: Signs of a Weakening Market Ahead** (1989–19)—The North American Market Watch is a monthly bulletin, released after the SIA book-to-bill flash report, that is designed to give a deeper insight into the monthly trends in North America semiconductor consumption. It indicates that prices have not declined significantly in the first quarter and semiconductor bookings remain considerably strong. However, Dataquest believes that the signs indicate a second half of 1989 that is not as rosy as the first.

- **National Semiconductor Restructures** (1989–20)—National Semiconductor has undergone a tremendous amount of change in its struggle to identify a structure that will result in profitable operations. This newsletter brings our Semiconductor User clients up to date on National's restructuring efforts. Dataquest believes that National's method of positioning its broad line of components products will bear watching as the company stakes its future on being a pure-play semiconductor company.

- **Semiconductor Users Eye the Risky "CISC-Y" World of 32-Bit Microprocessors** (1989–21)—Systems manufactures are confronting urgent decisions that could carry companies to prosperity or doom during the 1990s. They must decide which 32-bit CISC, RISC, or MPC to use and from which manufacturer. This newsletter highlights key issues of how Intel and Motorola are demonstrating to semiconductor users the continuing viability of CISC-based systems in the areas of performance, software, pricing, time to market, and worldwide manufacturing capability.

- **May Procurement Pulse: Inventory Levels Improve, DRAM Market Amiss** (1989–22)—The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin presents the results of the survey and analyzes what this information means to both semiconductor users and manufacturers. Dataquest concludes that accurate forecasting and inventory control by both users and vendors will be critical in preventing any slowdown from becoming a recession.

- **The Super Section 301: 1986 Trade Arrangement Déjà Vu?** (1989–23)—The May 30 Super Section 301 announcement raised many of the same questions that were asked in the summer of 1986 regarding semiconductors and their procurement. This newsletter briefly reviews the chronology of and the most common questions asked about this portion of the 1988 Ombudsman Trade Bill, analyzes what is in store for users of semiconductors in the wake of the announcement, and makes recommendations.

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SUIS April–June Index

- **Japanese Wafer Fab Update: New Fabs, Advanced DRAMs, and 8–inch Wafers** (1989–24)—In 1988, a three–month joint research project between Dataquest's San Jose and Tokyo offices was launched in order to provide in–depth information on Japan's semiconductor manufacturing activities. Thirteen production and pilot–based silicon fabs went into production during 1988. Japan has been very consistent about the addition of new fabs when compared with the United States. Dataquest concludes that if the Japanese rapidly adopt the single–generation DRAM fab strategy, a large bubble of advanced and low–cost capacity would begin to move into ASIC, MCU, and MPU production. By 1992, Japanese companies should be enjoying the fruits of their current ASIC and MPU efforts, which include many technology exchange agreements and joint development projects being conducted on– and offshore.

- **ISDN: Plans, Potentials, and Pitfalls** (1989–25)—Integrated Services Digital Network (ISDN) is an opportunity with high rewards and high risks for the semiconductor industry. This newsletter discusses the purpose behind ISDN, circuits and applications, and suppliers and demand. Dataquest concludes that ISDN represents an opportunity disguised as a challenge.

- **May Market Watch: System Shipment Rates Decline, Semiconductors Temporarily Steady** (1989–26)—This month's Market Watch focuses on the slowdown in booking growth, system shipment and order growth rates, low OEM semiconductor inventories, and the gradual decline reflected in Dataquest's price indicator. Despite the projected slowdown in the second half of 1989, Dataquest believes that the systems and semiconductor markets will remain healthy.

- **June Procurement Pulse: Order Rates Improving; Inventory Mix Changing** (1989–28)*—This month's Procurement Pulse survey results focus on the increased market confidence as June orders rise, lead times remain flat, and overall inventory levels drop. Dataquest does not expect the surge in June orders to be the beginning of a trend but rather a result of inventory adjustments, especially in memories.

* The number 27 (e.g., 1989–27) has been omitted.

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Research Bulletin

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JUNE PROCUREMENT PULSE: ORDER RATES IMPROVING; INVENTORY MIX CHANGING

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin will present the results of the monthly survey and analyze what this information means to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

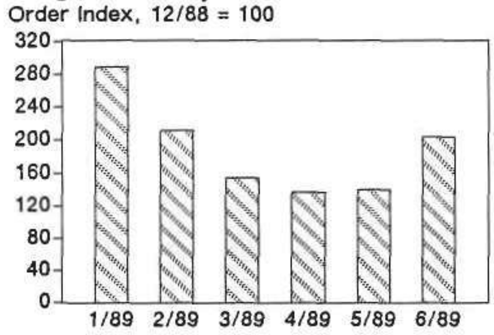


Figure 2
Averaged Semiconductor Lead Times

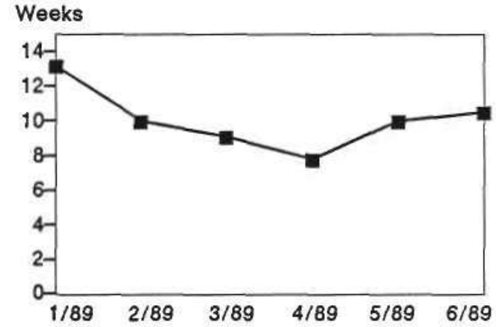


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

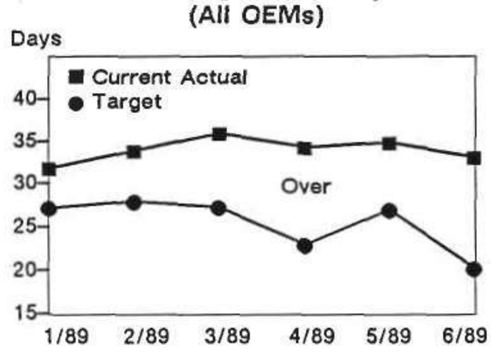
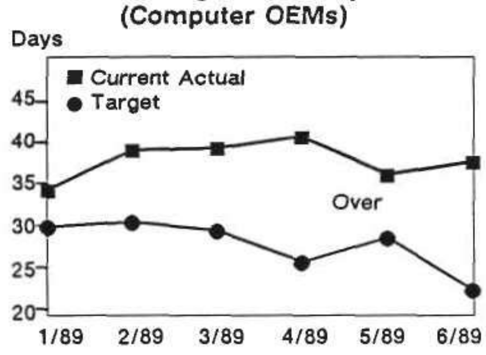


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



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Source: Dataquest
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INCREASED MARKET CONFIDENCE AS JUNE ORDERS RISE

Semiconductor purchasers in the Dataquest survey expect to increase their June orders sharply by 46 percent, as shown in Figure 1, paving the way for a possible rise in the June book-to-bill ratio. Two-thirds of these purchasers expect to have higher system shipments (of between 2 and 20 percent) in the second half of 1989, and the rest of the respondents expect flat sales. Although demand remains strong, Dataquest believes that the June order surge is not the beginning of a trend but rather a function of adjusting the poor mix of an already low inventory.

LEAD TIMES REMAIN FLAT

DRAMs and associated products continue to keep the average lead time high at 10.6 weeks, as shown in Figure 2. Slower speed (100 and 120ns) 1Mb DRAMs have become more available; some manufacturers are rumored to have full shelves and to be accepting lower prices. However, 80ns 1Mb DRAMs and 32Kx8 SRAMs are still in short supply, and allocations still exist. Other semiconductor lead times are at comfortable levels for both users and manufacturers.

OVERALL INVENTORY LEVELS DROP, BUT NON-DRAM LEVELS RISE SHARPLY

With easing of the DRAM shortage, many OEMs are reverting to traditional cost-cutting practices such as just-in-time shipments by cancelling delinquent orders and dramatically reducing targeted inventory levels, as illustrated in Figures 3 and 4. Actual inventories for all OEMs have dropped slightly from 35 to 33 days; those for computer OEMs rose slightly from 36 to 38 days.

However, non-DRAM inventory levels have risen dramatically. For all OEMs, actual inventory levels, less DRAM and work-in-process (WIP) inventory, have increased from 25.4 days in May to 33.7 days in June. For computer OEMS, actual inventory, less DRAM and WIP stock, jumped from 22 to 37 days. Target inventory levels of all OEMs increased from 21.6 days in May to 23.7 days in June, and those of computer OEMs also rose from 20.7 to 26.4 days.

DATAQUEST ANALYSIS

Dataquest does not expect the surge in June orders to be the beginning of a trend but rather a result of inventory adjustments, especially in memories. Any bookings surge should be interpreted with caution, as inventory levels for non-DRAM products have risen significantly in June. Manufacturers of these products should be concerned that the pipeline for their devices is filling up. Purchasers should be aware of the potential inventory-mix problem that could lead to higher inventory levels overall.

Mark Giudici
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MAY MARKET WATCH
SYSTEM SHIPMENT RATES DECLINE, SEMICONDUCTORS TEMPORARILY STEADY

Market Watch is a monthly bulletin that is released after the SIA book-to-bill flash report and designed to give a deeper insight into the monthly trends in the semiconductor market (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

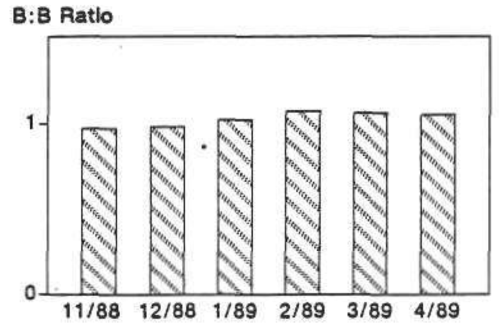


Figure 2
DOC Computer Demand

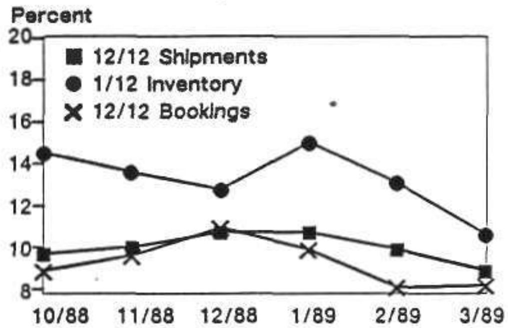


Figure 3
Semiconductor Inventory Level

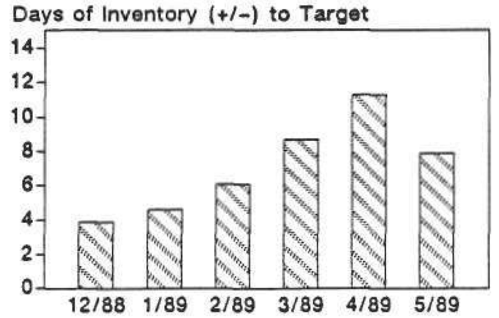
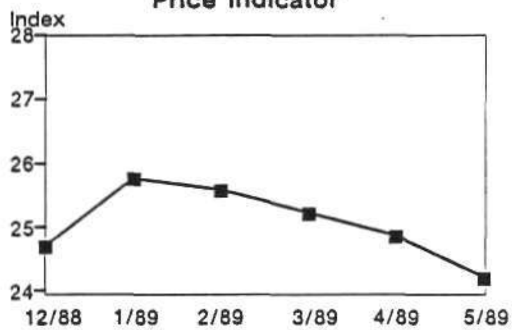


Figure 4
U.S. Weighted Semiconductor Price Indicator



0004012-1

Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
May 1989

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SLOWDOWN IN BOOKINGS GROWTH

The SIA book-to-bill report (see Figure 1) shows slower bookings growth both for April and on a moving three-month average basis. Dataquest's May procurement survey agrees with this, showing major OEM order rates slowing down to Q3 1988 levels after phenomenal first quarter performance. MOS memory continues to heavily drive the high levels of bookings and billings. Semiconductor sales are still expected to remain strong through the second quarter and into part of the third. Bookings are no longer spurred by product shortages, but more closely reflect true system demand, as lead times, shown in our May Procurement Pulse report, decline gradually.

SYSTEM SHIPMENT AND ORDER GROWTH RATES SLOW

The March 1989 computer shipment rate remains strong at about 9 percent above that of the previous year, but shipment growth is declining compared with last year (see Figure 2). Computer bookings show the same trend but are growing less than billings. Inventories are also decelerating. Although systems demand remains strong compared with last year, its growth is starting to slow. Declining growth in both inventory and computer orders shows a well-managed systems market, unlike that of 1985. This combination greatly reduces the possibility of severe order cuts, price declines, and a deep industry recession.

LOW OEM SEMICONDUCTOR INVENTORIES

There is also a decline in general OEM semiconductor inventories. The variance of actual to targeted inventories shown in Figure 3 dropped in May, primarily due to major buyers increasing their target inventory levels after having dropped them too much in April. Current actual semiconductor inventory levels of 35 days should keep order rates steady for the next two to three months.

DATAQUEST PRICE INDICATOR SHOWS CONTINUED GRADUAL DECLINE

The well-managed systems market combined with low inventory levels and improved semiconductor lead times are reflected in the continuing slow price decline in Dataquest's basket of products (Figure 4). Again it is unlikely that we will see severe price declines in 1989. Most of the price erosion comes from standard speed (120ns) 1Mb DRAMs and microprocessors. Prices of faster DRAMs remain very flat and high and will continue to make MOS memories the driving factor in overall semiconductor growth this year.

DATAQUEST ANALYSIS

A slowdown in the second half of 1989 is likely to be demand driven and will not necessarily be a devastating development. The computer market has displayed a good balance of orders and inventory, reducing the possibility of a repeat of 1985's deep recession. Despite the projected slowdown in the second half of 1989, Dataquest believes that the systems and semiconductor markets will remain healthy and profitable with sales in those months to be at or above those seen in 1988.

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ISDN: PLANS, POTENTIALS, AND PITFALLS

SUMMARY

Integrated Services Digital Network (ISDN) is an opportunity with high rewards and high risks for the semiconductor industry. As a result, technology alliances are being formed by semiconductor suppliers to reduce the costs of developing microelectronic components for ISDN (see Table 1).

ISDN semiconductors are highly integrated application-specific circuit functions that are used only in voice and data communications equipment. Sales of these chips depend on the rate at which a telephone network is converted over to ISDN.

Table 1

ISDN Technology Alliances

Announcement Date	Partners
June 1988	AMD, Siemens
July 1988	Level One, Mitel
October 1988	National, SGS-Thomson
February 1989	AT&T, Intel
March 1989	IMP, Mitel

Source: Dataquest
June 1989

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WHY ISDN?

ISDN is an open system. Interfaces between terminal equipment and the network are standard and invariant. However, technologies and services will change dramatically over the next several decades because of advances in science and new demands from users.

ISDN is intended to be a timeless architecture that would allow any new terminal or service to be connected to the network without reengineering the entire system each time.

Technology Evolution

Each new generation of semiconductor has more functions, while the price remains the same. For example, the industry average price of an integrated circuit (IC) has stayed between $0.90 and $1.10 since the early 1970s. However, the five dollars that would buy a single transistor in 1960 would buy an IC with the equivalent of 500,000 transistors in 1985.

These advancements are expected to continue. For example, discoveries that are still in the laboratory stage (e.g., bipolar quantum resonant tunneling) promise that semiconductors will be 100 times smaller and 1,000 times faster by the year 2000. ISDN is designed to allow the telephone network to adapt to this ever-increasing electronics capability.

Services Evolution

Telephone companies have always taken advantage of new technology to offer new communications services to users. Examples of past service innovations include direct dialing, touch-tone dialing, speed dialing, call blocking, call forwarding, and call waiting. These services were made possible by the declining cost of electronic components.

As electronic components continue to decline in cost, new services become more practical. Two examples include caller identification and central office voice mail. ISDN is designed to support the easy implementation of these and many other new services that users may demand in the future.

CIRCUITS AND APPLICATIONS

The sales potential for electronic circuits used with telephone lines is large (i.e., an estimated 19 million lines were shipped in the United States last year). Semiconductor suppliers can profitably build chips that are customized for this telecom application.

Some telecom ICs designed for pre-ISDN equipment are also needed for ISDN equipment, while other telecom ICs will be new. Table 2 compares the function content of pre-ISDN and ISDN equipment.

Table 2

Function Content of Telecom Equipment

Equipment	Pre-ISDN Content	ISDN Content
Central office switch line card	Codec, combo, or SLAC SLIC	N/A (in telephone) U-interface and basic rate access control
PBX line card	Codec, combo, or SLAC SLIC and SCC or UART	N/A (in telephone) S-interface and basic rate access control
Personal computer serial port	Modem and SCC or UART	S-interface and basic rate access control
Telephone	Dialer (tone, pulse)	S-interface and basic rate access control
	N/A (in switch)	Codec, combo, or SLAC

N/A = Not Applicable

Source: Dataquest
June 1989

Voice Equipment

Codecs, combos, and SLACs are ICs that convert analog speech into a digital waveform. These circuits, used on pre-ISDN line cards of central office switches and PBXs, will be located in ISDN telephones.

Dialers are ICs that generate either the pulses (rotary dial) or the tones (touch-tone dialing) needed to set up a telephone call. With ISDN, dialing (and other) information needed for a call will be placed directly on the basic access "D" channel at the telephone.

Data Equipment

SCCs and UARTs are ICs used for data communication within a system. These chips often are used in PBXs to send control signals between telephones and line cards. With ISDN, this communications function will be performed by the basic access "D" channel.

SCCs and UARTs also are in PCs to control the flow of data between memory and the serial port used by a modem. The S-interface will replace the modem, and it is capable of handling data rates up to 64 Kbps.

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Circuit Implementations

The equipment-level standards for ISDN are coordinated by the Consultative Committee on International Telephony and Telegraphy (CCITT) and finally are solidifying after many years of discussion. The ISDN standards at the chip level are defined by the industry, however, and the debate is just beginning. The proposed interchip connection standards are as follows:

- Concentration Highway (K2)
- General Component Interface (GCI, IOM-2, V*)
- Interchip Digital Link (IDL)
- Serial MPU Bus
- ST Bus (ST)
- Subscriber Line Datalink (SLD)

Another important item at the component level is software. An ISDN interface circuit requires both hardware and software to implement the CCITT standards. Most original equipment manufacturers (OEMs) require that ISDN software be certified before ISDN semiconductors can be used in their equipment.

SUPPLIERS AND DEMAND

Several companies either are or will be supplying semiconductors for ISDN equipment (see Table 3). Many of these companies have been shipping telecom ICs for pre-ISDN equipment. For these suppliers, ISDN ICs represent extensions of their existing product lines. For example, the design of the circuit functions needed in both pre-ISDN and ISDN equipment are determined by the requirements of the telecom application. In addition, the customer base is the same because the same OEMs are building both pre-ISDN and ISDN equipment.

Table 3

ISDN Semiconductor Suppliers

AMD	Gold Star	Motorola	SGS-Thomson
AT&T	Gould	National	Siemens
Cal Micro	Hitachi	NEC	Sierra
Cirrus	Harris	OKI	Siliconix
Crystal	IMP	Philips/Signetics	Silicon Systems
Dallas	Intel	Plessey	TI
Ericcson	Level One	PMI	Western Digital
Exar	Mitel	Rockwell	Zilog
Fujitsu	Mitsubishi	Samsung	

Source: Dataquest
June 1989

Demand Forecast

Dataquest estimates that ISDN semiconductor sales in the United States will be approximately $70 million in 1989 and approximately $700 million in 1995 (see Table 4).

Table 4

U.S. ISDN Semiconductor Forecast
(Thousands of Units, Millions of Dollars of Sales)

Function	Item	1989	1992	1995	CAGR 1989-1995
Basic Access	Units	725.0	3,400.0	19,000.0	72.4%
Control Function	ASP	$15.0	$ 8.0	$ 6.0	(14.2%)
	Sales	$10.9	$ 27.2	$114.0	48.9%
S-interface	Units	710.0	3,050.0	17,000.0	70.0%
	ASP	$18.0	$ 10.0	$ 7.0	(14.6%)
	Sales	$12.8	$ 30.5	$119.0	45.0%
U-interface	Units	540.0	2,400.0	15,000.0	74.0%
	ASP	$95.0	$ 45.0	$ 30.0	(17.5%)
	Sales	$51.3	$108.0	$450.0	43.6%
Total Sales		$75.0	$165.7	$683.0	44.5%

Source: Dataquest
June 1989

DATAQUEST CONCLUSIONS

ISDN represents an opportunity disguised as a challenge. Semiconductor companies have traditionally relied on learning curves for success (i.e., lower the price, increase unit production, reduce unit cost, and make a profit).

This scale-economies strategy worked for the consumer electronics revolution in the 1970s and the PC revolution in the 1980s. Growth of the telephone business, however, is related to growth of the population and is more inelastic in price than other semiconductor markets.

Semiconductors Are Now Subsystems

The semiconductor industry also may have become a victim of its own success. Integration has meant that more circuit functions have moved onto the chip, so that a chip now has become a subsystem.

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An equipment manufacturer has to be able to specify the functions inside these VLSI chips, because the equipment in which the chips are to be used has to be differentiated from competing brands. Since each equipment model is slightly different, the semiconductor manufacturer has to make it easy for each chip to be slightly different.

OEMs also want integrated components for the design of the electronic circuits inside the equipment. This sometimes means having both analog and digital functions on the same chip.

Timeliness and Added Value Command A Price

The new element of success for semiconductor suppliers may well be aiming for and hitting market windows of opportunity. Having a chip with the right functions when new equipment is being designed is becoming more important than creating a chip with a minimum size well after the design of the equipment is completed.

Dataquest recommends that semiconductor users do the following:

- Know about the different types of ISDN offered and choose a vendor with alternate sources to account for the long life cycle of communications products.

- Make arrangements with a supplier for early joint planning of the ISDN designs needed in the equipment.

- Link the end systems with the life cycle of the ISDN component technology to ensure adequate supplies and proprietary features.

- Realize that the systems nature of ISDN components makes them similar to the sourcing of semicustom components and that pricing will be a secondary issue.

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JAPANESE WAFER FAB UPDATE: NEW FABS, ADVANCED DRAMS, AND 8-INCH WAFERS

INTRODUCTION

In 1988, a three-month joint research project between Dataquest's San Jose and Tokyo offices was launched in order to provide in-depth information on Japan's semiconductor manufacturing activities. The results are discussed in this newsletter, and include information on manufacturing trends and fabs that went into production during 1988, as well as information on the announced, initiated, and forecast fab lines that will go into production through the early 1990s.

MANUFACTURING TRENDS

Thirteen production and pilot-based silicon fabs went into production during 1988. In 1989, 14 will go into production, and 12 more are expected to come on-line in 1990. Eight other gallium arsenide and R&D lines also should come on-line during 1988 through 1990. Dataquest also knows of 13 more fab lines that are planned to go into production after 1990.

Details of all known fabs started up since 1988 are listed in Table 1. Table 2 lists the status definitions used in Table 1.

Nine of the 13 production and pilot-based silicon fabs that began operations during 1988 produce advanced DRAMs and SRAMs. Ten of the 14 fabs begun during 1989 and 9 of the 12 during 1990 also will produce advanced DRAMs and SRAMs. Approximately 75 percent of these new fabs will produce advanced 1Mb or 4Mb DRAMs and, with few exceptions, all will process linewidths at 1 micron or less, on 6-inch or 8-inch wafers. The average wafer-start capacity for future production-based DRAM lines is 21,133 wafers per four-week period, while the average wafer-start capacity for future DRAM pilot lines is 8,500 wafers per four-week period. Capacity figures stated here reflect capacity of the fab when it is completely filled with equipment.

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Table 1

Japanese Fab Activity Planned or Initiated to Begin Producing During 1988 and Beyond

Company	Prefecture	City	Plant Name	Fab Name	Status	Target Date Prod. Begins	Wafer Size (In.)	Clean Room Square Feet	Drawn Line Width	Process Technology	Products to be Produced	Start Capacity Per Month	Fab Type
					PRODUCTION BEGAN 1988								
FUJITSU	FUKUSHIMA	AIZU WAKAMATSU-SHI	AIZU F	VLSI 3	EQUIPMENT UPGRADE		6	0	1.00	CMOS MOS	1Mb DRAM SRAM ROM	40,000	F
FUJITSU	KANAGAWA	KAWASAKI-SHI	N/A	N/A	NEW SHELL/CLEAN ROOM		6	0	0.70	CMOS	16Mb DRAM	8,000	R
FUJITSU	KANAGAWA	KAWASAKI-SHI	N/A	N/A	NEW SHELL/CLEAN ROOM		3	0	0.00	GaAs	HEMT PHET	0	R
FUJITSU	KANAGAWA	KAWASAKI-SHI	N/A	N/A	NEW SHELL/CLEAN ROOM		5	0	0.00	N/A	3D ICs JOSEPHSON JUNCTION	15,000	P
HITACHI	HOKKAIDO	CHITOSE-SHI	HOKKAI S/C	CHITOSE F	EQUIPMENT EXPANSION	12/01/88	6	20,000	1.00	CMOS	64K 256K SRAM	15,000	F
HITACHI	IBARAGI	KATSUTA-SHI	NAKA WORKS	N/A	EQUIPMENT UPGRADE		6	20,000	0.80	CMOS	1Mb DRAM SAMPLE 4Mb	35,000	F
HITACHI	IBARAGI	KATSUTA-SHI	NAKA WORKS	N/A	NEW CLEAN ROOM	01/01/88	6	0	1.00	CMOS	1Mb DRAM 1Mb SRAM	9,000	F
HITACHI	YAMANASHI	NAKAKOMA-GUN	KOFU WORKS	NO. K4-2	NEW CLEAN ROOM		6	0	1.00	CMOS	1Mb DRAM	20,000	F
IBM	SHIGA	YASU-GUN	S/C RSRCH CTR	N/A	NEW SHELL/CLEAN ROOM	05/01/88	8	0	0.00	CMOS	1Mb 4Mb DRAM	0	P
MATSUSHITA	NIIGATA	ARAI-SHI	ARAI F	FAB D	EQUIPMENT EXPANSION		5	0	1.50	BIP	LOG LIN CCD	40,000	F
MATSUSHITA	TOYAMA	UOZU-SHI	UOZU F	FAB C-1	NEW SHELL/CLEAN ROOM	07/01/88	6	0	1.00	CMOS	1Mb DRAM SAMPLE 4Mb	20,000	F
MITSUBISHI	EHIME	SAIJO-SHI	SAIJO C	N/A	EQUIPMENT UPGRADE		6	43,060	0.80	CMOS	256K 1Mb DRAM SAMPLE 4Mb	30,000	FAT
MITSUBISHI	KOCHI	KAMI-GUN	KOCHI FACTORY	N/A	EQUIPMENT EXPANSION	06/01/88	6	0	1.00	CMOS	8-bit 16-bit MCU 1Mb DRAM	10,000	FAT
NEC	KANAGAWA	SAGAMIHARA-SHI	SAGAMIHARA	ULSI R&D	NEW CLEAN ROOM	06/01/88	8	0	0.80	CMOS	4Mb DRAM ASIC	13,500	P
NEC	KUMAMOTO	KUMAMOTO-SHI	KYUSHU	FAB 7	NEW CLEAN ROOM	06/01/88	6	30,000	1.00	CMOS MOS	ASIC 32-bit MPU 1Mb DRAM	35,000	F
NEC	YAMAGUCHI	ASA-GUN	YAMAGUCHI LTD	PHASE 2	NEW SHELL/CLEAN ROOM	06/01/88	6	24,760	0.80	CMOS	4Mb DRAM 1Mb SRAM MPU	20,000	FAT
NEC	YAMAGUCHI	ASA-GUN	YAMAGUCHI LTD	PHASE 1	EQUIPMENT UPGRADE		6	0	1.00	CMOS MOS	256K 1Mb DRAM SRAM MPU	20,000	F
NMB SEMICONDUCTOR	CHIBA	TATEYAMA-SHI	N/A	FAB 2	EQUIPMENT EXPANSION	10/01/88	6	43,000	1.00	CMOS M1	1Mb DRAM SRAM SAMPLE 4Mb	10,000	NFAT
OKI	MIYAZAKI	MIYAZAKI-GUN	MIYAZAKI OKI	M1	UPGRADE	04/01/88	5	0	1.50	CMOS	256K DRAM SRAM ARRAYS MPU	50,000	FAT
SEIKO EPSON	NAGANO	SUWA-GUN	FUJIMI PLANT	BLDG D	EQUIPMENT EXPANSION	12/01/88	6	0	1.20	CMOS	ARRAYS CBIC 256K SRAM	20,000	NF
SHINDENGEN	YAMAGATA	HIGASHINE-SHI	HIGASHINE DIV.	BLDG 2 MOS	NEW CLEAN ROOM		5	27,311	2.00	CMOS MOS	CUSTOM	25,000	F
SONY	KAGOSHIMA	KOKUBU-SHI	SONY KOKUBU	N/A	EQUIPMENT EXPANSION		5	0	1.30	BIP CMOS MOS	SRAM MPU CCD LIN A/D D/A	30,000	FAT
SONY	KANAGAWA	ATSUGI-SHI	ATSUGI PLANT	N/A	EQUIPMENT EXPANSION		3	0	0.00	GaAs	FET LASER CCD	0	FAT
TI	IBARAGI	INASHIKI-GUN	MIHO PLANT	MIHO 6.2	EQUIPMENT EXPANSION	12/01/88	6	30,000	0.80	CMOS BICMOS	SRAM 1Mb DRAM SAMPLE 4Mb	24,000	F
TOHOKU SEMICONDUCTOR	MIYAGI	IZUMI-SHI	SENDAI FACTORY	N/A	NEW SHELL/CLEAN ROOM	08/01/88	6	42,000	1.00	CMOS	1Mb DRAM 256K SRAM MPU	20,000	FAT
TOSHIBA	FUKUOKA	KITAKYUSHU-SHI	KITAKYUSHU P	KUBIC 2	NEW CLEAN ROOM	10/01/88	5	21,530	2.00	BICMOS	ASIC OPTO LOG	20,000	NF
TOSHIBA	KANAGAWA	KAWASAKI-SHI	ULSI LAB	N/A	NEW CLEAN ROOM		6	0	0.70	BIP CMOS	3D ICs 16Mb DRAM	4,000	R
TOSHIBA	OITA	OITA-SHI	TOSHIBA OITA	STEP 3 #7	NEW CLEAN ROOM	06/01/88	6	0	1.00	CMOS	1Mb DRAM	30,000	F
YAMAHA	KAGOSHIMA	AIRA-GUN	KAGOSHIMA PLANT	N/A	EQUIPMENT UPGRADE	09/01/88	5	0	1.20	CMOS	ROM CBIC ASSP	35,000	FAT
YAMAHA	SHIZUOKA	HAMAMATSU-SHI	TOYOOKA WORKS	EE DEV CTR	NEW SHELL/CLEAN ROOM	12/01/88	6	0	0.80	CMOS	CBIC LOG	6,000	P

(Continued)

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Table 1 (Continued)

Japanese Fab Activity Planned or Initiated to Begin Producing During 1988 and Beyond

Company	Prefecture	City	Plant Name	Fab Name	Status	Target Date Prod. Begins	Wafer Size (In.)	Clean Room Square Feet	Drawn Line Width	Process Technology	Products to be Produced	Start Capacity Per Month	Fab Type
PRODUCTION BEGINS 1989													
CANON	SHIGA	NAGAHAMA-SHI	NAGAHAMA WORKS	N/A	NEW SHELL/CLEAN ROOM	03/01/89	3	0	0.80	GaAs	AMORPHOUS IMAGE SENSORS	0	P
FUJITSU	FUKUSHIMA	AIZU WAKAMATSU-SHI	WAKAMATSU F	NO. 3	NEW SHELL/CLEAN ROOM		6	0	0.00	CMOS	1Mb DRAM ASIC	0	P
FUJITSU	MIE	KUWANA-GUN	MIE F	NO. 3	NEW SHELL/CLEAN ROOM	06/01/89	8	0	0.80	CMOS	4Mb DRAM	7,000	P
FUJITSU	MIYAGI	SHIBATA-GUN	MIYAGI	N/A	NEW SHELL/CLEAN ROOM		6	0	1.20	CMOS	ASIC	0	P
MITSUBISHI	KOCHI	KAMI-GUN	KOCHI FACTORY	N/A	NEW SHELL/CLEAN ROOM	10/01/89	6	0	1.00	CMOS	1Mb DRAM SAMPLE 1Mb SRAM	12,000	P
NEC	IBARAGI	TSUKUBA-GUN	TSUKUBA R&D CTR	N/A	NEW SHELL/CLEAN ROOM	04/01/89	0	0	0.40	GaAs CMOS	OPTO 3D 64Mb DRAM SOR	0	R
NIPPON PRECISION CIRCUITS	TOCHIGI	NASU-GUN	N/A	N/A	N/A		6	21,530	0.00	CMOS	LOG LIN	7,000	P
OKI	MIYAGI	KUROKAWA-GUN	MIYAGI OKI	N/A	NEW SHELL/CLEAN ROOM	05/01/89	6	0	1.00	CMOS	ARRAY 1Mb DRAM SAMPLE 4Mb	20,000	PAT
ROHM	KYOTO	KYOTO-SHI	LSI RESEARCH	N/A	NEW SHELL/CLEAN ROOM	05/01/89	6	27,000	1.20	CMOS	256K SRAM	15,000	P
SANYO	NIIGATA	OJIYA-SHI	NIIGATA SANYO	BLDG 2 CMOS	NEW CLEAN ROOM	06/01/89	6	0	1.00	BICMOS CMOS	ASIC PLD 1Mb DRAM	16,000	P
SHARP	HIROSHIMA	FUKUYAMA-SHI	FUKUYAMA PLANT	BLDG 2	NEW SHELL/CLEAN ROOM	07/01/89	6	0	0.80	CMOS	1Mb DRAM 16Mb ROM CCD	20,000	PAT
SONY	NAGASAKI	ISAHAYA-SHI	SONY NAGASAKI	N/A	READY FOR EQUIPMENT	03/01/89	6	25,000	1.00	CMOS	1Mb SRAM CCD	5,000	P
SORTEC	IBARAGI	TSUKUBA-GUN	N/A	N/A	NEW SHELL/CLEAN ROOM	05/01/89	8	0	0.40	N/A	SOR LITHO RESEARCH	0	R
TI	OITA	ITSUMI-GUN	HIJI PLANT	N/A	NEW SHELL/CLEAN ROOM	06/01/89	8	26,912	0.80	CMOS	4Mb DRAM	0	P
TOSHIBA	IWATE	KITAKAMI-SHI	IWATE TOSHIBA	PHASE 3	NEW SHELL/CLEAN ROOM	10/01/89	6	0	0.00	CMOS	ASIC	36,000	P
TOSHIBA	OITA	OITA-SHI	TOSHIBA OITA	STEP 3 #8	NEW CLEAN ROOM	04/01/89	6	0	0.80	CMOS	4Mb DRAM	30,000	PAT
TOYOTA	AICHI	TOYOTA-SHI	CENTRAL LAB	N/A	NEW SHELL/CLEAN ROOM	03/01/89	5	0	0.00	CMOS	MCU PWR ICs CUSTOM	0	P
PRODUCTION BEGINS 1990													
FUJITSU	IWATE	IZAWA-GUN	IWATE F	NO. 4	NEW SHELL/CLEAN ROOM	10/01/90	8	0	0.80	CMOS MOS POLY3	4Mb DRAM SRAM	25,000	P
HAMAMATSU PHOTONICS	SHIZUOKA	HAMAMATSU-SHI	HAMAKITA R&D	N/A	NEW SHELL/CLEAN ROOM	03/01/90	0	0	0.00	N/A	OPTO	0	R
HITACHI	TOKYO	KODAIRA-SHI	MUSASHI WORKS	N/A	NEW SHELL/CLEAN ROOM	01/01/90	8	0	0.80	CMOS	4Mb DRAM	0	P
HITACHI	YAMANASHI	NAKAKOMA-GUN	KOFU WORKS	IMASUWA F	NEW SHELL/CLEAN ROOM	02/01/90	6	0	0.80	CMOS	4Mb DRAM	0	P
IBM	SHIGA	YASU-GUN	N/A	N/A	NEW SHELL/CLEAN ROOM	04/01/90	8	0	0.80	N/A	1Mb 4Mb DRAM LOG	0	P
MATSUSHITA	TOYAMA	UOZU-SHI	UOZU F	FAB C-2	NEW CLEAN ROOM		6	0	0.80	CMOS	4Mb DRAM	0	P
NATIONAL SEMICONDUCTOR	N/A	N/A	N/A	N/A	NEW SHELL/CLEAN ROOM		0	0	0.00	N/A	N/A	0	R
NEC	HIROSHIMA	HIGASHI-HIROSHIMA	CHUGOKU	PHASE 1	NEW SHELL/CLEAN ROOM	08/01/90	6	38,754	0.80	CMOS	4Mb DRAM SRAM 32-bit MPU	30,000	PAT
NEC	KANAGAWA	SAGAMIHARA-SHI	SAGAMIHARA	16Mb PROTO	NEW SHELL/CLEAN ROOM	02/01/90	8	20,000	0.55	CMOS	16Mb DRAM	5,000	P
NIPPON DENSO	AICHI	KARIYA-SHI	KODA WORKS	BLDG. 2	NEW SHELL/CLEAN ROOM	12/01/90	0	0	0.00	MOS	MCU	0	P
NMB SEMICONDUCTOR	CHIBA	TATEYAMA-SHI	N/A	FAB 3	NEW SHELL/CLEAN ROOM	06/01/90	6	0	0.80	CMOS	4Mb DRAM	10,000	P

(Continued)

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Table 1 (Continued)

Japanese Fab Activity Planned or Initiated to Begin Producing During 1988 and Beyond

Company	Prefecture	City	Plant Name	Fab Name	Status	Target Date Prod. Begins	Wafer Size (In.)	Clean Room Square Feet	Drawn Line Width	Process Technology	Products to be Produced	Start Capacity Per Month	Fab Type
					PRODUCTION BEGINS 1990 (Continued)								
RICOH	OSAKA	IKEDA-SHI	N/A	N/A	NEW SHELL/CLEAN ROOM		6	0	1.00	CMOS	ARRAYS	0	F
SHINDENGEN	YAMAGATA	HIGASHINE-SHI	HIGASHINE DIV.	BLDG 3	NEW SHELL/CLEAN ROOM		0	0	0.00	CMOS MOS	CUSTOM	0	F
TOSHIBA	OITA	OITA-SHI	TOSHIBA OITA	STEP 3 #9	NEW CLEAN ROOM		6	0	0.80	CMOS	4Mb DRAM	0	F
					PRODUCTION BEGINS 1991								
ASAHI MICRO SYSTEMS	MIYAZAKI	N/A	N/A	N/A	NEW SHELL/CLEAN ROOM		8	0	0.00	N/A	ASIC LIN A/D D/A ASSP	0	F
INTERNATIONAL RECTIFIER	AKITA	KAWABE-GUN	AKITA FACTORY	N/A	NEW SHELL/CLEAN ROOM		0	0	0.00	N/A	DIS	0	FAT
MITSUBISHI	EHIME	SAIJO-SHI	SAIJO D	N/A	NEW SHELL/CLEAN ROOM	01/01/91	6	0	0.80	CMOS	4Mb DRAM	0	P
MOTOROLA	MIYAGI	IZUMI-SHI	SENDAI PLANT	MOS 10	NEW SHELL/CLEAN ROOM		6	0	0.80	CMOS	4Mb DRAM MPU	0	F
NEC	HIROSHIMA	HIGASHI-HIROSHIMA	CHUGOKU	PHASE 2	NEW SHELL/CLEAN ROOM	06/01/91	8	0	0.80	CMOS	4Mb DRAM EPROM	0	F
OKI	MIYAZAKI	MIYAZAKI-GUN	MIYAZAKI OKI	M3	NEW CLEAN ROOM	02/01/91	6	0	1.00	CMOS	4Mb DRAM	0	F
SEIKO EPSON	NAGANO	SUWA-GUN	FUJIMI PLANT	BLDG E	NEW SHELL/CLEAN ROOM		6	0	0.80	CMOS	ARRAYS CBIC 1Mb SRAM	0	F
SONY	KANAGAWA	KAWAHARA, OKADA	ATSUGI PLANT	N/A	N/A		0	0	0.00	GaAs CMOS	MEM LIN OPTO DIS	0	P
TI	IBARAGI	TSUKUBA-GUN	N/A	N/A	NEW SHELL/CLEAN ROOM	01/01/91	0	0	0.00	N/A	64Mb DRAM CONSUMER ICs	0	R
					PRODUCTION BEGINS 1992								
KAWASAKI STEEL	N/A	N/A	N/A	N/A	NEW SHELL/CLEAN ROOM		0	0	0.00	CMOS	ASIC	0	F
SONY	KAGOSHIMA	KOKUBU-SHI	SONY KOKUBU	N/A	N/A		6	0	0.80	BIP CMOS MOS	LOG MEM MPU LIN DIS OPTO	0	FAT
					PRODUCTION BEGINS 1993								
NEC	HIROSHIMA	HIGASHI-HIROSHIMA	CHUGOKU	PHASE 3	NEW SHELL/CLEAN ROOM		8	0	0.60	CMOS	16Mb DRAM MPU EPROM	0	F
					PRODUCTION BEGINS 1994								
NEC	HIROSHIMA	HIGASHI-HIROSHIMA	CHUGOKU	PHASE 4	NEW SHELL/CLEAN ROOM		8	0	0.60	CMOS	16Mb DRAM MPU EPROM	[illegible]	[illegible]

Note: F = Production-based fab line
P = Pilot line
R = R&D line
A = Assembly
T = Test

N/A = Not Available

Source: Dataquest
May 1989

Table 2

Nomenclature and Definitions
Status Field

Nomenclature	Definition
New Shell/Clean Room	Brand new from the ground up (green field)
New Clean Room	The building is complete and ready for clean room installation
Ready for Equipment	The clean room is complete and ready for equipment installation
Clean Room Expansion	Increase of total square footage for an existing clean room
Equipment Expansion	The installation of additional equipment to an existing clean room
Expansion	An increase in total clean room square footage and installed equipment
Clean Room Upgrade	Improved cleanliness, design, DI water, and/or vibration isolation
Equipment Upgrade	Conversion to larger wafer size and/or finer linewidths; equipment replacement, retrofit, and/or refurbishment
Upgrade	Clean room upgrade and equipment upgrade
Reramp from Shutdown	Brought back into production from a shutdown

Source: Dataquest
May 1989

Along with the 13 new fabs turned on during 1988, 13 additional fabs received major upgrades and/or capacity expansions. From 1984 through 1990, Japan has, and will, consistently add approximately 12 new fabs per year. When looking at upgrades and capacity expansions, Japan jumped to 13 upgrades and capacity expansions during 1988, up from approximately 3 per year for the years 1984 through 1987.

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To summarize, Japan has brought up new fab lines at a fairly consistent rate of 12 per year since 1984. However, upgrade and capacity expansion activity during 1988 increased four times over previous years. Japan has been very consistent about the addition of new fabs when compared with the United States. While Japan will continue to add approximately 12 new production and pilot-based silicon fabs per year from 1984 through 1990, the United States fluctuates between 8 and 21 per year during the same time period. Dataquest believes that most new fabs that have or will come on-line in Japan during industry downturns begin production with a small fraction of the equipment that they will ultimately contain. The companies that own these fabs are therefore well positioned for the next upturn by quickly adding equipment to their partially utilized floor space. There also are new fabs coming on-line during the upturn years that fill their own fab floor with equipment very quickly.

NEXT-GENERATION FABS

During 1988 and 1989, we will see the first dedicated 4Mb DRAM fabs begin operation in Japan. These fabs will most likely supply a good part of the more than 10 million 4Mb DRAMs expected to be shipped per month during 1990 (see Table 3).

Table 3

Fab Generations by DRAM Density

Fab Line Generation	DRAM Density	Sample Year	> 10 Million Units/Mo	Peak Prod. Year	Linewidth, Sample to Full Shrink	Lithography Tools Used in Japan
First	16K	1976	1978	1982	5-3um	Contact/proximity aligner
First	64K	1979	1981	1984	3-2um	Proximity/projection aligner
Second	256K	1983	1984	1988	2-1.2um	G-line stepper
Second	1Mb	1985	1987	1991	1.2-0.8um	High N.A. G-line stepper
Third	4Mb	1988	1990	1994	0.8-0.6um	High N.A. G-line/I-line stepper
Fourth?	16Mb	1991	1993	1997	0.6-0.4um	I-line/excimer laser stepper
Fifth?	64Mb	1994	1996	2000	0.4-0.3um	Excimer laser/SOR X-ray
Sixth?	256Mb	1997	1999	2003	0.3-0.2um	SOR X-ray

Source: Dataquest
May 1989

Historically, an advanced fab in Japan has produced two generations of DRAMs. It has been logical to try to produce as many generations of a DRAM as possible from the same fab because DRAMs have represented the clear majority of Japanese production. Traditionally, these fabs have upgraded or replaced some of the installed equipment in order to produce the second DRAM generation through its die shrink.

Now, however, Japanese DRAM production is decreasing relative to total Japanese IC production. This is due to Japanese gains in ASICs, MCUs, MPUs, and other ICs for consumer, computer, and automotive applications. As Japanese companies gain more market share in the non-DRAM categories, shifting production down the "product food chain," as opposed to retooling the fab for next-generation DRAMs, will be easier to do. Examples of the product food chain that a fab could produce during its useful life, from beginning to end, include: DRAMs/SRAMs, gate arrays, CBICs, MCUs/MPUs, opto devices, standard logic, analog, power ICs, and discretes. Dataquest believes that more of these new and future DRAM fabs will produce one, or perhaps one-and-a-half, DRAM generations instead of two generations due to these gains in non-DRAM IC products and the ability to take production down the product food chain. Other factors that could influence semiconductor manufacturers to move toward this single-DRAM generation fab concept include the following:

- The implementation of common "core" manufacturing processes for all product divisions (Under ideal conditions, this concept only requires that the mask set be changed for manufacturing a different product while using the same "core" process recipe)
- The rapidly increasing cost of semiconductor processing equipment
- Conversion to 8-inch wafers for volume production of next generation DRAMs
- Required purity improvements in deionized (DI) water and gas-handling systems for next generation DRAM manufacturing
- The reduction of process capability overlap for semiconductor processing equipment when moving from one DRAM generation to the next

Dataquest has observed the beginning of this movement toward single-generation DRAM fabs, with some companies bringing up dedicated 1Mb fab lines that are not expected to be upgraded to 4Mb DRAM production. Rather than upgrading, these fabs most likely will shift production down the product food chain toward gate array and MCU/MPU products after 1Mb production peaks in 1991. Although 4Mb DRAMs have been sampled out of these 1Mb fabs, Dataquest has noted that, so far, all Japanese manufacturers have plans to do volume production in new, dedicated 4Mb lines (see Table 4).

Two of the factors that could contribute to the decline of two-generation DRAM fabs are the high costs and physical restrictions associated with the conversion to 8-inch wafers and major improvements in DI water and gas-handling systems. Most conversions from starting up new 6-inch lines to new 8-inch lines will occur during the ramp-up of the 4Mb generation and the following 16Mb generation of DRAMs.

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Table 4

Progression of 4Mb/16Mb/64Mb DRAM Activity in Japan

	R&D/Trial Production				Pilot/Prototype Line				Production Line			
Company	Location	DRAM	Year	Wafer Size	Location	DRAM	Year	Wafer Size	Location	DRAM	Year	Wafer Size
NEC	Tamagawa Works	4Mb 16Mb	1986	5-inch	Yamaguchi Ltd.	4Mb	1988	6-inch	Chugoku Ltd.	4Mb	1990	6-inch
NEC					Sagamihara	4Mb	1988	8-inch	Chugoku Ltd.	4Mb	1991	8-inch
NEC					Sagamihara	16Mb	1990	8-inch	Chugoku Ltd.	16Mb	1993	8-inch
NEC									Chugoku Ltd.	16Mb	1994	8-inch
NEC	Tsukuba R&D Ctr.	64Mb	1989	5-inch								
Hitachi					Mobara Works	4Mb	1987	6-inch	Kofu Works	4Mb	1990	6-inch
Hitachi					Naka Works*	4Mb	1988	6-inch				
Hitachi					Musashi Works	4Mb	1990	8-inch				
Hitachi	Central Lab	16Mb	1986	5-inch								
Toshiba					Tamagawa Plant	4Mb	1987	6-inch	Oita Plant	4Mb	1989	6-inch
Toshiba									Oita Plant	4Mb	1990	6-inch
Toshiba	ULSI Lab	16Mb	1988	6-inch								
Fujitsu					Mie Plant*	4Mb	1987	6-inch	Iwate Works	4Mb	1990	8-inch
Fujitsu					Mie Plant	4Mb	1989	8-inch				
Fujitsu	Atsugi Lab	16Mb	1987	6-inch								
Fujitsu	Kawasaki	16Mb	1988	6-inch								
Mitsubishi					Saijo*	4Mb	1988	6-inch	Saijo	4Mb	1991	6-inch
Mitsubishi	Central Research	16Mb	1986	5-inch								
Matsushita	Kyoto Lab	4Mb	1985	6-inch	Uozu Factory	4Mb	1988	6-inch	Uozu Factory	4Mb	1990	6-inch
Matsushita	S/C Research Ctr.	16Mb 64Mb	1986	6-inch								
TI					Miho*	4Mb	1988	6-inch				
TI					Hiji Plant	4Mb	1989	8-inch				
TI	Tsukuba	64Mb	1991	N/A								
IBM					Yasu Plant	4Mb	1988	8-inch	Yasu Plant	4Mb	1990	8-inch
NMB					Chiba	4Mb	1989	6-inch	Chiba	4Mb	1990	6-inch
Oki					Miyagi	4Mb	1989	6-inch	Miyazaki	4Mb	1991	6-inch
Motorola									Sendai	4Mb	1991	6-inch

Note: This table does not include existing fab lines that may be upgraded to more advanced DRAM production in the future.

*Denotes fab line that went into production before the year listed on this table and was upgraded for sample production, not newly built.

Source: Dataquest
May 1989

Dataquest also believes that major improvements in the purity of DI water and gases have become necessary for the production of 4Mb DRAMs. We note that many new dedicated 4Mb lines are being built. Dr. Ohme, a professor at the School of Engineering, Tohoku University, Sendai, Japan, is the founder of the ultra clean room and is widely recognized as the originator of the total concept approach to clean room and advanced semiconductor process technologies. His concepts for ultra-clean DI water and gas-handling systems now are gaining acceptance for installation into the future production environment. Recently, an Ultra Clean Technology (UCT) group with nearly 40 Japanese companies as founding members was organized by Dr. Ohme. This group will develop a UCT-based system for supplying materials, parts, and production equipment necessary for manufacturing submicron devices.

Dataquest also notes NEC's announcement that it will build a small, 5,000 wafer per month, dedicated 16Mb DRAM pilot line in Sagamihara at a cost of $160 million, including process equipment. Part of the high cost for NEC's 16Mb line will come from the 8-inch equipment that we expect that it will use. However, Dataquest also believes that major improvements in DI water and gas-handling systems can also help explain the high cost of this pilot line.

Lithography Limits and Options

Companies that construct new 4Mb lines using high numerical aperture (N.A.) g-line steppers are expected to achieve a minimum linewidth of 0.65 micron at 0.55 N.A. Unless unexpected advancements in high N.A. g-line lens technology occur, the final die shrink for 4Mb production at 0.6 micron and initial 16Mb production starting at 0.6 micron will not be likely (see Table 3). This 0.65-micron limit would force the users of g-line to install new lithography tools for the final die shrink of the 4Mb DRAM and to begin production of the 16Mb DRAM.

Companies that construct new 4Mb lines using i-line lithography are expected to achieve the full die shrink of the 4Mb DRAM and get into initial 16Mb production at 0.6 micron. However, they are not anticipated to be capable of achieving any die shrinks, and excimer laser lithography would be required to finish the 16Mb die shrink at 0.4 micron. New 4Mb fabs brought up on high N.A. g-line steppers could, at best, make the final die shrink of the 4Mb DRAM. This shift will mark the end of a long series of incremental improvements in g-line lithography that will have lasted more than 15 years. For new 4Mb fabs brought up on i-line steppers, this shift will mark the beginning of a rather short transitory phase in Japan, most likely beginning and ending with the 4Mb DRAM.

In Japan, little effort appears to be going into i-line lithography when compared with excimer laser lithography. While the future of excimer laser lithography is not clear, most people expect excimer technology to achieve 0.35 micron linewidths. This scenario would take the excimer laser stepper halfway through the 64Mb die shrink, and would provide the most longevity if it becomes production worthy while the 4Mb fabs are still being installed.

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The lithography requirements for 4Mb, 16Mb, and 64Mb DRAM production, although not perfectly clear, appear to be more defined and to show less process capability overlap than in the past for the 16K through 1Mb generations. This reduction of equipment overlap from one DRAM generation to the next, and the escalating cost of these systems, are two factors that could influence semiconductor manufacturers toward the single DRAM generation fab concept.

Synchrotron orbital radiation (SOR) X-ray lithography appears to be the next choice in Japan for 64Mb DRAM production, instead of the point-source X-ray stepper. The Japanese have spent large amounts of money on SOR research at 10 major SOR facilities currently installed in Japan. At least 10 more facilities are in the planning stages. The known SOR facilities that are developing 64Mb+ devices include the following:

- The Ministry of Education's High-Energy Physics laboratory in the Tsukuba Science City, a joint development with Fujitsu, Hitachi, NEC, and NTT

- The NTT LSI Laboratory in Atsugi, a joint development with Hitachi and Toshiba

- SORTEC in Tsukuba, formed by the Japan Key Technology Center and 13 Japanese companies; Canon, Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, Nikon, Oki Electric, Sanyo, Sharp, Sony, Sumitomo, and Toshiba.

NEC also will open a 64Mb DRAM R&D laboratory in Tsukuba that will conduct SOR research this year. The Japanese seem to believe that there are too many difficulties in both mask and photoresist technology for point-source X-ray stepper lithography when compared with SOR X-ray lithography.

8-Inch Production

The first pilot and production-based manufacturing activity on 8-inch wafers began with NEC in Japan during 1988 (see Table 4). IBM also started 8-inch operations in Japan in 1988 with its third 8-inch location; IBM's other two locations are in the United States and Germany. Fujitsu and TI will begin 8-inch pilot production this year. TI's first 8-inch operation in Japan will be at Hiji; however, TI's locations at Miho and Dallas also will process 8-inch wafers shortly after Hiji comes on-line. IBM's second 8-inch line in Japan and Hitachi's first are expected to begin production during 1990.

All of these 8-inch fabs will be producing 4Mb DRAMs with the exception of IBM, which is currently producing 1Mb DRAMs on 8-inch wafers and 4Mb DRAMs on 5-inch wafers. The peak production year for the 4Mb DRAM is forecast to be 1994. At that time, at least one-third of the 4Mb fabs are expected to be processing 8-inch wafers, with the remainder processing 6-inch wafers. By 1997, the peak production year for the 16Mb DRAM, Dataquest anticipates that more than two-thirds of the 16Mb fabs will be processing 8-inch wafers, with the remainder processing 6-inch wafers.

Manufacturing on 8-inch wafers is not without its risks. Future DRAM prices are a consideration for companies that have not yet committed to 8-inch manufacturing. Prices are being looked at because of the high initial cost of setting up an 8-inch fab and because 8-inch manufacturing during the early stages of the learning curve will not be as cost-effective as a more mature, 6-inch production line. Eight-inch manufacturing in its early stages is not as cost-effective as 6-inch due to the following factors:

- Manufacturing equipment using 6-inch wafers is much more refined than 8-inch equipment.
- Processes using 6-inch wafers are less complex and more mature than processes using 8-inch wafers.
- The cost per square inch for a raw, 6-inch wafer is currently less than for an 8-inch wafer.
- The cost for 6-inch equipment is in many cases less than that for comparable 8-inch equipment.

These risks can be very costly to companies that are just entering 8-inch production if DRAM price competition reappears at the same time. Most companies will prefer to enter price competition on the newest generation of DRAMs with 6-inch lines unless they feel they will be far enough along the 8-inch learning curve to compete when the price competition begins.

All of the companies that have committed to going 8-inch so far will pay a high initial price to drive the 8-inch technology. These companies have the deep pockets that are required for the commitment, and see the long-term rewards that will be realized during future manufacturing battles.

DATAQUEST CONCLUSIONS

Japan is consistently adding fabs, and approximately 75 percent of its new fabs are for the production of advanced DRAMs. New fabs going into production during upturns are quickly filled with equipment, whereas, during downturns, they have a small fraction of the floor space equipped. Fabs turned on during the downturn are poised to respond to the next upturn. Almost all of Japan's new fabs will run submicron processes.

Dataquest believes that more of these new and future DRAM fabs will move toward single-generation DRAM production, because DRAM production is decreasing relative to total IC production. This decrease is due to gains in production and market share being made in ASICs, MCUs, MPUs, and other ICs for consumer, computer, and automotive applications. As Japanese companies gain more market share in the non-DRAM categories, shifting production down the product food chain—as opposed to retooling the fab for next-generation DRAMs—will become more practical. Other factors that could influence semiconductor manufacturers to move toward this single DRAM generation fab concept include:

- The implementation of common "core" manufacturing processes for all product divisions. This concept, under ideal conditions, only requires that the mask set be changed for manufacturing a different product while using the same "core" process recipe. Those companies that implement this concept will be able to switch production over to another product with the least complications while at full capacity.

- The rapidly increasing cost of semiconductor processing equipment. The most cost-effective use of semiconductor equipment is to keep it in the same fab and keep it highly utilized for at least six years.

- Conversion to 8-inch wafers for volume production of next generation DRAMs. Most of the companies that do not adopt 8-inch production during the 4Mb generation will do so at the 16Mb level. The food chain concept will provide alternative products for the 6-inch 4Mb lines.

- Required purity improvements in DI water and gas-handling systems for next generation DRAM manufacturing. The move to 4Mb production appears to require new fabs and support facilities as opposed to upgrading existing fabs. There is a chance that 16Mb production will be better addressed with new fabs and support facilities instead of upgraded 4Mb lines.

- The reduction of process capability overlap for semiconductor processing equipment when moving from one DRAM generation to the next. This issue goes back to the high cost of equipment, as mentioned above.

If the Japanese rapidly adopt the single-generation DRAM fab strategy, a large bubble of advanced and low-cost capacity would begin to move into ASIC, MCU, and MPU production. The first capacity bubble would begin to come in after the 1Mb production peak during 1992, and the second capacity bubble would begin to come in after the 4Mb production peak during 1995. By 1992, Japanese companies should be enjoying the fruits of their current ASIC and MPU efforts that include many technology exchange agreements and joint development projects being conducted on and offshore. At the same time, the Japanese will have some very low-cost and advanced DRAM capacity become available that will contain equipment close to being written off the books, and that should already have provided a minimum of three good years of DRAM profits. The end result could be large gains of market share for Japan in the ASIC and MPU arenas, due to severe price competition as the result of low-cost manufacturing.

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THE SUPER SECTION 301: 1986 TRADE ARRANGEMENT DÉJÀ VU?

SUMMARY

The upcoming Super Section 301 announcement, due May 30, is raising many of the same questions that were asked in the summer of 1986 regarding semiconductors and their procurement. This newsletter will briefly review the chronology of and the most common questions asked about this portion of the 1988 Ombudsman Trade Bill, analyze what is in store for users of semiconductors in the wake of the announcement, and make recommendations.

KEY DATES OF THE SUPER SECTION 301

The Super Section 301 specifies certain actions by certain dates, as follows:

- 4/30/89—The United States Trade Representative (USTR) published the National Trade Estimates (NTE). This document identifies significant trade barriers and distortions, estimating the total impact on U.S. commerce.

- 5/30/89—The USTR must identify "priority practices" and "priority countries" from the NTE report that have caused U.S. commerce to suffer loss of export revenue. This loss is to be identified in dollars by practice and country.

- 6/20/89—The USTR must initiate Section 302 investigations—of all priority practices in each priority country—aimed at rectifying the alleged practices via negotiations or compensation within three years after the investigation was initiated (by 6/19/92).

- 4/30/90 and beyond—The USTR will publish an annual report with revised estimates for each priority country. A priority country may be removed, if, for two consecutive years, its priority practices have been eliminated.

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COMMON QUESTIONS ABOUT THE PROCEDURE

Q: What is the difference between a regular Section 301 action and a Super Section 301 action?

A: In the Super Section 301 procedure, the U.S. government, via the USTR, is the instigator of an investigation, rather than a company or trade organization that has traditionally utilized the Section 301 of the Trade Act of 1974.

Q: If a country is named as a "priority country," and semiconductor trade access is named as a "priority practice," what will happen?

A: The USTR can choose three of the following responsive actions:

- Suspend or withdraw trade agreement concessions
- Impose import duties or restrictions on goods
- Enter into a settlement agreement to eliminate the practice, or accept compensation that benefits the affected economic sector of the domestic industry

Q: What can my company or trade organization do within the law?

A: A request for a public hearing in a Section 302 investigation may be filed with the USTR by any "interested person"; the hearing will be held within 30 days of a Section 302 investigation initiation (after 5/30/89). The USTR also must seek advice from private sector advisory committees in preparation for consultations with the foreign government involved.

DATAQUEST ANALYSIS

This latest round of trade saber rattling unfortunately may end up causing more semiconductor procurement problems than it tries to solve. In the worst-case scenario, if a country has been found to have committed "priority practices" in restricting U.S. exports, import duties would be imposed on like products that would increase the cost of the imported U.S. product. If there is no alternative source of product (i.e., DRAM), this situation would result in increased offshore procurement of the semiconductor products that were tariffed for larger companies with offshore facilities. For the companies faced with domestic procurement, the higher prices either would be passed on to the customer or would be realized in lower profit margins.

The above scenario is exactly what the 1986 U.S.-Japan Semiconductor Trade Arrangement attempted to prevent. For example, if Super Section 301 sanctions are applied to Japanese semiconductors, the Electrical Industry Association of Japan (EIAJ) has threatened to terminate the 1986 pact. If the arrangement is nullified, price monitoring will cease and Japanese market access understandings will not endure the trade retaliation. Affected U.S. semiconductor prices (primarily DRAM and SRAM) naturally will go up, and the gray market would again flourish, primarily benefiting Japanese semiconductor manufacturers.

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As seen in Table 1, the major U.S. semiconductor manufacturers doing business in Japan had robust sales growth in 1988.

Table 1

Top Five U.S. Semiconductor Companies in Japan

Company	Sales in Japan	Sales Growth in Yen (%)	Year Ended
Texas Instruments	$591 million	32%	12/88
Motorola	$290 million	54%	12/88
Intel	$285 million	65%	12/88
National Semiconductor	$135 million	11%	12/88
AMD	$134 million	39%	12/88

Note: Japanese semiconductor growth in 1988 = 20.7% (yen)

Source: Dataquest
May 1989

The USTR also may determine whether a Super Section 301 action would be effective in addressing trade issues. Use of sanctions against imported goods that do not have a substantial domestic alternative source would not be effective in altering trade practices other than raising prices for the offending countries. In light of the competitive growth experienced in Japan by U.S. semiconductor companies, sanctions against foreign semiconductor suppliers that sell memories in the United States to further increase U.S. export sales would be counterproductive.

DATAQUEST RECOMMENDATIONS

Now that the Pandora's box of trade legislation has been opened, there are three things a semiconductor user company or organization can do:

- Educate the government (USTR) about what is at stake in the upcoming decisions, which have been forced on the USTR by the government.
- Plan on stepping up offshore procurement and assembly activities for affected semiconductor companies in affected countries.
- Plan on paying higher U.S. prices for affected semiconductors.

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It is not fair to assume that the government is fully aware of all the arguments regarding each priority country and practice. Protectionist actions against any country in any industry have not proven to improve domestic competitiveness. Avoidance of tariffs is possible if the penalized commodity is "materially transformed" prior to shipment into the United States. Assembly of chips onto boards fulfills this transformation requirement.

It is ironic that a potential result of this trade law will be to weaken U.S. electronic manufacturing when the intent is to strengthen U.S. competitiveness. The improved position of U.S. goods in both quality and currency exchange should increase foreign market share without resorting to legislative actions that often have unforeseen repercussions.

Mark Giudici

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Research *Bulletin*

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1989–22
0003873

MAY PROCUREMENT PULSE: INVENTORY LEVELS IMPROVE, DRAM MARKET AMISS

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin will present the results of the monthly survey and analyze what this information means to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

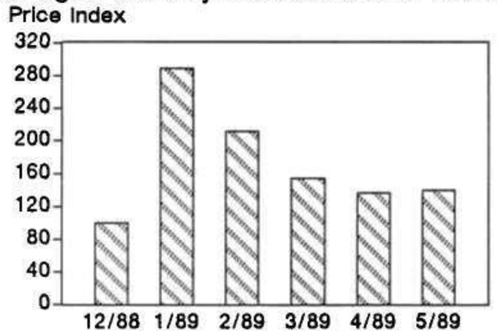


Figure 2
Averaged Semiconductor Lead Times

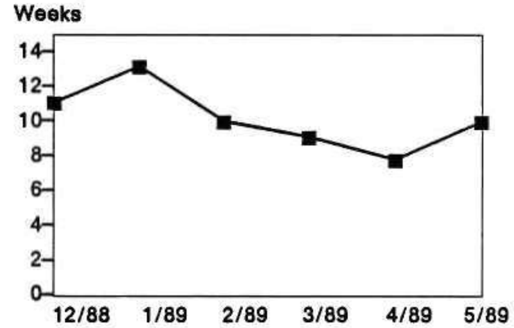


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

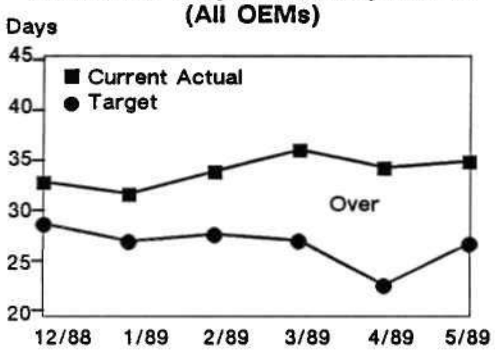
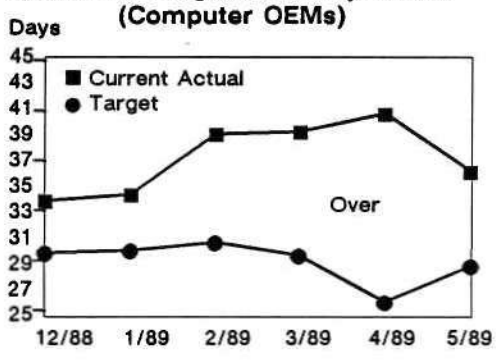


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



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Source: Dataquest May 1989

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SEMICONDUCTOR ORDER RATE STABILIZES; DITTO SYSTEM SALES OUTLOOK

The large increase in semiconductor orders in January and February is now hitting semiconductor suppliers' books as billings (Figure 1). The rosy situation that led to strong Q1 book-to-bill ratios will not last. Threatening to dampen the Q1 rally of suppliers, semiconductor order rates for the past three months dipped to just above Q4 1988 levels. Now that overall semiconductor availability is just a concern, not a crisis, procurement managers are trying to balance order rates with overall system sales, which are expected to grow 4 percent to 15 percent during the next six months.

OVERALL SEMICONDUCTOR LEAD TIMES ARE MANAGEABLE

Except for DRAM-process-related semiconductors, the overall availability of devices continues to improve compared with earlier this year (10.1 weeks in May versus 13.3 weeks in January). The rebound in lead times this month (Figure 2) is due to SRAM and DRAM products refusing to become more available despite increased capacity levels. Korean memory products are the exception, being lower than average in price and lead time. Users of DRAMs and SRAMs should expect slower price declines this year relative to past supply/demand cycles, resulting from a seemingly concerted supplier strategy.

INVENTORY LEVELS DECLINE; TARGET LEVELS AGAIN IN SIGHT

Overall target inventory levels rose this month to 27.1 days over last month's low level of 23.1 days (Figure 3). With memories relatively more available now, inventory target levels have risen; this reflects increased confidence that order rates can be balanced with system sales. The relative stability of actual inventory levels (35.0 over 34.4 days) also correlates with the flattened order rate, which the industry hopes will keep pace with system shipments. Without work in process (WIP) or DRAM constraints, overall actual levels were less than 4 days over target levels (25.4 and 21.6 days, respectively). While computer sales rolled on, eating inventory, specific semiconductor order reductions had their intended effect (Figure 4). Current target and actual levels of 29.0 and 36.3 days are a large improvement over the respective levels of 26.2 and 40.8 days seen last month. Without WIP and DRAM inventory noise, computer semiconductor inventories were less than 2 days over target (22.0 days actual, 20.7 days target)! Inventory controls in this volatile segment improve as memory supplies increase, lessening the need for insurance stock.

DATAQUEST ANALYSIS

Improved availability of components for users is indicated by the following:

- Reduced semiconductor order levels
- Lead-time and price reductions (except for DRAMs/SRAMs)
- Historically low inventory levels
- A steady electronics market

Dataquest recommends that users closely match long-term contract levels to system sales rates. Semiconductor suppliers should not expect monthly billing levels to be the same in Q3 as in the first half of 1989. Suppliers should anticipate Q2 1989 booking levels comparable with those of Q3 1988. Accurate forecasting and inventory control by both users and vendors will be critical in preventing any slowdown from becoming a recession.

Mark Giudici

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Research *Newsletter*

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SEMICONDUCTOR USERS EYE THE RISKY "CISC–Y" WORLD OF 32–BIT MICROPROCESSORS

SUMMARY

Systems manufacturers are confronting urgent decisions that could carry companies to prosperity or doom during the 1990s. They need to decide which 32–bit complex–instruction–set computing (CISC) or reduced–instruction–set computing (RISC) microprocessor component (MPC) to use, and from which manufacturer. Table 1 summarizes Dataquest's assessment of five critical user issues: IC features, software compatibility, time to market, price, and global manufacturing capability. Dataquest recommends that current CISC IC users not switch from CISC technology midstream in system life cycles. Furthermore, Dataquest recommends that users evaluate both CISC and RISC products for use in next–generation systems.

Table 1
32–Bit Microprocessor Component Choices

	CISC		RISC
	Intel 80486	Motorola 68040	IDT (MIPS) 79R3000*
Features			
Speed	High	High	Very high
Memory Management	On-board	On-board	Off-chip
Floating Point	On-board	On-board	Off-chip
Software Compatibility			
Backward	High	High	Low
UNIX Compatible	Yes	Yes	Yes
Time to Market (First Volume Shipments)	Second half 1989	First half 1990	Now
Price	Less competitive	Highly competitive	Competitive
Manufacturability	High	Very High	High

*Representative RISC product.
Note: The RISC supplier base includes a host of world-class manufacturers such as AMD (proprietary device), Fujitsu (Sun's SPARC architecture), and LSI (MIPS design).

Source: Dataquest
May 1989

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OVERVIEW

The information in Table 1 is derived from information presented in the other three tables in this newsletter. For prospective users of 32-bit devices, Table 2 on CISC/RISC IC performance tracks select features of 25-MHz versions of 80486 and 68040 devices and a representative RISC product, IDT's 79R3000. This table serves as a guide for systems manufacturers on benchmarks like speed, transistors per IC, memory management, floating point, and packaging. Table 3 provides Dataquest's forecast of expected availability and price of the Intel 80486 and Motorola 68040 devices. This table tracks timing and price of samples, first volume shipments, full-volume production, and each supplier's expected cost curve. Finally, Table 4 weighs the global manufacturing strengths of Intel, Motorola, and IDT. This table compares each supplier's manufacturing process technology and worldwide fab strength.

PROCESSOR FEATURES

Table 2 gauges the performance features of 25-MHz versions of the 80486, 68040, and 79R3000 products. As shown, Intel and Motorola pack 1.2 million transistors into the 68040 and 80486 MPCs, a blunt statement of the complexity of the new CISC devices.

Speed

In terms of speed as expressed in VAX mips, RISC ICs hold an edge over 25-MHz CISC devices. The speed advantage of RISC over CISC should narrow over time.

On-Chip Functionality

The CISC processors from Intel and Motorola offer impressive levels of chip integration in terms of on-board memory management and floating-point functionality.

Memory Management

The on-board memory management feature of the 80486 and 68040 products permits efficient and quick handling of input/output interrupts, thus off-loading critical high-speed DRAMs for critical system needs.

Floating point

For systems manufacturers, the Intel and Motorola 32-bit CISC MPCs extend system families into new financial and graphics applications. For example, bank spreadsheet analysis demands floating-point accuracy to prevent the loss of thousands of dollars during rounding. Users can base PC-like systems suitable for major bank applications on CISC architectures.

Table 2

32-Bit MPC Product Performance Specs: CISC versus RISC

	CISC		RISC
	Motorola 68040	Intel 80486	IDT (MIPS) 79R3000
Number of Transistors	1.2 million	1.2 million	0.1 million
Speed/mips	25 MHz 15.0 mips	25 MHz 15.0 mips	25 MHz 16.7 mips
Drystones/Second	Not specified	37,000	41,000
On-Board Memory Management			
Data Cache	4K	8K	Off-chip
Instruction Cache	4K	Totally user reconfigurable	Off-chip
Bus Snooping Capability	Yes	Yes	N/A
Related Features	Bus controller, paged memory management	80385-type cache memory controller	64-entry translation look-aside buffer
Floating Point	On-chip: 68882-type, IEEE Standard 754 conformity	On-chip: 80387-type math coprocesssor	Off-chip: R3010
mflops	4-5	Not specified	4-7
Packaging	168-pin ceramic pin grid array (CPGA)	168-pin CPGA	172-pin ceramic flat pack

N/A: Not Applicable

Source: Dataquest
May 1989

PRICING AND AVAILABILITY: 80486 versus 68040

Table 3 forecasts expected availability and price of the Intel 80486 and Motorola 68040 products. For North American and European users, the information in Table 3 can be used in planning system design/production schedules.

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Table 3

Estimated Price and Availability of 68040 and 80486 ICs

	Intel 80486	Motorola 68040
Speed at 25 MHz	15 mips	15 mips
Samples		
Timing	Q3 1989	Q4 1989
ASP	$950	$625
First Volume Shipments		
Timing	Q4 1989	Q1 1990
ASP	$750-$900	$495
Ramp Stage		
Timing	Q2 1990	Q2/3 1990
ASP	$475	$250-$300
Supplier Cost Experience (Ramp Stage)	5% quarterly declines	5-10% quarterly declines

Source: Dataquest
May 1989

Price

Motorola is anticipated as a price leader in the 32-bit CISC processor marketplace during the short and long terms, as Table 3 shows. Motorola will offer attractive price to secure design-ins for the 68040 in the face of user delay in obtaining silicon products.

Time to Users

As Table 3 reveals, Intel leads over Motorola in terms of market availability of the 68040 and 80486 products. North American and European users can expect to obtain samples as well as first volume shipments from Intel one quarter in advance of Motorola. Motorola should narrow the gap as output ramps during the first half of 1990.

WORLDWIDE MANUFACTURING

Table 4 weighs the global manufacturing strengths of Intel, Motorola, and representative RISC IC supplier IDT in terms of manufacturing process technology and worldwide fab strength.

Table 4

32-Bit MPC Worldwide Manufacturing Process Technology and Fab Capability: CISC versus RISC

	CISC		RISC
	Intel 80486	Motorola 68040	IDT (MIPS) 79R3000
Process and Linewidth	CMOS 1.0 micron	CMOS 1.0 micron	CMOS 1.2 micron
Number of Fabs by World Region*			
North America	2	2	3
Europe	0	1	0
Japan	0	1**	0
Rest of World	1#	0	0
Total Square Feet of Clean Room by World Region			
North America	47,000	51,000	28,000
Europe	0	34,000	0
Japan	0	26,000**	0
Rest of World	N/A	0	0

*Only includes Intel and Motorola fabs dedicated to these CISC ICs.
**Joint Motorola-Toshiba facility
#Israel
N/A = Not Available

Source: Dataquest
May 1989

Manufacturing By World Region

Intel, Motorola, and IDT are well-positioned to serve long-term North American demand, as Table 4 shows.

Intel plans to supply European users from its Israel fab. Motorola's U.K. fab puts the supplier in a good position to supply European users as 1992 approaches. In the RISC camp, Fujitsu recently revealed massive fab expenditures targeted at Europe for the early 1990s.

The joint Motorola-Toshiba facility augurs well for Japanese users of this product as long as the alliance runs smoothly.

DATAQUEST CONCLUSIONS

Two giants of the global semiconductor industry--Intel and Motorola--are bluntly demonstrating to semiconductor users the continuing viability of CISC-based systems into the performance-driven world of the 1990s. The companies show uncanny ability to adapt to user-driven global forces. For system manufacturers, the new 32-bit CISC products deliver competitive performance backed by the worldwide manufacturing capabilities of Intel and Motorola.

This newsletter specifically highlighted these key issues:

- Performance
  - RISC chips and RISC-based systems hold a continuing edge over CISC devices.
  - Memory management systems in the Intel 80486 and the Motorola 68040 MPCs enhance the competitiveness of CISC systems versus some RISC machines by minimizing processing delay associated with input/output interruption.
  - On-chip floating point brings CISC-based PCs and workstations into new business and graphics applications.
- Software
  - CISC-based systems now hold a major edge now over RISC machines as measured by software installed base, an edge that will not quickly erode.
  - The 80486 offers a migration path that takes users to future compatibility with the now emerging UNIX operating system.
- Price
  - Motorola will use global manufacturing expertise and strength to exert market price discipline and competitiveness in the high-performance segment of the 32-bit marketplace.
- Time to market
  - RISC IC suppliers and Intel will wage a pressurized battle to win system designs as Motorola brings the 32-bit MPC to market more slowly.
- Worldwide manufacturing capability
  - CISC and RISC component suppliers are well-positioned in North America.
  - Looking to 1992 in the CISC arena, Motorola has established a better worldwide position as of 1989 in the eyes of European and Japanese users.
  - Fujitsu is targeting Europe for new RISC component fabs.

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DATAQUEST RECOMMENDATIONS

Dataquest makes the following recommendations:

- North American and European system designers should stay with CISC in current systems, but should also carefully evaluate both CISC and RISC product technologies for use in future PCs, workstations, and other advanced systems. This strategy protects the installed software base, while allowing future migration to UNIX.

- Supply base managers should carefully balance immediate concerns, such as a time to market, and long-range issues, such as total system cost of production, when deciding which CISC or RISC device to use in system designs/redesigns.

- Systems manufacturers should compare their worldwide system-production targets and the global manufacturing capabilities of prospective suppliers to ensure an uninterrupted, long-term supply of 32-bit devices.

Ronald A. Bohn

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Research Bulletin

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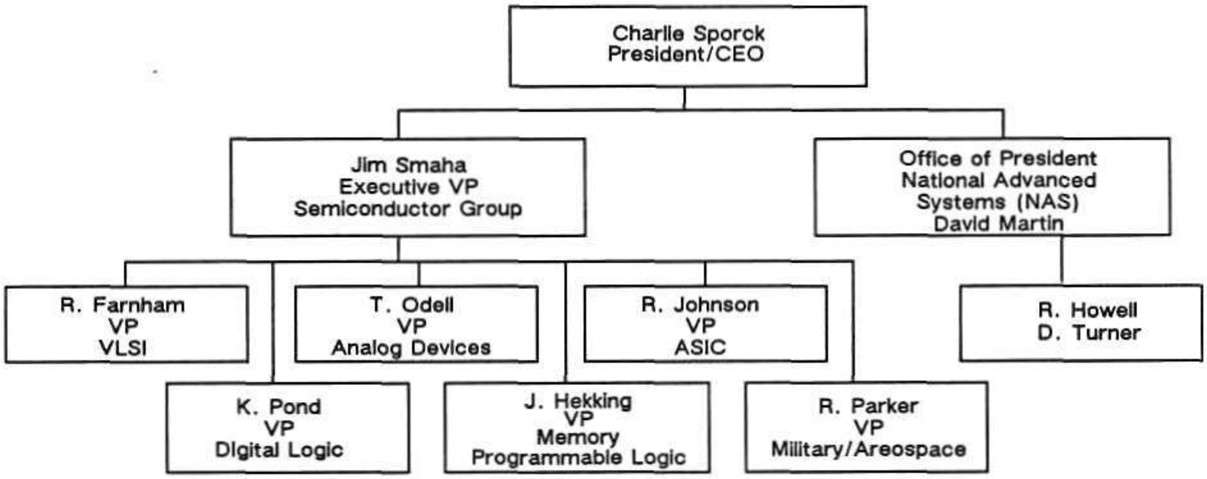
NATIONAL SEMICONDUCTOR RESTRUCTURES

National Semiconductor has undergone a tremendous amount of change in its struggle to identify a structure that will result in profitable operations. Organizationally, the most significant outcome of these efforts so far has been the shedding of its nonsemiconductor-related lines of business, allowing the company to focus entirely on the successful positioning of its components products. Figure 1 illustrates the revised organizational structure of National Semiconductor in the wake of announcements made during the past two months. Because of the number and nature of these announcements, Dataquest offers this Research Newsletter to our Semiconductor User clients in order to bring them up to date on National's restructuring efforts.

Figure 1

National Semiconductor Organizational Structure
(As of March 1989)



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Source: National Semiconductor

In December 1988, National Semiconductor announced the sale of its retail systems unit, Datachecker Systems, to a U.K.-based company, ICL. This move was followed in mid-January 1989 by an agreement with Memorex Telex to form a joint venture in which

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each company would own a 50 percent interest in National Advanced Systems (NAS). Memorex Telex, a Dutch company, is a $2 billion supplier of plug-compatible computer equipment and accessories. The deal with Memorex Telex called for National to receive a cash payment of $250 million and 4 million shares of Memorex Telex common stock. In addition to its 50 percent share of NAS, the agreement gave Memorex Telex an option to purchase the remaining stock in the organization, which would be operated as a separate entity headquartered in Santa Clara, California. At the end of February 1989, National broke off its tentative agreement with Memorex Telex, which had apparently encountered difficulties in financing the buyout of NAS. Instead, National has accepted a $398 million cash offer from Hitachi Ltd. of Japan and Electronic Data Systems (EDS), a subsidiary of General Motors Corporation. Under the agreement, NAS will be sold to a joint venture created by Hitachi and EDS. NAS acts as a distributor of IBM-compatible, large and medium-size computers and peripherals made by Hitachi.

Shortly after the initial disclosure of its deal with Memorex Telex, National announced that it would lay off 2,000 employees. The work force reduction affects all levels of staff in Asia, Europe, and the United States, and took place through March 1989. The number represents about 5 percent of the corporation's reported head count as of the close of fiscal year 1988. National, which reported a loss of approximately $56 million for the first half of its fiscal year 1989, has said that the reductions are necessary to bring the company's staffing levels and cost structure into alignment with its current business environment.

As evidence of its renewed emphasis on its core semiconductor businesses, National recently announced the formation of a new VLSI division, which comprises the company's microprocessor, microcontroller, advanced peripherals, and interface groups. This new division will report to vice president Ray Farnham. The memory and programmable logic groups will be combined under John Hekking. The military and aerospace group will report to Randy Parker. National intends to strengthen its position in the military market, in which it became a more powerful contender through its acquisition of Fairchild. All of these groups will report to James Smaha, executive vice president of the semiconductor group. Clark Davis will be in charge of the newly formed function of worldwide strategic planning. The strategic market development group will be headed by Walt Curtis. These last two individuals will report to Joe Van Poppelen, vice president of semiconductor marketing.

National's information systems group, of which NAS is the major part, accounted for approximately 43 percent of National's fiscal 1988 revenue of $2.5 billion. Its 1988 fiscal year ended May 29. The divestiture of NAS signals a major change in National's strategy, and a significant impact will be felt on the company's revenue. Nevertheless, National should see an improvement in profitability as a result of the sale of NAS. Partly due to the yen appreciation during the past few years, which has affected the cost of its equipment purchases from Hitachi, NAS has experienced increased pressure on its profit margins. By increasing its reliance on its semiconductor products, however, National becomes more vulnerable to the boom/bust cycles that have up to now typified the semiconductor industry. Just how National goes about positioning its broad line of components products will bear watching as the company stakes its future on being a pure-play semiconductor company.

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Michael J. Boss

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Research *Bulletin*

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NORTH AMERICAN MARKET WATCH, APRIL 1989: SIGNS OF A WEAKENING MARKET AHEAD

The North American Market Watch is a monthly bulletin, released after the SIA book–to–bill flash report, and is designed to give a deeper insight into the monthly trends in North American semiconductor consumption (see Figures 1 through 4).

Figure 1
Semiconductor Book-to-Bill Ratio

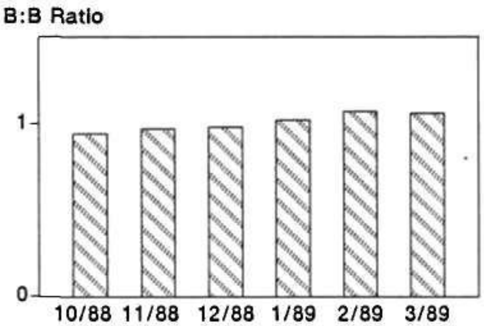


Figure 2
DOC Computer Demand

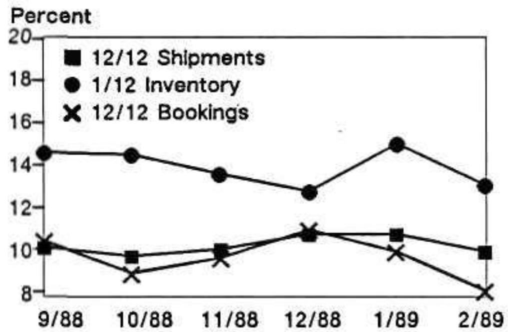


Figure 3
Semiconductor Inventory Level

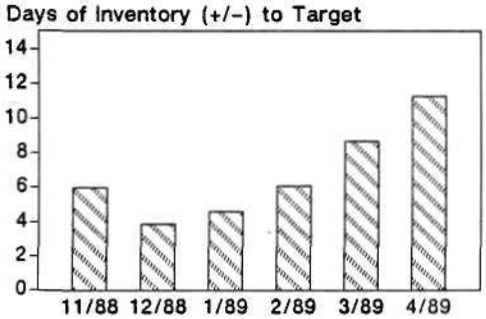
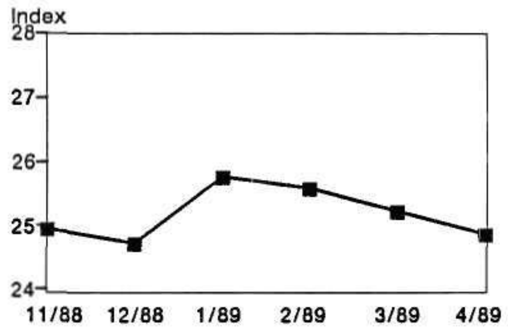


Figure 4
U.S. Weighted Price Index



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Source: U.S. Department of Commerce
World Semiconductor
Trade Statistics

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STRONG BOOK-TO-BILL, BUT MEMORY ACCOUNTS FOR MOST OF GROWTH

As shown in Figure 1, the April SIA flash report carries encouraging news as the semiconductor industry accomplishes a rebound in the first quarter of 1989 after the dismal final months of 1988. However, caution must be exercised in the interpretation of the strength of this upturn. Much of the growth is attributable to MOS memory. The latest WSTS blue book report shows an overall billings decline from December to January of 9.9 percent. MOS memory actually declined by only 0.1 percent, while non-MOS memory products dropped by 14.6 percent. Shipments of 1Mb DRAMs increased in the first quarter by about 30 percent, but prices dropped by only about 10 percent for the more available devices.

SYSTEM ORDERS SHOW SIGNS OF WEAKENING

As presented in Figure 2, computer inventories, relative to last year, have declined, but computer shipments have remained at a steady growth, which verifies the strong first quarter for semiconductor shipments. However, the rate of computer bookings has been declining for three consecutive months, suggesting a possible slowdown in computer production rates by the end of the second quarter or the beginning of the third quarter. In fact, Dataquest's monthly survey of major OEM buyers indicates weaker 1989 system revenue growth projections in March compared with projections made in February.

OEM INVENTORIES APPEAR TO BE GROWING

Dataquest's monthly survey of major OEM buyers, presented in Figure 3, shows actual inventories continuing to increase beyond target inventories. Actual inventories are now more than 11 days of sales above target compared with an excess of less than 5 days in January. OEMs also appear to be reducing target inventories in anticipation of slower revenue growth, but actual inventories still need to adjust to the drop in target inventories. However, actual inventory levels are still at 34 days of sales, which should not affect semiconductor order rates in the near term.

DATAQUEST'S PRICE INDEX SHOWS STEADY PRICING

Dataquest compiles a monthly price index from a basket of 25 semiconductor products, as shown in Figure 4. The price index has dropped by only 3 percent since January. Generally, prices have been holding well since November, but the slight decline may be the signal for more price drops if computer demand indeed weakens and OEM inventories continue to increase.

DATAQUEST ANALYSIS

The benefits of semiconductor shipment growth do not appear to be equally distributed. MOS memory manufacturers appear to be reaping most of the benefits. Despite the resurgence, signs of a weakening market prevail: OEM inventories are up; target inventories are down; system revenue growth forecasts are lower; and computer orders have been slowly declining. Until then, the semiconductor industry seems poised for a mildly healthy second quarter, since prices have not declined significantly in the first quarter and semiconductor bookings remain considerably strong. But the signs indicate that the second half of 1989 may not be as rosy.

Victor de Dios

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Research Newsletter

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THE ASIC PACKAGE PROLIFERATION

SUMMARY

Surface-mount technology is now mainstream. Dataquest believes that surface-mount devices (SMDs) will continue to grow at a pace that exceeds traditional packaging and assembly techniques. As ASICs continue to grow in usage, many new surface-mount package families will be developed. This will cause multiple package choices for the same IC, resulting in difficulties for design engineers, assembly engineers, and purchasing agents (i.e., nonstandard packages for second-sourcing). It could make it more costly for semiconductor manufacturers to compete.

This newsletter will discuss the packages currently being used or under development for ASICs. It will also review the issues and choices pertaining to standards involved in ASIC packaging.

INDUSTRY ANALYSIS

Dataquest expects the worldwide integrated circuit package market to grow at a 10 percent compound annual growth rate (CAGR) from 1987 to 1992. We expect surface-mount devices to continue to show the greatest gain. They are expected to grow from the current level of 20 percent (year-end 1988) to almost one-half of all IC packages (48.4 percent) by 1992. These statistics are shown in Tables 1a and 1b.

The forecast shows the fastest growth area to be the quad flat package (76.3 percent CAGR). This is directly related to the worldwide increase in ASIC production.

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Table 1a

Estimated Worldwide Shipments by Package Type
(Millions of Units)

Package	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
Plastic DIP	23,194	26,282	25,292	21,741	21,103	20,625	(2.4%)
CERDIP	3,346	3,738	3,274	2,778	2,783	2,727	(4.2%)
Ceramic DIP	270	277	250	231	225	203	(5.9%)
Quad/Ceramic and Plastic	284	805	1,357	1,640	2,785	4,833	76.3%
Ceramic Chip Carrier	207	315	374	383	430	562	22.1%
Plastic Chip Carrier	508	1,024	1,412	1,513	1,987	2,792	40.6%
SO	3,092	4,954	6,202	7,167	9,396	12,881	33.0%
PGA/Ceramic and Plastic	234	614	983	1,118	1,583	2,339	58.5%
Other (TAB/COB/ FCHIP)	470	860	1,224	1,480	2,249	3,817	52.0%
Others	479	657	684	596	612	608	4.9%
Total	32,084	39,526	41,051	38,647	43,153	51,386	9.9%
Total of SMT	4,561	7,958	10,569	12,183	16,847	24,885	40.4%
Percent of SMT	14.2%	20.1%	25.7%	31.5%	39.0%	48.4%	

Table 1b

Estimated Worldwide Shipments by Package Type
(Percent)

Package	1987	1988	1989	1990	1991	1992
Plastic DIP	72.3%	66.5%	61.6%	56.3%	48.9%	40.1%
CERDIP	10.4	9.5	8.0	7.2	6.5	5.3
Ceramic DIP	0.8	0.7	0.6	0.6	0.5	0.4
Quad/Ceramic and Plastic	0.8	2.0	3.3	4.2	6.5	9.4
Ceramic Chip Carrier	0.7	0.8	0.9	1.0	1.0	1.1
Plastic Chip Carrier	1.6	2.6	3.4	3.9	4.6	5.4
SO	9.6	12.5	15.1	18.6	21.8	25.1
PGA/Ceramic and Plastic	0.7	1.6	2.4	2.9	3.7	4.6
Other (TAB/COB/ FCHIP)	1.4	2.2	3.0	3.8	5.2	7.4
Others	1.4	1.6	1.7	1.5	1.4	1.2
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Percentages may not add to 100.0% because of rounding.

Source: Dataquest
May 1989

PACKAGE TYPES

Quad Flat Packs—Old and New

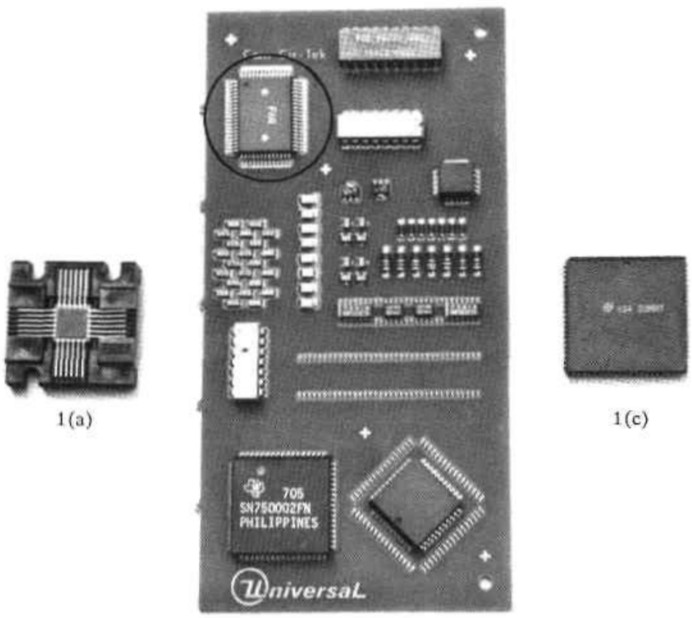
The true, original flat package is not new. Based on 50-mil lead spacing and ceramic technology, it has been and still is used primarily in military applications. The quads are mostly flat, retangular packages with bodies constructed of alumina or beryllia, with glass-to-metal seals. The long leads are splayed out away from the package body on all sides, in a gull-wing-style lead form. Lead counts generally range from 12 to 28 leads. Figure 1(a) shows a photograph of a ceramic quad flat package.

As commercial development of surface mount became prevalent in the early 1980s, the Electronic Industries Association of Japan (EIAJ) began to develop its own plastic versions of the quad flat package. These packages were based on the premise of keeping package body sizes the same and varying the lead pitch, thus increasing lead count density. Pitches of 1.0mm (39.4 mils), 0.8mm (31.5 mils), and 0.65mm (25.6 mils) form standards that define packages from 20 to 240 leads, depending upon body size. This package is also called the quad flat pack (QFP), as seen in Figure 1(b).

Expanding on this, the U.S. manufacturers agreed that placing leads on all four sides of a package was beneficial. But bending the leads underneath the package would increase density even further, and it also could be compatible with the ceramic leadless chip carrier board footprint. Thus the J-bend plastic leaded chip carrier (PLCC) was developed, with lead counts ranging from 18 to 100 leads on 50-mil center lead spacing (see Figure 1(c)).

Figure 1

Ceramic Quad Flat Package



1(a) 1(b) 1(c)

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Source: Dataquest
May 1989

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However, the PLCC on 50-mil spacing did not address the increasing demand of ASIC products for higher lead counts (more than 100 pins). So, the United States through the Joint Electronics Device Engineering Council (JEDEC) developed the plastic quad flat package (PQFP) for this requirement. It uses the same plastic body sizes as the PLCC, but has leads on 25-mil centers and a molded "bumper" protruding from each corner for lead protection during handling. Lead counts for this package family range from 44 to 244 leads, and the gull wing is the preferred lead form (see Figure 2).

Figure 2

Plastic Quad Flat Package

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Source: Dataquest
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Finer Pitch Packages

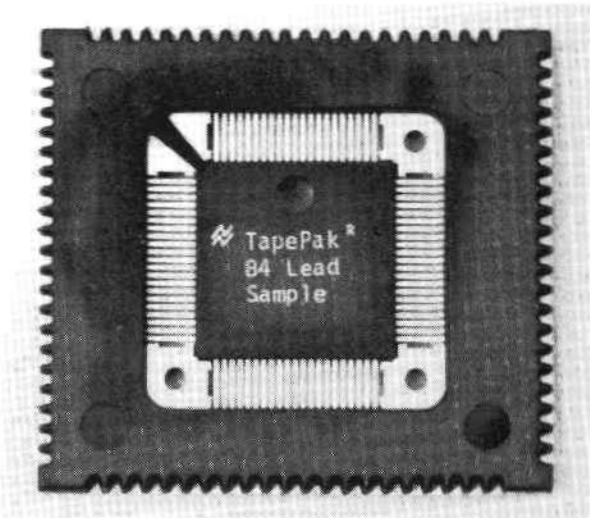
With the consumer market driving for smaller, less costly electronic gadgets and the ASIC market needing higher lead count packages, the Japanese have developed yet another package family: The shrink quad flat package (sometimes called the very small quad flat package (VQFP)). In some ways, this family is an extension of the EIAJ quad flat package (QFP). It also uses standard body sizes, but the package is one-half the thickness, and the lead pitches are reduced to 0.5mm (19.7 mils), 0.4mm (15.7 mils), and 0.3mm (11.8 mils). Lead counts range from 32 to 520 leads.

Besides those mentioned, two more surface-mount package families have recently been introduced into the market for ASIC packaging. One is TapePak developed by National Semiconductor; the other is the TQFP, a TAB quad flat pack developed by LSI Logic.

TapePak uses TAB (tape automated bonding) tape as the lead frame that is attached directly to the die. No wire bonding is used. This die-on-tape combination is then molded in plastic so that an outside ring is formed apart from the inside encapsulated die. This outside ring provides for lead protection and test capabilities. The package body is excised from the carrier ring by the pick-and-place machine and is subsequently attached to the printed circuit board. Like the Japanese quad flat pack, the TapePak family uses standard body sizes with lead counts from 40 to more than 460 leads on 20-, 15-, and 10-mil pitch. This package is shown in Figure 3.

Figure 3

TapePak



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Source: Dataquest
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The TQFP is similar to TapePak, except for the following:

- It uses wire bonding for lead counts up to 300 and TAB from 300 to 524 leads.
- The die is encapsulated, using a liquid epoxy "blob."
- A two-piece plastic disposable slide carrier is used for lead protection and test.
- Pin counts range from 164 to 524 leads.

A picture of the TQFP is shown in Figure 4.

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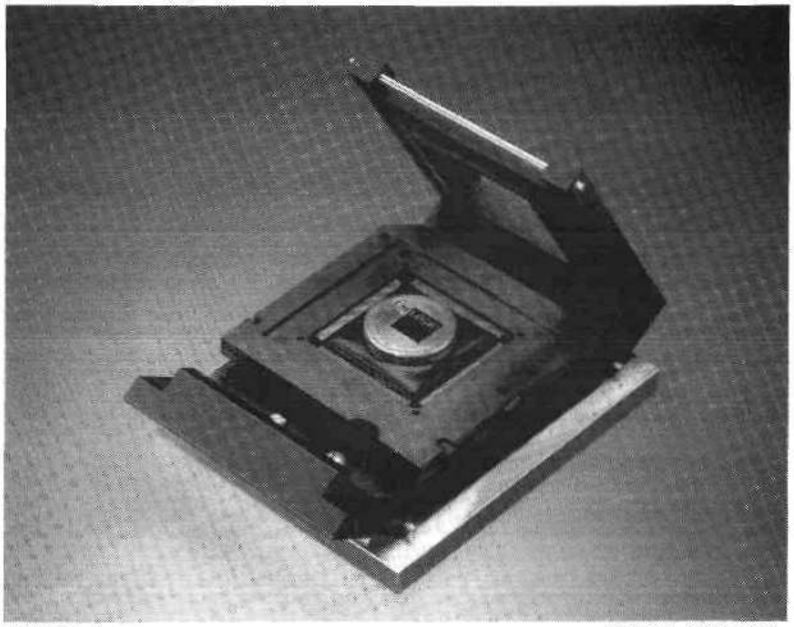
Figure 4

TAB Quad Flat Pack



0003757-4 Source: Dataquest May 1989

Higher Lead Counts and the No-Package Package

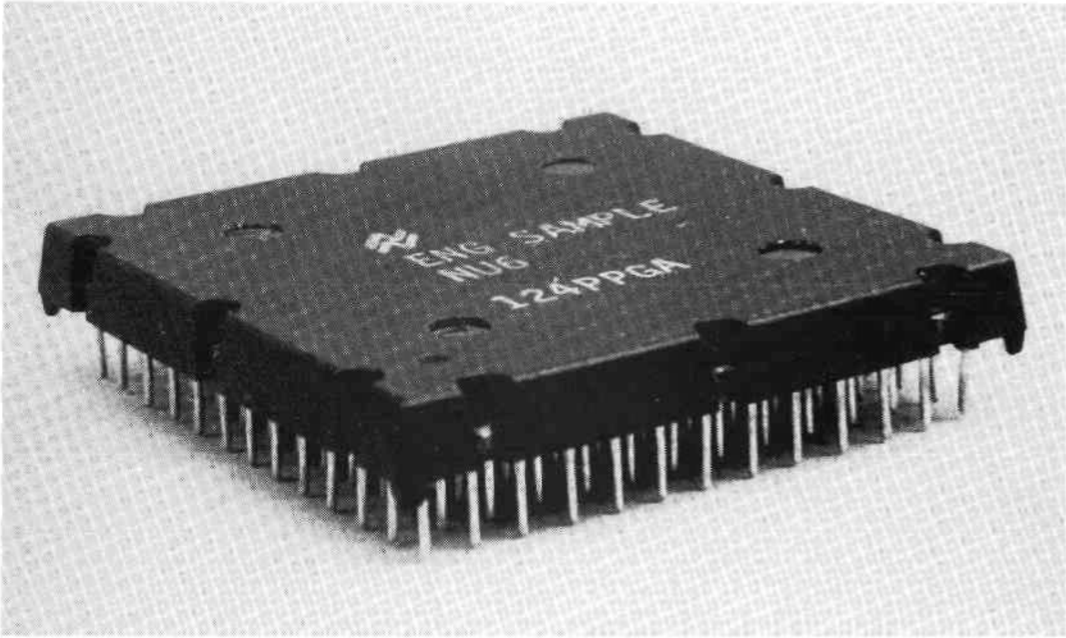
Another packaging solution to ASICs is the pin grid array. Although not assembled to the board using surface-mount technology, it does provide high-density capability to 1,000 leads and beyond. Rows of pins on 100-mil spacing (and more recently 50 mil) are arranged in a grid format to form the PGA (see Figure 5). It is available in both ceramic and plastic and is capable of dissipating more heat than most surface-mount packages.

There is one more approach to ASIC packaging that does not really use a package in the traditional sense. Chip-on-board (COB) technology enables the bare die to be attached directly to the printed circuit board. The die is attached to the board via an adhesive (usually epoxy) and wire-bonded directly to the pads or traces on the PCB. After bonding, the die is usually coated with a blob of plastic material to provide for mechanical and environmental protection.

Variations of the COB approach include TAB-on-board (TOB). Component leads are etched on single-layer or multilayer copper/copper-polyimide tape. The tape is etched to form patterns that correspond to the die pad layout. These patterned leads then make the connection between the die and the printed circuit board. Whereas wire-bonded COB is done on a chip-by-chip basis, TOB can be done via an automated, reel-to-reel process. The die-on-tape can then be attached to the board and encapsulated, as in the COB process. An example of TOB is Siemens' Micropak. A basic flow of the TOB process is shown in Figure 6.

Figure 5

Rows of Pins Forming the PGA



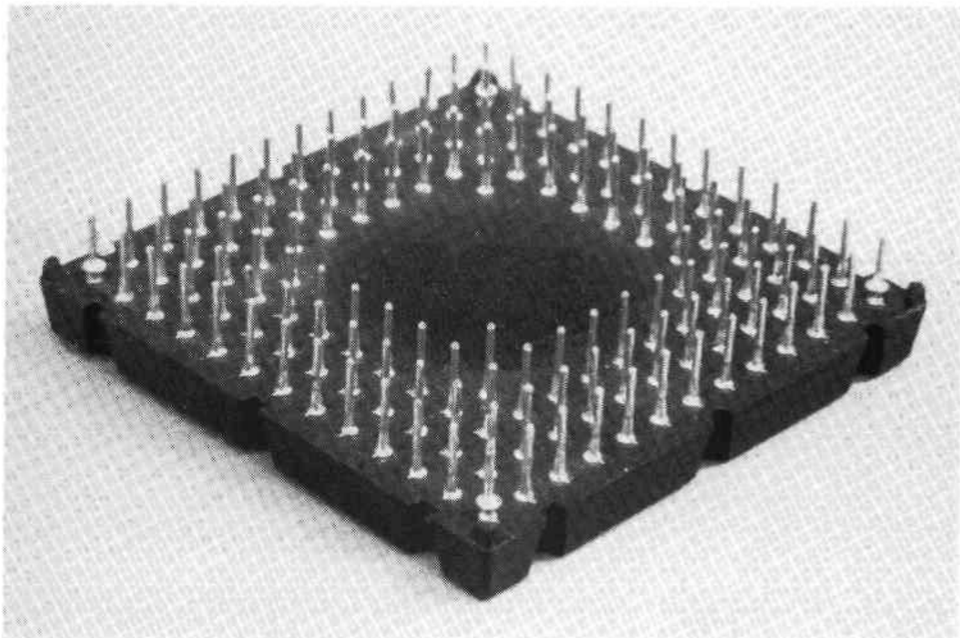


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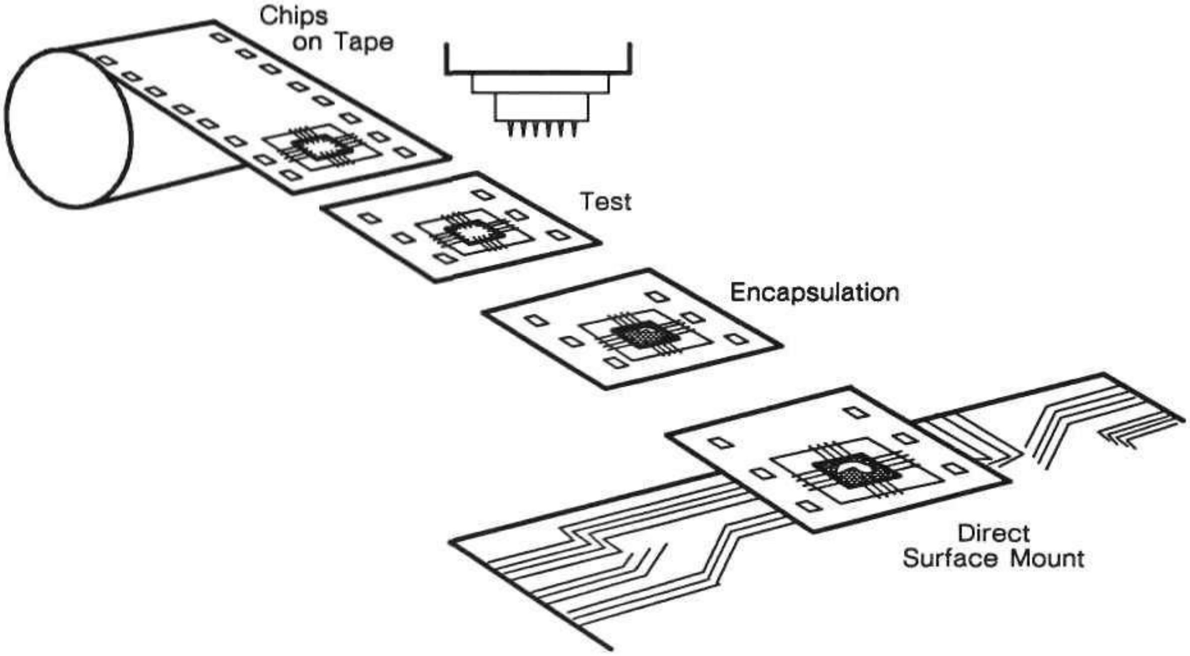
Figure 6

TOB Process (Basic Flow)



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Source: MESA Technology

Finally, flip chip is one other assembly process that can be used in ASIC packaging. This process was developed by IBM in the late 1960s and is known as C-4, for controlled-collapse chip connection. It is basically a process in which the chip is designed for facedown reflow soldering. The bond pads are bumped with solder while in wafer form. Passivation (silicon nitride) is added, and the wafer is tested via the solder bumps. After testing, the dice are placed facedown, or flipped, on the ceramic substrate, and the assembly is heated in a furnace to reflow the solder. The surface tension of the solder aligns the dice properly to the substrate. This is the maximum use of interconnect density, as no lead frame, wires, or tape are used.

A DESIGNER'S NIGHTMARE

What package should an ASIC design engineer choose? Assuming that it is an ASIC requiring 68 leads, the following choices can be made if a plastic package is desired:

- 68-lead PLCC (JEDEC)
- 68-lead PQFP (JEDEC)
- 68-lead QFP (EIAJ)
- 68-lead VQFP (EIAJ)
- 68-lead TapePak (JEDEC)
- 68-lead PPGA (JEDEC)
- 68-lead COB (No standard)
- 68-lead TOB (EIA/IPC/ASTM)
- 68-lead Micropak (Europe/DIN)

The following section discusses the above listing in more detail. Table 2 lists some common specifications for each package.

Table 2

68-Lead Package Options*

	Lead Pitch	Lead Width	Package Size	Package Height
PLCC	0.050"	0.028"	0.950" sq.	0.180"
PQFP	0.025"	0.012"	0.550" sq.	0.102"
QFP	0.0256"	0.0118"	0.394" x 0.551"	0.100"
VQFP	0.0118"	0.004"	0.197" x 0.276"	0.050"
TapePak	0.020"	0.010"	0.505" sq.	0.072"
PPGA	0.100"	0.018"	1.14" sq.	0.180"
COB	0.008"	0.0014"	0.378" sq.	0.032"
TOB	0.020"	0.010"	0.378" sq.	0.032"
Micropak	0.0197"	0.009"	0.386" sq.	0.025"

*See Appendix A attached to this newsletter.

Source: Dataquest
May 1989

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One can readily see that little, if any, compatibility exists among the various packaging styles, except possibly COB versus TOB. This means that designing with an ASIC from supplier A in PQFP (JEDEC) may not be compatible with the ASIC from supplier B in QFP (EIAJ), even if the silicon function is the same. The possible result is a sole-source supplier based primarily on package offering, not silicon.

STANDARDS ACTIVITY

There has been criticism of industry organizations for their lack of leadership in setting surface-mount standards. Some is justified, as it is difficult to get everyone to agree on one of anything, whether it be process, part, or package. There are major differences between the U.S. and Japanese styles of packages. Work needs to continue to bring commonality to this area.

Package standardization is proceeding within the United States at a faster rate as surface mount becomes a proven technology. To address industry awareness and the need for areas of standardization in surface-mount technology, representatives from EIA, IPC, JEDEC, and ASTM have joined together to form the Surface Mount Council. In January 1989, they issued a document entitled "Survey Report: Surface-Mount Standards, Requirements, and Issues."

This report surveyed responses regarding the awareness and usage of 14 typical standards currently available to the industry. In the case of integrated circuit components, the survey found that only 61 percent of the respondents used all or part of the EIA JEP-95 specification (JEDEC Registered and Standard Outlines for Semiconductor Devices). Eighteen percent were aware of this standard but did not choose to use it, and 16 percent were not aware of the standard. Highlights from this report related to component standards are shown in Table 3.

Table 3

Surface-Mount Component Standards

	Use Standard	Use Part of Standard	Do Not Use	Unaware of Standard
EIA RS 481A--Taping of SM Components for Automatic Placement	30.6%	18.8%	17.6%	20.0%
EIA PDP 100--Mechanical Outline for Registered and Standard Electronic Parts	14.1%	29.4%	16.5%	27.1%
EIA JEP 95-JEDEC--Registered and Standard Outlines for Semiconductor Devices	24.7%	36.5%	17.6%	16.5%
EIA JESD 11--Chip Carrier Pinouts for CMOS 4000HC and HCT Circuits	9.4%	17.6%	16.5%	44.7%

Source: EIA/IPC Surface Mount Council

In addition, many organizations worldwide have established committees to discuss issues related to surface-mount technology. A list of these is shown as follows:

- ACPI (Automated Component Placement and Insertion Group)—c/o AMP, 1000 AMP Drive, Harrisburg, PA 17112
- ANSI (American National Standards Institute)—1430 Broadway, New York, NY 10018
- ASTM (American Society of Testing and Materials)—1916 Race Street, Philadelphia, PA 19103
- BSI (British Standards Institute)—2 Park Street, London, W1A 12BS, United Kingdom
- CSA (Canadian Standards Association)—178 Rexsdale Boulevard, Rexsdale, Ontario, Canada
- DOD (U.S. Department of Defense, Naval Publications Center)—5801 Tabor Road, Philadelphia, PA 19120
- EIA (Electronic Industries Association)—2001 Eye Street N.W., Washington, D.C. 20006
- EIAJ (Electronic Industries Association of Japan)—250 West 34th Street, New York, NY 10119
- EMPF (Electronics Manufacturing Productivity Facility)—1417 North Norma Street, Ridgecrest, CA 93555
- IEC (International Electrotechnical Commission)—3 Rue de Varembe, 1211 Geneva 20, Switzerland
- IEPS (International Electronic Packaging Society)—114 North Hale Street, Wheaton, IL 60187
- IPC (The Institute for Interconnecting and Packaging Electronic Circuits)—7380 N. Lincoln Ave. Lincolnwood, IL 60646
- ISHM-I/SMT (International Society of Hybrid, and Microelectronics, Interconnect and SMT Division)—Box 2698, Reston, VA 22090
- SEMI (Semiconductor Equipment and Materials—International)—805 E. Middlefield Road, Mountain View, CA 94043
- SMART (Surface-Mount and Related Technologies Group)—3 Lattimore Rd., Wheathampstead, Herts AL4 8QF, United Kingdom
- SMC (Surface-Mount Club)—British Overseas Trade Board, 1 Victoria St., London SW1H 0ET

- SMC (Surface-Mount Council—Joint ASTM/IPC/EIA/JEDEC Committee)—c/o IPC, 7380 Lincolnwood Ave., Lincolnwood, IL 60646

- SMEMA (Surface-Mount Equipment Manufacturers Association)—71 West St., Medfield, MA 02052

- SMTA (Surface-Mount Technology Association)—5200 Wilson Road, Suite 107, Edina, MN 55424

- STACK (Standard Computer Komoponenten GmbH)—5775 Wayzata Blvd #700, Minneapolis, MN 55416

- VRCI (Variable Resistive Component Institute)—c/o Bourns, Inc., 1200 Columbia Avenue, Riverside, CA 92507

DATAQUEST CONCLUSIONS

We believe that package proliferation will continue as the ASIC market develops. Many new packaging schemes will arise to meet the speed, thermal, and density requirements needed. Custom and semicustom packaging, including multichip modules using COB and TOB, will become more prevalent. Procurement of semiconductor integrated circuits will depend upon package needs and functions in addition to the basic electrical parameters of the chip. As a result, purchasers will need to specify even more details when ordering.

Mark Giudici

Appendix A

Package Standards

PLCC	JEDEC Publication 95, MO-047AA-AH
PQFP	JEDEC Publication 95, MS-069
QFP	EIAJ Specification IC-74-4, 1986
VQPF	EIAJ Specification IC-74-4-I, 1988
TapePak	JEDEC Publication 95, MO-071
TQFP	JEDEC Publication 95, under consideration
PGA	JEDEC Publication 95, MO-083
COB	Standards not available. Use TOB guidelines.
TOB	JEDEC UO-017 and Surface Mount Council--IPC/EIA/ASTM Publication SMC-TR-001, Guideline Introduction to Tape Automated Bonding Fine Pitch Technology
Micropak	Based on DIN 15851

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Conference Schedule

1989

Semiconductor User/ Semiconductor Application Markets	February 27-28	Le Meridien Hotel San Francisco, California
Japanese Components	April 20-21	Tokyo Bay Hilton International Tokyo, Japan
Computer Storage	April 26-28	The Doubletree Hotel Santa Clara, California
Document Processing	May 16-18	Monterey Sheraton Hotel Monterey, California
Copiers	May 16-17	
Printers	May 16-17	
Electronic Publishing	May 18	
Imaging Supplies	May 18	
Color	May 18	
SEMICON/West Seminar	May 24	The Dunfey Hotel San Mateo, California
Telecommunications	June 5-7	Silverado Country Club Napa, California
European Components	June 7-9	Park Hilton Munich, West Germany
Asian Semiconductor and Electronics Technology Seminar	June 28	Radisson Hotel San Jose, California
Financial Services	August 22-23	The Doubletree Hotel Santa Clara, California
Technical Computing and Applications	September 11-13	The Doubletree Hotel Santa Clara, California
European Copying and Duplicating	September 18-19	Majestic Hotel Cannes, France
Western European Printer	September 20-22	Majestic Hotel Cannes, France
Taiwan Conference	September 25-26	Grand Hotel Taipei, Taiwan
Distributed Processing	September 26-28	The Doubletree Hotel Santa Clara, California
SIA/Dataquest Joint Conference	September 27	Santa Clara Marriott Santa Clara, California
Information Systems	October 2-6	Tokyo American Club Tokyo, Japan
Semiconductor	October 16-18	Monterey Sheraton Hotel Monterey, California
Asian Semiconductor and Electronics Technology	November 2-3	Kunlun Hotel Beijing, China
European Telecommunications	November 8-10	Grand Hotel Paris, France
European Personal Computer	December 6-8	Athens, Greece

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Research Bulletin

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1989-17
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DISTRIBUTORS: WILL THEY ADAPT OR WILL THEY DIE?

The semiconductor industry is changing, and semiconductor distributors must change with it. Integration, consolidation, and interdependence are placing new demands on the distributor's traditional role of stocking parts and providing credit to the smaller purchasers of electronic components. Currently, distributors supply 22 percent of the semiconductors sold in North America. Dataquest believes that the distribution channel can and will adapt to the changes it faces in order to maintain its market share in the 1990s.

THE NEEDS OF COMPONENT BUYERS

Supply base managers at equipment companies have two very basic concerns today:

- Reducing the cost of raw materials
- Assuring their availability for as long as the equipment using them is in production

Dataquest believes that close partnerships between distributors and customers are necessary because the issues they face are interrelated (see Table 1). For example, cost control (item #7) means fewer units in stock to reduce working capital needs; this, in turn, leads to a JIT system (#6), high component quality (#4), and consistent on-time delivery (#3). The innovative distributor will grow its business by saving its customers money.

Table 1

Major Issues for Buyers in 1989*

Rank	The Major Issues	Rank	The Major Issues
1	Availability	6	JIT/inventory control
2	Pricing	7	Cost control
3	On-time delivery	8	New products/obsolescence
4	Quality/reliability	9	Surface-mount technology
5	Memories	10	Second-sourcing

*According to Dataquest's Annual Procurement Survey.

Source: Dataquest
April 1989

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The size of electronics has been shrinking, while its complexity has expanded. For example, circuits that required several cards just a few years ago now fit on a single chip. The user of chips, however, must deal with whole subsystems at once rather than the simpler building blocks of a decade ago. The innovative distributor will grow its business by helping its customers understand these more complex parts.

THE NEEDS OF SEMICONDUCTOR SUPPLIERS

More than 150 semiconductor companies were formed between 1977 and 1987 to develop new niche markets and technologies, and they need sales channels. Access to the U.S. market may not be easy for the 15 Asian semiconductor companies formed during this 10-year period. For example, Asian-made DRAMs were sold for only two weeks in 1988 by a major U.S. distributor before pressure from several major U.S. semiconductor manufacturers forced these items off the shelf. The distributor willing to risk or tolerate ostracism from U.S. semiconductor manufacturers can also increase business by providing foreign manufacturers with access to the U.S. semiconductor market.

Computer-based tools are making it possible for more semiconductors to be designed in shorter periods of time and at lower costs. For example, there were approximately 200 semiconductor designs done worldwide in 1975 and about 10,000 semiconductor designs done in 1985. Dataquest predicts that there will be more than 100,000 semiconductor designs done in 1995. ASICs such as PLDs and field-programmable gate arrays allow the users of semiconductors to configure components for optimum design of a system. The innovative distributor will grow its business by helping its customers understand ASICs.

NEW TECHNOLOGY IS HELPING DISTRIBUTORS

Computers and communications equipment are revolutionizing the way wholesalers do business. For example, telemarketing programs can reduce the cost and increase the speed of getting orders, an electronic data interchange (EDI) link can reduce the cost and increase the speed of placing orders, and warehouse automation can reduce the cost and increase the speed of filling orders. Semiconductor manufacturers and purchasers are installing these systems, and we believe that all commercial transactions will be handled this way in the future. The innovative distributor will grow its business at the expense of its less innovative competitors.

DATAQUEST CONCLUSIONS

In the United States, entrepreneurs succeed by finding unmet needs and filling them. Semiconductor manufacturers need better technical support in their sales channels, and component users need better service from their suppliers. Dataquest believes that those distributors who do adapt to and meet these needs will both survive and thrive in the 1990s.

Roger Steciak

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Research *Bulletin*

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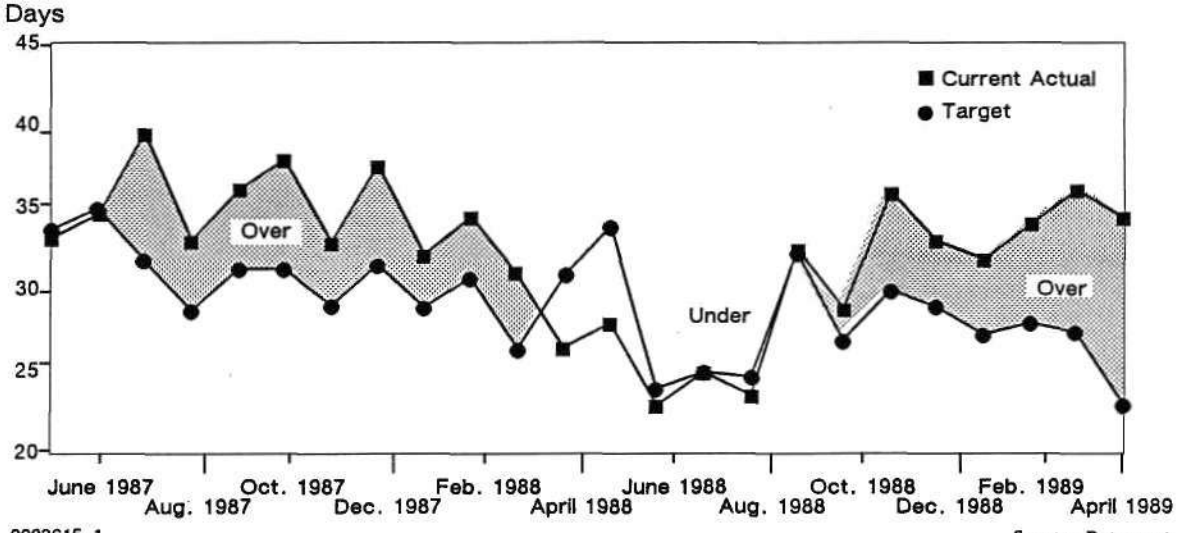
APRIL PROCUREMENT SURVEY: ORDER RATES STEADY, OVERALL AVAILABILITY DROUGHT OVER!

The semiconductor availability bubble has burst, according to this month's procurement survey respondents. Lead times have declined below eight (7.95) weeks for the first time since we began this poll. Although semiconductor booking rates remain relatively the same compared with last month's survey, half of our sample noted no difficulty in obtaining semiconductors (another survey first). Static RAM products still present somewhat of an availability problem for the other half of the survey population, however. Inventory levels for all OEMs (both target and actual) fell to 23.1 and 34.4 days, respectively, as shown in Figure 1.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



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Source: Dataquest April 1989

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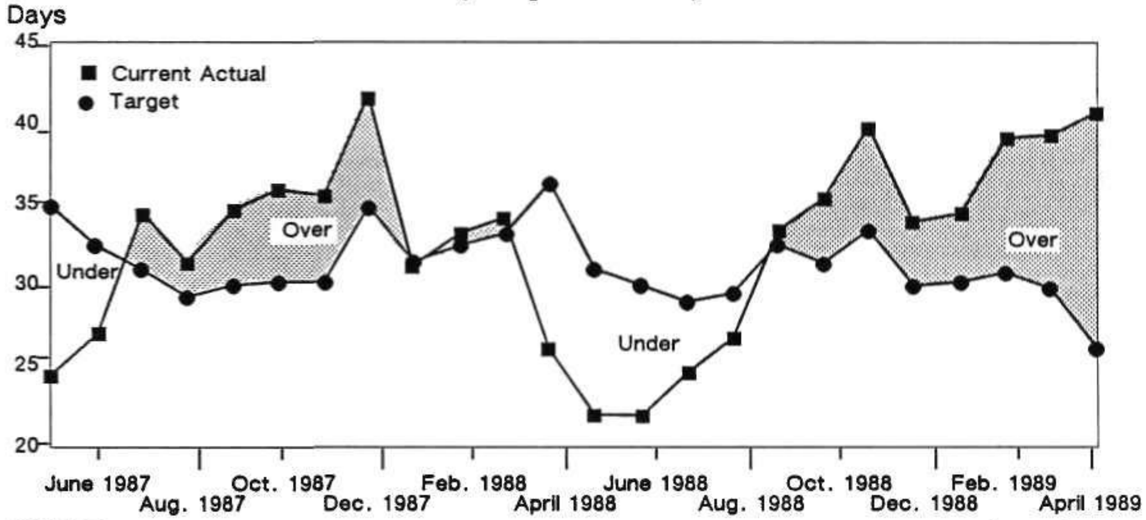
Conversely, as Figure 2 shows, the actual inventory situation in the computer segment has not improved. Targeted levels have declined, causing the current delta between target (26.2 days) and actual (40.8 days) to increase to 14.6 days versus the 9.6-day difference noted last month. The combined effect of increased key component availability and continued honoring of contracts made when parts were scarce keeps computer manufacturers grappling with inventory control. With system sales expected to range between flat and +10 percent during the upcoming 12 months, declines in semiconductor order rates are expected to control inventory levels.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



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Source: Dataquest April 1989

In line with the improved availability, overall pricing is gradually declining down a competitive-cost-induced curve. As mentioned above, the only areas that remain an availability problem are the devices dependent on 1Mb DRAM capacity (slow SRAMs, video RAMs, x4 DRAMs, and fast DRAMs). Quality requirements have become more stringent as availability becomes less a factor. Overall targeted functional reject rates in ppm declined by 10 percent from last month's figures.

DATAQUEST ANALYSIS

The market, with some exceptions, continues to show signs of balance between aggregate supply and demand. The direct implication for users is that overall prices and lead times will continue to decline at an accelerating rate as yields and run rates of 1Mb DRAM products improve and directly affect the rest of the semiconductor industry.

Users should write into their contracts (if they have not done so already) clauses that allow for quarterly price reviews. Opportunities for attractive margins will continue for semiconductor manufacturers who supply specialty memory, high-end 32-bit microprocessors, and CMOS PLD markets. With flat-to-moderate equipment sales expected, the requirement of accurate component forecasting still remains the number one tool to keep costs, inventories, and supply lines under control.

Mark Giudici

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Research *Newsletter*

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1989 SEMICONDUCTOR USER AND APPLICATIONS CONFERENCE: BUSINESS REMAINS STEADY; MOTOROLA WINS SUPPLIER OF THE YEAR AWARD

SUMMARY

This year's Semiconductor User and Applications Conference, held in San Francisco on February 27 and 28, was the most successful and widely attended to date. As it did last year, the conference agenda provided both users and suppliers of semiconductors with a forum to discuss industry issues in both a formal and an informal setting. This year's conference theme, "Buying and Selling Semiconductors in 1989," addressed the following four main areas:

- The 1989 industry outlook
- Purchasing issues
- A product and technology update
- Purchasing strategies

This newsletter will summarize the information presented at the conference, discuss how current issues are being addressed, and elaborate on the first annual Dataquest Semiconductor Supplier of the Year Award.

Dataquest's Fourth Annual Procurement Survey was used as the vehicle to allow semiconductor users to elect their Semiconductor Supplier of the Year. The five criteria used in determining the winner were quality, on-time delivery, overall price, technical support, and customer service. The overall winner of Dataquest's first annual Semiconductor Supplier of the Year Award was Motorola Inc.

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Accepting the award from Gene Norrett, corporate vice president of the Technology Division at Dataquest, was Chuck Thompson, senior vice president and director of world marketing for Motorola's Semiconductor Products Sector.

HIGHLIGHTS OF THE CONFERENCE

Economic Outlook for 1989

The consensus of opinion presented by the speakers on the first morning was that in comparison with 1988, 1989 will be a slowdown year regarding GNP, electronics, semiconductors, and semiconductor capital equipment.

Richard O'Brien, Hewlett-Packard's corporate economist, presented the economic framework that the electronics industry will be facing in the current and upcoming years. An overall slowing of the worldwide economy is expected to dampen capital equipment expansion primarily because of the large growth in industrial production seen during the past three years. GNP growth will be lower than last year's surge, in part resulting from the increase of inflation caused by continued high levels of debt-induced spending. The Federal Reserve is expected to continue to fight this inflationary trend with increased interest rates; these, in turn, will slow capital expenditure growth.

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The Dataquest electronic equipment forecast was presented by Terrance Birkholz, research analyst in Dataquest's Semiconductor User Industry Service. Buttressing Mr. Birkholz's forecast was the worldwide competitive environment, which he presented as a six-front war involving the following:

- Performance
- Quality
- Standards
- Pervasiveness
- Size
- Cost

These areas are coming under fire as the worldwide economy slows. The only increases in regional growth came in the North American transportation and consumer applications and in the European industrial and communications arenas.

Hal Feeney, group vice president and director of the Dataquest Components Division, next presented the 1989 semiconductor industry outlook. Citing the cyclicity of semiconductor growth relative to the end markets, Mr. Feeney pointed out that a combination of softening order rates, declining DRAM pricing, diminishing product constraints, selected personnel adjustments, and the concentration of supplier strength all show a trend toward slower growth in the next few years.

The former director of Dataquest's Semiconductor Equipment and Materials Service, Robert McGeary, spoke on this year's semiconductor capital equipment outlook. Capacity utilization is expected to decline this year because of the aforementioned slowing of overall semiconductor consumption. Although capital spending will remain flat relative to 1988, it is in line with lowered semiconductor revenue estimates.

Mark Giudici, product manager of the Semiconductor User and Applications Group, presented the results of Dataquest's Fourth Annual Procurement Survey. The 1988 DRAM shortage was in large part responsible for this year's top three issues (availability, price, and on-time delivery), which were also last year's top issues. Another direct result of the DRAM shortage was that Japanese semiconductor suppliers made large inroads in supplying their U.S. customers by doubling their overall market share (from 17.0 percent to 34.5 percent), while U.S. suppliers lost 20 percent of the market (from 80.0 percent to 60.5 percent) during 1988. The respondents noted that in the memory-dependent data processing market, Japanese and U.S. semiconductor suppliers now have nearly equal market share (46.7 percent and 47.3 percent, respectively). Another key outcome of the survey was that offshore production appears to have peaked with 80 percent of the respondents planning no offshore production movement. Inventory levels are targeted to decline this year with the highest percentage ever recorded (45 percent) of the respondents stating that inventories will be reduced in 1989.

As mentioned above, Motorola was chosen as the best Semiconductor Supplier in 1988. Motorola received the most votes in all five categories, but excelled in customer service (see Table 1). This result correlates with the overall need of semiconductor users for a vendor that supplies quality product, that is on time and reasonably priced, and that is both supported technically and displaying a "go the extra mile" attitude.

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Table 1

Top Five Semiconductor Suppliers

Company	Area of Excellence (Highest Votes)
Motorola	Customer service
Texas Instruments	On-time delivery
National	Price
Intel	Technical support
Hamilton-Avnet	Price

Source: Dataquest
April 1989

Purchasing Issues in 1989

The main issues that face users of semiconductors (availability, price, and on-time delivery) were addressed in a variety of ways by the following seven speakers.

Service

Bill Davidow, general partner with Mohr, Davidow Ventures, opened the afternoon with a call to arms as far as servicing the customer is concerned. Mr. Davidow stated that too few companies know how to produce the service level needed by their customers. Once a product becomes a commodity, the only differentiating factor companies have is how well they satisfy their customers' needs. The six elements of service, strategy, leadership, personnel management, design, infrastructure, and measurement, all have to be in place for a company to provide good service. The speaker noted that, because of the intangible nature of service, unfortunately, many companies get around to service once all the tangible factors of running a business are complete.

Procurement

The president of Nahabit & Associates, Robert Nahabit, discussed how the procurement function of an organization should be viewed as an investment, not a cost center. The speaker's message to CEOs is, "You might as well get the very best purchasing talent available, no matter what the cost, because you are going to pay for it anyway, one way or another." Outmoded is the idea that purchasing's function is solely to get the best price; rather, purchasing should be judged as a return on investment, with cost savings minus operating costs representing the return on investment.

Offshore Business

Fujitsu's director of ASIC operations, Larry Roffelsen, explained what is required of a foreign-owned company doing business offshore. The question of whether the offshore entity has local autonomy revolves around how well the local market is understood and how its needs can be met. Mr. Roffelsen emphasized that a foreign company cannot expect to fare well in the global marketplace unless it understands and incorporates the needs of the local market and is able to respond without always having to get offshore corporate approval.

Technology

Howard Bogert, a Dataquest vice president, spoke on how the importance of technology, rather than individual products, is often overlooked in the competitive global marketplace. By comparing Japanese and U.S. approaches used to address market needs, Mr. Bogert noted some of the strategic advantages Japanese companies have over their competitors. What the speaker suggested was that technology should be looked at as a highly valued bargaining chip that should not be squandered but should be used wisely to gain access to markets, to develop product knowledge, and to contribute to the health of the local economy.

Quality

Texas Instruments' vice president of total quality control, James Watson, discussed the fact that semiconductor quality improvement is an ongoing process. In the 1970s, the definition of quality was meeting the acceptable quality level (AQL); in the 1980s, the definition focused on meeting customer specifications. Mr. Watson contends that, in addition to these two measures, the yardstick of the 1990s will be customer satisfaction measured by process capability. The speaker noted that procurement's challenge is to be more knowledgeable about statistical process control (SPC), to know what is happening on the factory floor, to understand the supplier's capabilities, to work closely with the supplier, and to demand input on new product definition.

Electronic Data Interchange

Edwin Bjore, a senior systems analyst with Tektronix, spoke about how electronic data interchange (EDI) can benefit both buyers and suppliers of materiel. The speaker elaborated on what is needed and what can be gained by using EDI. In order to install EDI, the following prerequisites must be met:

- Vendor partnerships
- Reliable forecasts
- Reliable deliveries
- Trust in accuracy

The reasons to invest in EDI are varied. The following are but a few:

- Purchasing—supplier, lead time, and paperwork reduction
- Manufacturing—just-in-time (JIT) and computer-integrated manufacturing (CIM) programs

Mr. Bjore noted that, with the proper foundations laid, EDI has provided benefits that far outweigh the initial costs.

U.S.-Japanese Competition

Clyde Prestowitz, senior associate at the Carnegie Endowment for International Peace and author of Trading Places: How We Allowed Japan to Take the Lead, gave an inspirational dinner presentation on the cultural, business, and social differences that exist between the United States and Japan and why they exist. Citing that it is impossible (and probably a bad idea anyway) for the two countries to try to change each other, Mr. Prestowitz went on to say that, although different, the United States and Japan could compete with each other fairly if the United States had a centralized goal similar to the Apollo Project that landed a man on the moon. In order to define and act upon that goal, the federal government could, without gross expenditure, allow the productive force in this country to at least sing from the same sheet of music. Without going into detail about such things as taxation schemes, the speaker prompted the audience to think about how each of their companies might be if that sheet of music were widely distributed.

Products and Technology in 1989

Ron Bohn, industry analyst in the Semiconductor User and Applications Group, presented Dataquest's semiconductor price and lead time outlook for the year. Noting that the DRAM has been and will continue to be a major pricing problem, Mr. Bohn focused on how the availability of DRAMs will impact all other semiconductor products in the upcoming year. Due to the insatiable demand of memory in a "DRAM hungry world," supplies are expected to continue to lag demand in a steadily growing market. The impact of this situation on microprocessors, ASICs, and nonvolatile memory will be to lengthen life cycles as gradual price declines of generic (x1) and specialty (x4, video) DRAMs keep demand for these ancillary devices in check. Mr. Bohn concluded that, although mature products will experience flat to falling prices, newer products will follow traditional cost-curve price declines and technology dependence will continue to increase the likelihood of key component spot shortages.

The director of DSP products for Austek Microsystems, David Taylor, explained how digital signal processing (DSP) is being used in various applications and what it means to users and suppliers alike. Mr. Taylor noted that there are four different types of DSP products: ASIC DSP, algorithm-specific DSP, microprogrammable DSP, and DSP microprocessors. DSP microprocessors can be seen as "jacks of all trade" DSP components, while algorithm-specific DSP parts are "masters of one trade." The mature microprogrammable DSP components still hold a majority of the DSP market but are receiving stiff competition from the two newer technologies. The understanding of DSP and its applications will pose challenges to both users and buyers, Mr. Taylor noted, but the advantages are well worth looking into.

The ASIC world was reviewed by Andy Prophet, the senior industry analyst covering ASICs for Dataquest's Semiconductor Industry Service. In his speech, "ASICs and the Graveyard of Overriding Considerations," Mr. Prophet stated that the ASIC segment of the industry is due for a shakeout as small companies without the financial and technical wherewithal to provide cutting-edge technologies either will be absorbed by larger companies or will cease to exist. The speaker foresees ASIC technology as another technology driver equal to the DRAM for the customized segment of the marketplace. This new function of ASICs necessarily requires large outlays of research funding that only the most successful of ASIC vendors will have available. In order of stability,

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companies selling cell-based product will fare well, yet the number of companies now in the gate array segment are expected to be fewer within this year. The highest growth area in ASICs is in the MOS programmable logic device (PLD) segment. Many new companies with state-of-the-art technology are providing customers with ASIC solutions at very competitive pricing.

Stephen Diamond, Sun Microsystems' director of component marketing, spoke about the reduced-instruction set computing (RISC) versus complex-instruction-set computing (CISC) application decision. Mr. Diamond noted that although each type of processor has merits, the intended application of the individual system will ultimately determine what type of processor best suits the market. Machines that require high-volume calculation capability with or without enhanced graphics often are designed for RISC processors, while machines that are used as multipurpose tools either in business or technical applications often are designed with CISC processors. The message here was that RISC is not a fad but a very viable option in designing state-of-the-art systems.

The chairman and CEO of Micron Technology, Joseph Parkinson, presented the DRAM suppliers' perspective of the past year's DRAM shortage. Citing the increasingly high costs of producing advanced memory products, Mr. Parkinson spoke of how strategic alliances between user and supplier can be a solution to the ongoing shortages of key components. He said that quality, on-time delivery, pricing flexibility, open communications between user and supplier, and fulfilling commitments are the keys to a good working relationship.

Purchasing Strategies for 1989

The strategies emphasized this year concerned the planned use of strategic partnering, coordinated sourcing, and product definition as companies mature in the worldwide marketplace.

Bill Krist, vice president of international trade affairs for the AEA, presented the user's views on last year's DRAM debacle. Mr. Krist briefly explained why the U.S.-Japan Semiconductor Trade Arrangement was instituted and discussed measures proposed to prevent a repetition of recent events in the electronics industry. Systematically tracking the demand of the PC/workstation markets and proposing changes to the existing trade arrangement are on the current agenda for the AEA with Dataquest in order to mollify the dramatic swings of the semiconductor supply situation. The speaker emphasized that long-term purchase agreements and formalized alliances and/or consortia between users and suppliers of semiconductors will continue to provide the most stable supply of components for users and revenue for suppliers.

Carl Salanitro, the Corporate Materiel Manager of Hughes Aircraft Company, spoke about procurement's role in keeping a company competitive. Citing the need for a balance in supply sourcing and another call for buyer/supplier partnering, the speaker discussed how procurement involvement can greatly ease the implementation of corporate alliances by ensuring the correct choice of suppliers and the products they supply. Mr. Salanitro stressed that increased competition and alliances can ensure top quality, lower costs, and reliable supplies both now and in the future.

NCR Corporation's director of contract negotiation and management, Derrell Hauser, presented the five key points necessary for a successful supply line management program. The five criteria that purchasing needs to review critically are the following:

- Technology
- Reliability
- Quality
- Delivery
- Price

To become a key supplier, a company must excel at these elements. Mr. Hauser contends that, in order for a supply line management program to work effectively, a sense of ownership must exist to provide the incentive to perform best. In turn, each stakeholder in the equation gains, be it a supplier with increased sales, a design group with the latest technology, or the traffic department with the highest on-time delivery schedule. The bottom line for the user is that once the rules of supply line management are understood by all, every company involved comes out ahead.

John Patterson, senior vice president of Tandy Computers-Tandy Electronics, next discussed his company's perspective on worldwide sourcing. Dr. Patterson focused on how the combination of internally manufacturing proprietary components and externally sourcing commodity products on a region-by-region basis can lower supply line risk in the personal computer industry. Buyers need to become more technically proficient in order to know the rudiments of the products they are buying. For external suppliers, close working relationships are mandatory and will continue to be so in today's competitive market.

Apple Computer's vice president of product marketing, Randy Battat, spoke about Apple's combining design, manufacturing, and marketing to shorten the product cycle from inception to production. To best utilize a company's resources, the funnel approach is used on an idea. The idea is first previewed by all departments directly involved (design, manufacturing/procurement, and marketing). This approach is used in order to best understand any of the pitfalls in manufacturing, procurement, or design constraints long before the drawings are released for production. By combining the efforts of normally diverse departments, ownership of the new product (if approved) is already in place as a result of the in-depth preapproval process.

OVERALL CONFERENCE REVIEW

The latest Semiconductor User and Applications Conference again provided the forum for semiconductor manufacturers and users to formally and informally discuss strategic and tactical issues of importance today and in the coming year. Although the urgency of DRAM availability has ebbed since last year's conference, the continued uneasiness of key component supplies will continue on through 1989. The anticipated overall slower economy will affect all areas of the electronics industry. How buyers and sellers of semiconductors react to this environment remains to be seen. Nevertheless, the strategies and tactics presented at this year's conference, if carefully implemented, will help smooth the ruts in the anticipated bumpy road that lies ahead for the electronics industry.

Mark Giudici

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Research Newsletter

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SEMICONDUCTOR PRICE SURVEY: SPOTLIGHT ON 1Mb DRAM PRICE DECLINES

SUMMARY

The year 1989 marks an overall downward trend in North American semiconductor pricing, with prices continuing to decline in commodity areas such as standard logic and nonvolatile memory. The big news, however, centers on declining average selling prices (ASPs) for critical devices such as 1Mb DRAMs, ASICs, and 32-bit microprocessors. An increasing supply of 1Mb DRAMs translates into a year-long decline in price for this key component, with supply and demand moving into balance by early in the third quarter. This newsletter highlights the key points of Dataquest's latest North America-based price survey and forecast.

STANDARD LOGIC TRENDS

Supply of standard logic products should exceed demand during the first half of 1989. General lead times narrowed during the first quarter of 1989 to a range of seven to nine weeks versus the longer lead times of 1988. Figure 1 illustrates the consequent downward pressure on standard logic pricing.

As shown in this figure, the mature bipolar and HCMOS families should gradually decline in price as suppliers ponder their future in these older markets. Pricing for newer families (AS, ALS, Advanced ECL) will drop more aggressively to keep in line with cost-curve experience as suppliers battle to keep design-ins.

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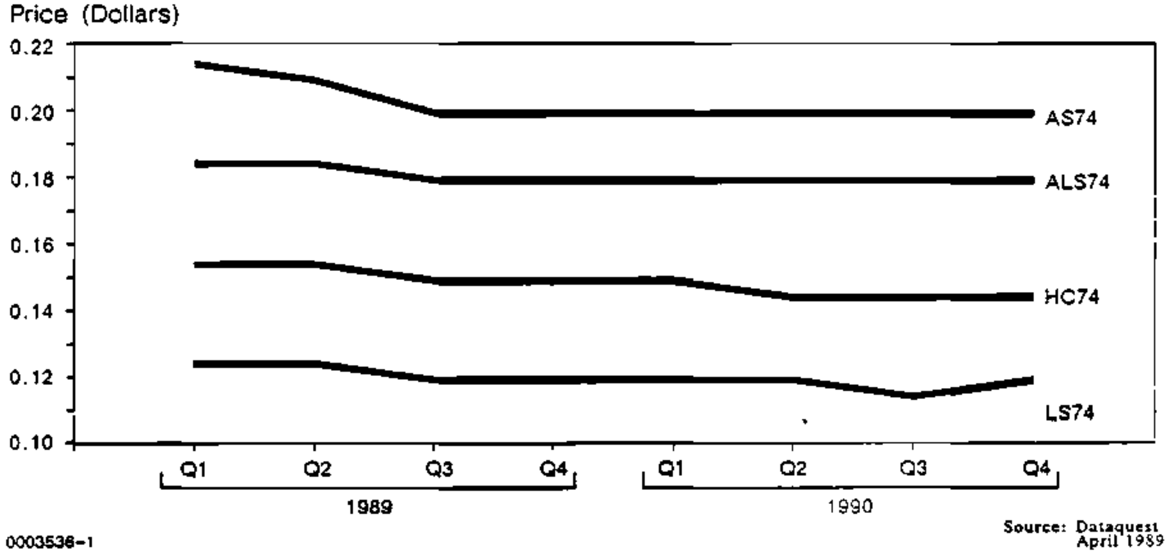
Figure 1

Standard Logic Price Trends



MICROPROCESSOR TRENDS

With demand from PC manufacturers slowing from the torrid 1988 pace, the microprocessor component (MPC) marketplace stands at supply-demand equilibrium except for unmet demand for high-speed 16- and 32-bit MPCs. Lead times range from 8 to 16 weeks with most deliveries running 10 to 12 weeks.

Pricing for the mature mainstream 8-bit and 16-bit MPUs should be stable. A major exception to this trend is a price battle that has erupted among suppliers of high-speed 80286 devices (> 12 MHz) and suppliers of 16-MHz 32-bit products. Manufacturers such as Intel and Motorola are cutting prices now in order to move users from high-speed, 16-bit MPCs to the low end of the 32-bit camp. ASPs for 32-bit MPCs continue to decline as expected, at a rate of 5 percent per quarter.

MEMORY TRENDS

Events in the DRAM segment set the stage for memory price/lead time trends with several exceptions. As shown in Figure 2, North American users of the critical 1Mb DRAM can expect a year-long decline in price that drops to $10.09 by the fourth quarter. The supply of 1Mb DRAMs is ramping up so that overall supply and demand should balance by the third quarter. There will be little price/availability relief for users of 256K DRAMs until after the 1Mb market achieves an equilibrium. Obtaining more specialized DRAMs such as the x4 parts (64Kx4, 256Kx4) or higher-speed devices (sub-100ns) will continue as a procurement challenge. Samples of 4Mb DRAMs are available at an ASP of $200 to $300 from an ever growing supplier base. Seven suppliers have 4Mb samples of DRAMs now, and 10 more firms will do so by the end of 1990.

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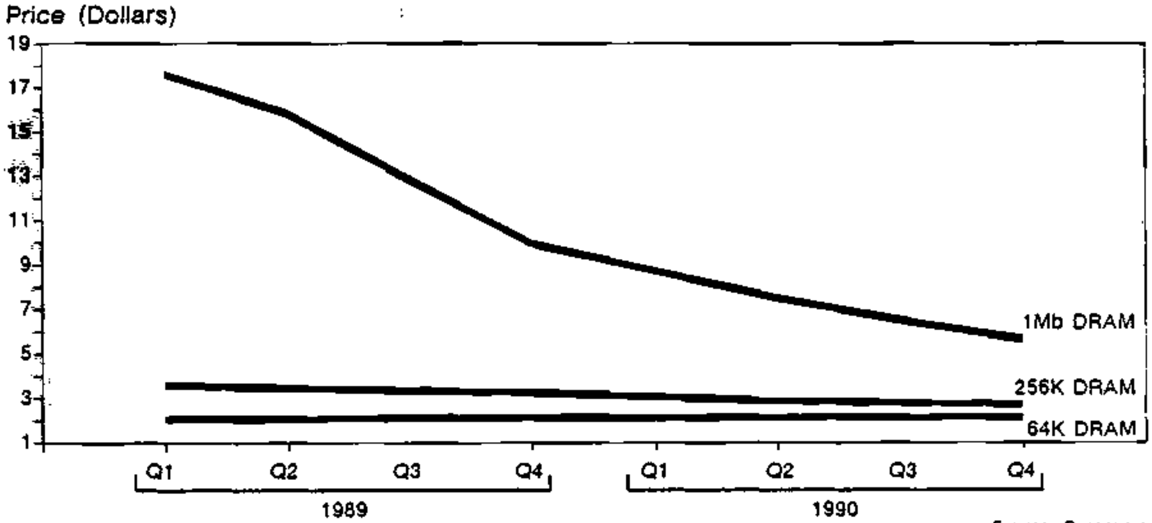
Figure 2

DRAM Price Trends



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Source: Dataquest April 1989

The supply and pricing of slow SRAMs remain a DRAM-driven function. Specifically, suppliers of slow SRAMs have little incentive to produce slow SRAMs (given the more lucrative choice of producing DRAMs); therefore, slow SRAM lead times are expected to remain long and pricing firm during the second quarter of 1989. By the third quarter, however, users can expect an increase in the supply of slow 8Kx8 and 32Kx8 SRAMs.

Fast SRAM trends remain largely independent of the DRAM world. Demand for fast SRAMs is driven by performance, which for suppliers allows for a high degree of product differentiation and higher ASPs. During 1989, 16K and 64K fast SRAM prices will decline as suppliers compete for customers' sockets.

The nonvolatile memory business (EPROMs, EEPROMs) should avoid major impact from the DRAM crunch this year. Pricing will be flat or it will decline moderately, with lead times holding at 6 to 16 weeks, due to the relatively small size of this marketplace.

ASICs

So far during 1989, all ASIC implementations are declining in price. The sole exception is 3-micron gate arrays, which continue to move down the phase-out stage of the product life cycle. Figure 3 reveals pricing pressure in the ASIC world.

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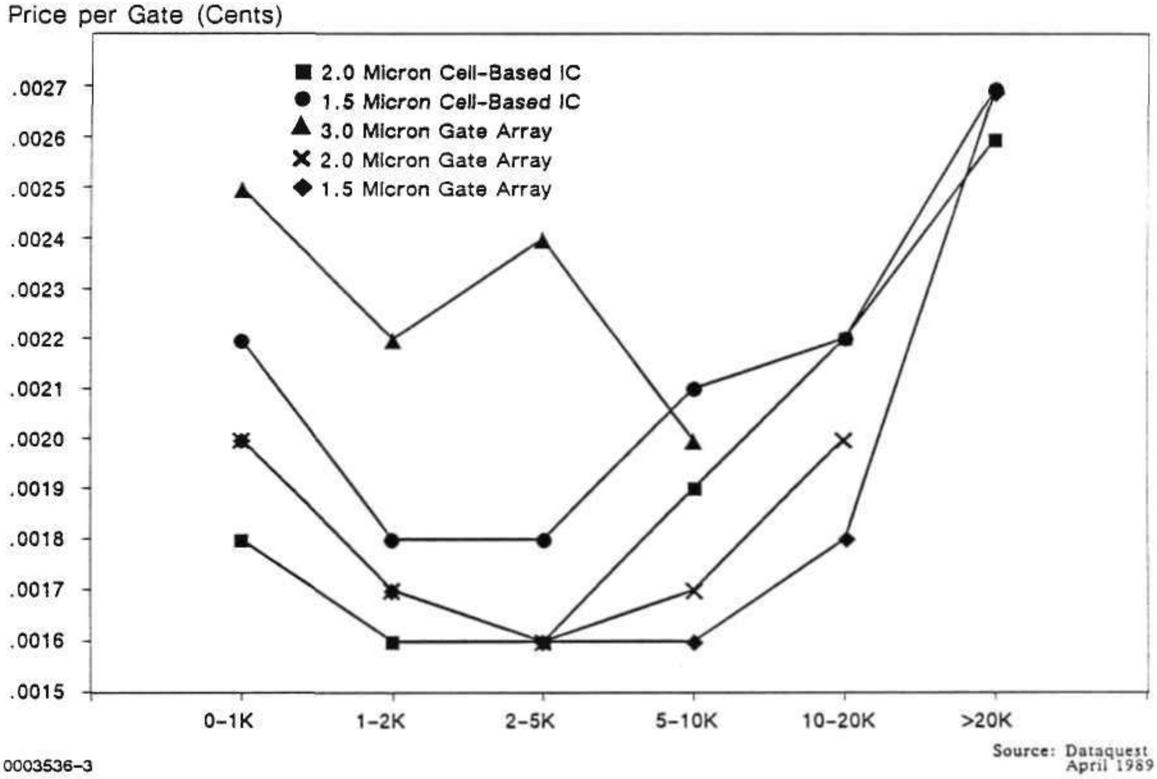
Figure 3

1988 ASIC Price Trends



Gate arrays are declining in terms of both price per gate and nonrecurring engineering (NRE) costs, with the trend most apparent in the 1.5-micron segments. Nevertheless, suppliers of other ASICs (cell-based ICs, or CBICs; PLDs) are throwing gasoline onto the flames of gate array price competition. Price competition in the CMOS PLD segment makes those devices increasingly attractive as a design alternative to gate arrays in select applications. On a long-term strategic basis, the downward trend in CBIC pricing requires users to give CBICs a close look in terms of total system cost savings for systems being designed today for production in the 1991 to 1992 period.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

During 1989, Dataquest recommends that users of semiconductors should structure their supply-base activities by wearing the following two different procurement hats:

- Commodity products hat
- Higher-performance products hat

Commodity Products

Commodity-type semiconductors will be available from a wide supplier base in ample quantities at declining prices and narrowing lead times. These commodity devices include 1Mbx1 DRAM (100ns or greater), 1Mb EPROM, standard logic, 1.5- to 2.0-micron CMOS gate arrays (10K gates or less), and lower-speed 8- and 16-bit microprocessors ($\leq$ 12 MHz). Downward pricing trends also show up in noncommodity areas such as 32-bit microprocessors and CMOS PLDs. For supply-base managers, the commodity product scenario translates into a steadier supply at lower prices during 1989.

Higher-Performance Products

Dataquest recommends that supply-base managers devote extra procurement effort and also be prepared to pay stiffer premium prices this year in order to procure specialized chips required for high-performance systems. In the DRAM arena, the x4 configuration (64Kx4, 256Kx4) will be in heavy demand but not amply supplied. The supply-demand imbalance and erratic price swings that characterize the 256K DRAM business will plague users of 256Kx4 DRAMs (as well as 64Kx4 devices). Users of sub-100ns DRAMs must also compete against heavy demand and should expect to pay 15 to 20 percent premiums for 80ns devices. Similarly, supply-base managers must aggressively source devices such as video RAM, slow SRAM (8Kx8, 32Kx8, 1Mb), and 4Mb DRAM on a worldwide basis because of their limited availability.

Ronald Bohn

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Research Newsletter

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A SAMPLING OF SUB–1.5–MICRON DEVICES JULY THROUGH DECEMBER 1988

INTRODUCTION

This newsletter lists the new commercial products with line geometries of 1.5 microns or below that were announced from July through December 1988. For the most part, the products are either being sampled or in production. (Although the list is not the result of a thorough literature search, Dataquest believes that it represents a fair cross section of sub–1.5–micron products introduced during the six–month period.) The intent of this newsletter is to provide our clients with a barometer of the changes occurring in fabrication technology, along with an idea of the types of leading–edge products entering production.

Table 1 summarizes the number of new product introductions by linewidth. (A product family, such as an ASIC family, is considered a single product.) Of the 99 new products listed in this newsletter, 37 percent are (or will be) fabricated with 1.5–micron linewidths, while 63 percent are fabricated with 1.3 microns or less. Thirty–eight percent of the new products are fabricated with 1–micron or lower linewidths, and 16 percent are fabricated with submicron geometries. Figure 1 illustrates the breakdown by linewidth and category of the 99 new products.

Figure 2 shows how the number of new products for July through December 1988 compares with the number for March through June 1988. (See SUIS Newsletter 1988–18, entitled "A Sampling of Sub–1.5–Micron Devices, March Through June 1988.") Note that for both periods, 37 percent of the products introduced are fabricated with 1.5–micron linewidths; however, there is a definite shift toward smaller geometries in the later period. In the previous period, 29 percent of the products were introduced at 1.1–micron geometries or below, while in the latest period, the figure has grown to 38 percent.

Table 2 lists the 38 new products that have linewidths of 1 micron or lower and the companies that will manufacture the products.

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Table 1

Number of New Products by Linewidth
(Microns)

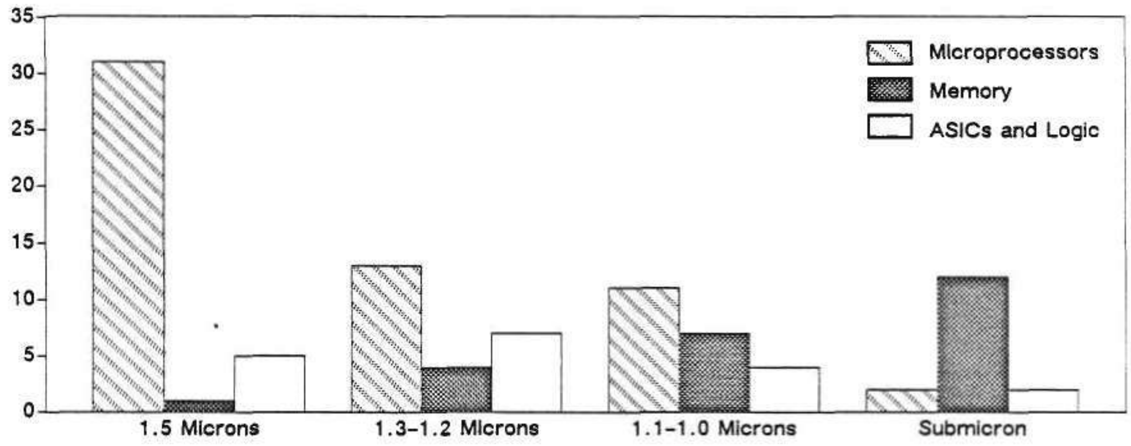
Product Category	1.5	1.3-1.2	1.0	Submicron	Total
Microprocessor Products	31	13	11	2	57
Memory Products	1	4	7	12	24
ASIC and Logic Products	5	7	4	2	18
Total	37	24	22	16	99
Percent of Total	37%	24%	22%	16%	100%

Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
April 1989

Figure 1

Number of New Products
by Linewidth and Product Category
(July–December 1988)



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Source: Dataquest
April 1989

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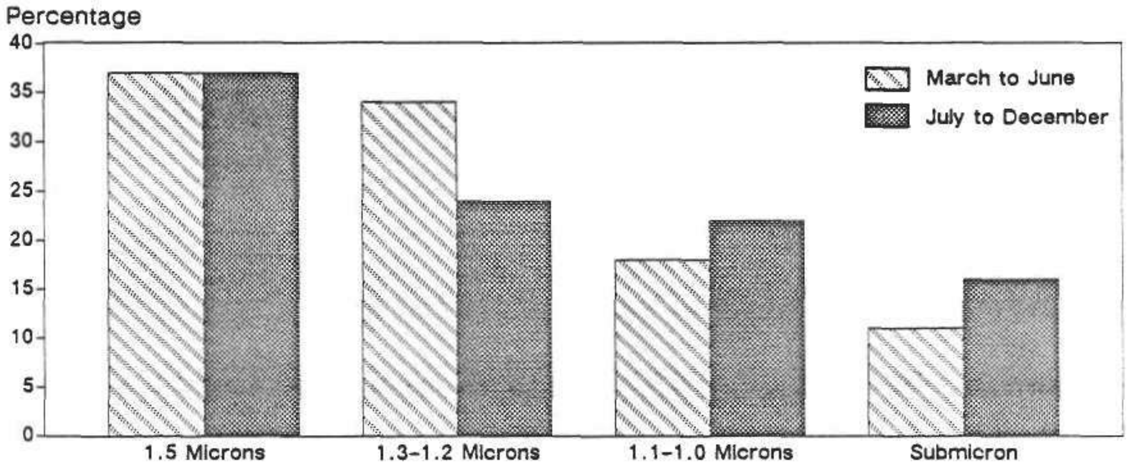
Figure 2

Number of New Products
by Linewidth and Time Period



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Source: Dataquest
April 1989

Table 2

1-Micron and Submicron Devices

Company	Linewidth (Microns)	Device Type
Microprocessors		
Fujitsu	1.0	32-bit TRON MPU
Hitachi	1.0	32-bit TRON MPU
LSI Logic	1.0	RISC MPU
Mitsubishi	1.0	32-bit TRON MPU
Texas Instruments	1.0	Communications coprocessor
Texas Instruments	1.0	RISC DSP
Texas Instruments	1.0	32-bit interface controller
Texas Instruments	1.0	Palette-DAC
Toshiba	1.0	32-bit TRON MPU
TRW	1.0	Integer divider
Weitek	1.0	64-bit FPUs
AT&T	0.75	16-bit DSP
AT&T	0.75	DSP

(Continued)

Table 2 (Continued)

1-Micron and Submicron Devices

Company	Linewidth (Microns)	Device Type
Memory		
Intel	1.0	256K EPROMs
Mitsubishi	1.0	Fast 256K SRAMs
NEC	1.0	4-Mbit EPROM
Siemens	1.0	1-Mbit DRAM
S-MOS	1.0	Fast 256K SRAMs
Toshiba	1.0	Fast 64K SRAMs
Toshiba	1.0	Fast 8K x 9 SRAM
Cypress Semiconductor	0.8	Fast 64K SRAMs
Cypress Semiconductor	0.8	Fast 4K SRAM
Cypress Semiconductor	0.8	Fast 128K SRAM
Hitachi	0.8	4-Mbit DRAM
NEC	0.8	16-Mbit ROM
Waferscale Integration	0.8	1-Mbit EPROM
Waferscale Integration	0.8	512K EPROM
Waferscale Integration	0.8	256K EPROM
Performance Semiconductor	0.7	Fast 4K SRAMs
Performance Semiconductor	0.7	Fast 16K SRAMs
Performance Semiconductor	0.7	Fast 64K SRAMs
NEC	0.55	16-Mbit DRAM
ASIC/Logic		
Altera	1.0	EPLD
LSI Logic	1.0	Gate arrays
VLSI Technology	1.0	Gate arrays
VLSI Technology	1.0	Standard cells
Altera	0.8	EPLD
Vitesse	0.8	GaAs gate array

Source: Dataquest
April 1989

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NEW PRODUCTS

Microprocessor, Microcontroller, and Peripheral Products

The following microprocessor, microcontroller, and peripheral products were introduced between July and December 1988:

- Japan's 32-bit Gmicro TRON microprocessors are beginning to hit the market. Hitachi is sampling its Gmicro 200 (700,000 transistors); Fujitsu will began sampling its 900,000-transistor chip, the Gmicro 300 in the spring of 1989; and Mitsubishi is scheduled to begin sampling its 300,000-transistor Gmicro 100 chip, also in the spring of 1989. In addition, Toshiba is working on a 400,000-transistor chip called the TX1. All four devices are fabricated with a 1-micron CMOS process. (12/26/88)

- AT&T has available the DSP32C intended for use in graphics, telecommunications, and speech recognition systems. The device has more than 400,000 transistors and is fabricated with a 0.75-micron, double-metal CMOS process. (12/12/88)

- Hitachi is sampling the H8 532 8-bit microcontroller, which has 32K of EPROM and a 200ns instruction execution time. The device, the first in Hitachi's H8 family, is fabricated with a 1.3-micron CMOS process and is scheduled to be in full production by April 1989. (12/12/88)

- TRW has introduced an integer divider for use in radar systems, workstations, and imaging systems. The TMC3211 performs at 20 million operations per second; it is fabricated with TRW's 1-micron CMOS Omnicron process. (12/12/88)

- Data Translation has entered the chip business with its MicroChannel interface chip designed for use in its line of add-in boards for IBM's PS/2 computers. The device, manufactured by LSI Logic, is fabricated with a 1.5-micron CMOS process. (12/12/88)

- SGS-Thomson Microelectronics has introduced two families of 8-bit microcontrollors, the ST62XX and ST63XX. The devices are fabricated with a 1.5-micron CMOS process. (12/5/88)

- NSI Logic has introduced an advanced video controller, the EVC-415A, and a companion video palette DAC, the PS00004, for implementing VGA-compatible subsystems. Both devices are fabricated with a 1.5-micron CMOS process. (12/5/88)

- Advanced Micro Devices has introduced a single-chip 32-bit floating-point processor. The Am29C325 device is fabricated with a 1.2-micron CMOS process. (12/5/88)

- Texas Instruments (TI) has introduced its single-chip communications coprocessor for implementing a 16-Mbps token-ring local area network (LAN). The TMS380C16 chip is fabricated with TI's 1-micron CMOS EPIC process. The chip is sampling now, with full production expected in mid-1989. (12/5/88)

- Austek Microsystems is sampling the A41102 frequency domain processor, capable of real-time fast Fourier transforms for spectral analysis of speech, radar, and sonar signals. The device is fabricated with a 1.5-micron CMOS process. (11/28/88)

- LSI Logic has begun shipping its new RISC chip set, which consists of the LR3000 32-bit microprocessor, LR3010 floating-point accelerator, and LR3020 write buffer. Available in 16.7 MHz and 25 MHz, the LR3000 CPU is fabricated with a 1-micron CMOS process. (11/21/88)

- Fujitsu has introduced a 25-MHz memory management unit (MMU) for its S-25 Sparc RISC microprocessor. The MB86920 MMU is fabricated with a 1.2-micron CMOS technology. The device is available in sample quantities with production volumes expected in January 1989. (11/21/88)

- Weitek has introduced faster versions of its WTL3164 and WTL3364 64-bit floating-point processors that were originally introduced earlier this year. The devices, previously fabricated with a 1.25-micron process that allowed 100ns speeds, will now be fabricated with a 1-micron process to obtain speeds as fast as 50ns. (11/14/88)

- G-2 Inc. has introduced a 80386SX-compatible chip set, the GCK101SX, which allows designers to build a 80386SX system with nine chips. The GCK101SX, a three-chip set fabricated with a 1.5-micron HCMOS process, is being sampled currently; production is scheduled for the first quarter of 1989. (11/7/88)

- NCR has introduced its 90C98 Arcnet LAN chip, which combines the functions that were previously contained on the 90C26 and 90C32 chips. The device is fabricated with a 1.5-micron CMOS process. Samples will be available in December, with production scheduled for February 1989. (11/7/88)

- Fujitsu is beginning production volume on its second-generation version of the SPARC RISC microprocessor. The S-25 is a standard cell implementation of the SPARC architecture and is fabricated with a 1.2-micron CMOS process. (10/10/88)

- Oki Semiconductor is offering the MSM699210 DSP, a 1.5-micron upgraded version of the 2-micron MSM6992 DSP. The MSM699210 will eventually shrink to a 1.2-micron process and then to a 1-micron process by the end of 1989. (10/17/88)

- AT&T is sampling the WE DSP16A 16-bit DSP device that AT&T claims is the fastest 16-bit DSP on the market, with an instruction execution time of 33ns and a 30-mips performance. The chip is fabricated with a 0.75-micron, double-metal CMOS process. (10/10/88)

- Edsun Laboratories will sample early in 1989 an improved color palette DAC that will make a standard PC monitor look like a high-resolution graphics screen. Production is scheduled for the second quarter of 1989, and the chip will be fabricated with a 1.5-micron, double-metal CMOS process. (10/3/88)

- Chips and Technologies has introduced a six-device chip set intended for the 80286- and 80386SX-based laptop computers. This chip set is offered in two versions for the different microprocessors, and all devices are fabricated with a 1.5-micron CMOS process. (9/26/88)

- Texas Instruments is now sampling the TMS320C30 digital signal processor. Employing RISC architecture, it is capable of 33 Mflops and can execute instructions in 60ns. The chip integrates 700,000 transistors and is fabricated with TI's 1.0-micron EPIC CMOS process. (9/19/88)

- Vadem will sample in November the VG-501 and VG-502 chip set that was developed in conjunction with Intel. The two chips consolidate peripheral functions for the 80C186-based PC XT and PS/2 Model 30 compatible systems. VLSI Technology will manufacture the chip set using a 1.5-micron, double-metal CMOS process. (9/19/88)

- NEC will begin sample shipments of a 122ns DSP in October. The uPD77220 will be fabricated with a 1.2-micron CMOS process; volume shipments will begin in the spring of 1989. (9/13/88)

- Advanced Hardware Architectures has developed a codec chip that can operate at 15 Mbytes per second. The company was spun off last March from the University of Idaho's Microelectronic Research Center, which conducted research on the chip. The AHA4510 chip is fabricated with a 1.2-micron CMOS process, and shipments will begin in October. (9/12/88)

- Matsushita has developed the MN8605, a modem chip for 9,600-bps facsimile transmission. The chip will be fabricated with a 1.5-micron, double-poly, double-metal CMOS process. Volume production will start in the fall of 1988. (9/1/88)

- Texas Instruments is sampling a standard NuBus interface chip set designed to be used in add-in boards for Apple's Macintosh II system and other 32-bit computers using NuBus. The chip set includes the SN74ACT2440 32-bit interface controller and the SN74BCT2420 16-bit address/data transceiver. The 2440 device is fabricated with TI's 1-micron CMOS EPIC process; the 2420 is fabricated with a BICMOS process. Volume production is scheduled for October. (8/29/88)

- Toshiba will sample a 32-bit MPU in December. The TX1 microprocessor, based on the Tron architecture, is its first development in the Tron project. The TX1 is fabricated with a 1-micron process and has 450,000 transistors on a 10.89mm x 10.27mm chip. Average operating speed is 5 mips; at maximum speed, it can perform 12.5 mips at a clock speed of 25 MHz. (8/29/88)

- Samsung has introduced two CMOS DRAM controllers, the KS84C21 and KS84C22. Each controls both 256K and 1-Mbit DRAMs; in addition, the KS84C22 can control 4-Mbit DRAMs. The chips will be fabricated with a 1.2-micron process at Samsung's San Jose, California, facility. (8/15/88)

- Advanced Micro Devices has introduced its first family of CMOS graphics peripheral circuits. The Am81C458 color palette chip (or P-DAC) is fabricated with a 1.2-micron process, which is the same process that AMD uses on its Am29000 family. The chip can support displays up to 1,280 x 1,024 pixels and run at pixel rates up to 125 MHz. The device is being sampled now with volume production scheduled for September. (8/15/88)

- Yamaha has introduced the YM7109 modem chip, which is designed for use with 9,600-baud fax systems. The device is fabricated with a 1.2-micron CMOS process, and sampling will begin in September. (8/15/88)

- Texas Instruments is designing a P-DAC, that will run from 37.5 MHz to 125 MHz. The chip will be fabricated with a 1-micron CMOS process. (8/8/88)

- Intel is sampling the 87C75PF Port Expander device, which is used with 16-MHz 8-bit microcontrollers such as the 8051 and 80C51 series. The Port Expander is for use with embedded controllers that have tight constraints on board space; consequently, it combines on one chip several functions such as two microcontroller I/O ports, interface and logic circuitry, and 32-Kbits of EPROM memory. The device is fabricated with a 1.2-micron CHMOS process and will be in volume production in October. (8/8/88)

- Cypress is shipping the first two members of a family of 16-bit microprocessors, the CYC9116-45JC and CYC9116-45DC, that have been optimized for peripheral controller applications such as disk controllers, graphics controllers, communications controllers, and modems. The devices are fabricated with a 1.2-micron CMOS process. (7/25/88)

- LSI Logic's affiliate, G-2, has entered into an agreement with Groupe Bull of France to manufacture an IBM PS/2 compatible chip set. The chip set includes the GC181 CPU bus controller, the GC182 memory controller, the GC183 DMA controller, the GC184 address-data buffer, and the GC186 peripheral controller. The 20-MHz chip set, which will be sampled in the third quarter of 1988, will be fabricated with a 1.5-micron (1.2-micron effective) CMOS process. (7/25/88)

- NEC is offering five ISDN devices fabricated with a 1.5-micron CMOS process. The uPD72305, uPD72107, and uPD98001 devices are now in production; samples of the uPD72307 and uPD98201 are available with full production scheduled for the third quarter of 1988. (7/11/88)

Memory Products

Memory products introduced between July and December 1988 include the following:

- NEC has a prototype 16-Mbit DRAM with an access time of 55ns and measurement of 8.2mm x 15.9mm. The chip is fabricated with a 0.55-micron CMOS process. (12/26/88)

- NMB Semiconductor has introduced fast 1-Mbit DRAM with access times as low as 60ns. The devices, offered in 1Mx1 and 256Kx4 configurations, will be fabricated with a 1.2-micron process. Volume production is scheduled for the second quarter of 1989. (12/19/88)

- Logic Devices has entered the static RAM market with a family of seven fast 64K SRAMs with access speeds down to 20ns. The parts are fabricated with a 1.5-micron CMOS process and will be produced at the company's foundries in the United States and Japan. (12/19/88)

- Hitachi has begun sampling its 4-Mbit DRAM to a select group of worldwide customers. The chip is fabricated with a 0.8-micron CMOS process using stacked capacitor cells. Large volume availability is expected by 1990. (12/12/88)

- Intel is offering two new 256K EPROMs, the 27C202 and 27C203 devices, which provide zero wait state performance for 32-bit microprocessors. The 27C202 has a 70ns access time, while the 27C203 has a 45ns address setup time. The devices are fabricated with Intel's 1-micron CHMOS III-E process. Samples are available now, with volume production set for the first quarter of 1989. (12/12/88)

- Performance Semiconductor has available a series of fast 4K, 16K, and 64K CMOS SRAMs fabricated with its 0.7-micron gate length, double-metal PACE II process. Performance claims that, at 10ns for the 4K and 64K (64Kx1) parts and 15ns for the 16K and 64K (8Kx8, 16Kx4) parts, they are the world's fastest SRAMs. (12/5/88)

- Xicor is sampling a 1-Mbit EEPROM device, which Xicor claims is the industry's first monolithic 1-Mbit EEPROM. The X28C010 is fabricated with a 1.2-micron CMOS process and measures 359 mm^2. Volume production is scheduled for mid-1989. (11/28/88)

- Toshiba has introduced three fast 64K SRAMs (TC5588, TC55416, and TC55417) and an 8Kx9 memory chip with parity (TC5589). All four chips have access times as low as 15ns. The devices are fabricated with a 1-micron CMOS process with different aluminum masks added to the base die to create the final memories. (11/28/88)

- Siemens has upgraded its 1-Mbit DRAM technology from a 1.2-micron N-well process to a 1.0-micron double-well process, allowing a 15 percent reduction in chip size. Chip size has been reduced from 55 mm^2 to 47 mm^2. The devices are manufactured in Siemens' Mega facility at Regensburg, West Germany. Siemens also has begun sampling 4-Mbit DRAM devices based on a 1.0-micron process as well. The 4-Mbit devices will be manufactured at Perlach, West Germany. (11/21/88)

- Cypress Semiconductor will have available in mid-1989 samples of the CY7C184 128K cache RAM that it is designing in conjunction with Compaq Computer. The CY7C184 will have speeds of 25ns and will be fabricated with a 0.8-micron CMOS process. (10/31/88)

- Cypress Semiconductor is offering a 12ns 4K SRAM intended for cache tag applications. The CY7C150 is fabricated with a 0.8-micron CMOS process. (10/17/88)

- S-MOS is offering the SRM21256 and SRM22256 256K SRAMs that range in speed from 35ns to 70ns. The devices are fabricated with a 1-micron CMOS process. (10/17/88)

- Mitsubishi has introduced three fast 256K SRAMS that have access times of 25ns, which Mitsubishi claims is the fastest in the industry. The M5M5257A, M5M5258A, and the M5M5260A are designed with CMOS peripheral logic technology and an NMOS memory array. The devices are fabricated with a 1-micron process that will be shrunk to 0.8 micron to gain even faster access times. (10/3/88)

- NEC has introduced the uPD23C16000CZ 16-Mbit ROM chip that has an access time of 200ns. The chip, which is fabricated with a 0.8-micron CMOS process, measures 8.49mm x 17.09mm. Production is scheduled for the fourth quarter of 1988. (9/14/88)

- Cypress has introduced a lineup of 20ns 64K SRAMs fabricated with a 0.8-micron CMOS process. The lineup includes the CY7161, CY7162, CY7164, CY7166, CY7185, CY7186, and CY7187 64K SRAMs. (8/22/88)

- NEC will begin sampling a 150ns 4-Mbit EPROM this month. The device, which is the first 4-Mbit EPROM to be sampled, is configured 512Kx8 and will be produced with a 1.0-micron CMOS process. Volume production is scheduled for January 1989. (8/1/88)

- Waferscale Integration is sampling a new family of EPROMs that includes the WS27C010L 1-Mbit device with an access time of 100ns, the WS27C512L 512K device, and the WS27C256L 256K device; the latter two devices both have access speeds of 90ns. The devices are fabricated with a 0.8-micron, split-gate CMOS process that uses a single transistor cell. (7/25/88)

- Integrated Device Technologies has introduced a new family of dedicated FIFO memories. The IDT72131 and IDT72141 FIFOs are for bidirectional serial data communications applications and read in parallel data and read out serial data. The IDT72142 and IDT72132 FIFOs are for serial-to-parallel applications and are intended for tape-drive controllers, hard-disk controllers, and CD-ROM drive controllers. All devices have a shift rate of 50 MHz and an access time of 35ns. They will be fabricated with a 1.2-micron CMOS process. Depending on the part number, sampling will begin either in August or September. (7/25/88)

- Atmel is offering a 70ns 256K EEPROM fabricated with a 1.25-micron (previously reported in SUIS Newsletter 1988-18 as a 1-micron process), double-metal CMOS process. The device, called the AT28HC256, is produced at a Japanese facility. (7/11/88)

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ASIC and Logic Products

ASIC and logic products introduced between July and December 1988 include the following:

- Altera is sampling the EP1810, a new version of its EP1800 erasable programmable logic device (EPLD) that operates 50 percent faster than the EP1800. The chip is manufactured with a 1-micron CMOS process. Volume production is scheduled for the first quarter of 1989. (12/26/88)

- United Technologies Microelectronics Center has a new series of gate arrays with gate counts of up to 11,000 usable gates and typical gate delays of 630ps. The devices are fabricated with a 1.5-micron (1.2-micron effective channel length) CMOS process. (12/26/88)

- Plessey Semiconductors is offering a 50,000-gate MEGACELL, which is fabricated with a 1.5-micron CMOS process. (12/12/88)

- Altera is sampling the EPM5032 EPLD logic device, which is the first of many devices that will be based on Altera's MAX (multiple array matrix) architecture. Altera says that the EPM5032 packs more logic than any other programmable logic device (PLD), as it achieves nearly six times the density of popular PLDs. The chip is fabricated with a 0.8-micron CMOS EPROM technology. (11/21/88)

- Vitesse has introduced the VSC10000 gallium arsenide gate array that is intended to compete with ECL gate arrays. The VSC10000 operates at speeds up to 1.2 GHz at one-half to one-third the power of ECL devices; typical gate delays are 100ps. The device is manufactured with an 11-mask process that features 0.8-micron gate length with four layers of metal. Device size is 335 mils x 280 mils; ECL gate arrays are about 20 to 30 percent larger. Power consumption of the VSC10000 is 5 to 12 watts compared with 10 to 30 watts for ECL devices. (11/21/88)

- LSI Logic has introduced a new cell-based ASIC CMOS technology, the LCB007, that is capable of integrating 200,000 equivalent gates on a single chip. The LCB007 will be fabricated with a 1-micron gate length (0.7-micron effective channel length). LCB007 wafers will be manufactured at LSI Logic's facilities in California, Japan, and England. The design library will be made available by the end of 1988, and first customer samples will be shipped by mid-1989. The LCB007 technology will allow the incorporation of up to 144 Kbits of fast SRAM and 1 Mbit of ROM on the chip. (11/14/88)

- VLSI Technology is now accepting orders for its new VGT300 gate array family and VSC300 standard cell family. The VGT300 series has gate counts ranging from 28,090 to 243,360 available gates, with estimated gate utilization of between 30 and 40 percent, and the VSC300 series has usable gate counts of up to 150,000. Both families are fabricated with a 1-micron (effective channel length of 0.85 micron), double-metal CMOS process. The 1-micron process is presently being used at VLSI's San Jose, California, facility and will be transferred to the San Antonio, Texas, facility by mid-1989. VLSI is developing the next family of ASIC products, which will be 0.8-micron, triple-metal devices. (10/31/88)

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- Oki Semiconductor is offering a new channeled gate array family with densities up to 30,000 usable gates and a new standard cell family with densities up to 60,000 gates and speeds of 600ps. Both families are fabricated with a 1.2-micron CMOS process. (10/24/88)

- Sony has introduced a fast ECL 200-gate-array chip that rivals similar gallium arsenide chips in speed and power. The E3G200 has toggle frequencies on the order of 2.5 GHz, a typical gate delay of 150ps, and a power dissipation of less than 1 watt. The chip is fabricated with a 1.2-micron, double-metal bipolar process. Sony plans to release 1,000-gate and 2,000-gate versions in July 1989. (9/19/88)

- Motorola is designing gate-array-based interface chips for use in laser printers. The chips will contain a core of the 68000 microprocessor and the dedicated laser printer functions. The LPC-1 will have 5,000 gates and will be fabricated with a 2-micron CMOS technology, while the ALPC-1 will have 16,000 gates and will be the first commercial application of Motorola's HDC series of 1-micron CMOS channelless architecture gate arrays. The LPC-1 is currently available in sample quantities; samples of the ALPC-1 will be available in December, with volume production scheduled for February 1989. (9/5/88)

- Toshiba is offering the TC23SC series standard cell library available from 700 to 50,000 gates and with typical gate delays of 1.0ns. The family is fabricated with a 1.5-micron, double-metal HC^2MOS process. (8/29/88)

- General Electric Solid State has added the CGA10 and CG100 series of continuous-gate arrays to its ASIC offerings. The CGA10 series, ranging from 1,590 gates to 10,648 gates, is fabricated with a 2-micron CMOS process; the CG100 series, ranging from 12,149 gates to 66,550 gates, is fabricated with a 1.5-micron CMOS process. The two families are alternate sources for VLSI Technology's VGT10 and VGT100 families. (8/8/88)

- General Electric's Microelectronics Center is offering a 1.25-micron CMOS gate array family fabricated with a VHSIC I process. The AGC40000 family consists of arrays of 1,750 gates, 6,246 gates, and 13,600 gates. The family, which will also be available in rad-hard CMOS, has a typical gate delay of 0.685ns for a two-input NAND gate. (8/1/88)

- Atmel has introduced the AT2500, a 2500-gate EPROM-based PLD that can run at 40 MHz. The device, fabricated with a 1.2-micron CMOS process, is being sampled now; full production is scheduled for August. (7/25/88)

- Advanced Micro Devices and SEEQ are shipping a jointly developed electrically erasable PAL device. The PALC20RA10Z is built with a double-poly, single-metal 1.2-micron CMOS process. Initially, it will be fabricated only by Seeq, with assembly and test being done by AMD. This is also the first E^2 CMOS product that AMD will be shipping. (7/25/88)

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- NEC is taking designs on the uPD65000 series of gate arrays, which range from 858 gates to 5,632 gates. Gate utilization is about 95 percent, and propagation delays average 10ns. The family is fabricated with NEC's 1.5-micron CMOS 4L process. (7/11/88)

- Samsung has begun shipping four parts of its CPL20 PLD family, which has a propagation delay of 25ns. The CPL24 family, which has a delay of 35ns, will begin shipping in August. Both families are manufactured with a 1.2-micron CMOS process at Samsung's Santa Clara, California, facility. (7/4/88)

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Joseph Grenier

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July – September Index

The following is a list of the newsletters in this index:

- **Cost Trends—High Lead-Count Packaging** (1989-29)—Input and output (I/O) requirements increase as dice become more complex. To minimize silicon costs and improve processing speed, feature sizes are being shrunk continually so that traditional package assembly using wire bonding is no longer cost effective. This newsletter analyzes high I/O package assembly costs and how design component engineers need to work with procurement to decrease system assembly costs. Dataquest concludes that theemphasis on reducing the cost of systems now must focus on the packaging area as well as the silicon.

- **Semiconductor Price Survey: Suppliers Aim to Manage 1Mb DRAM Price Decline** (1989-30)—Trends for the first half of 1989 continued to mark 1989 as a period of declining semiconductor prices and shorter lead times. This newsletter highlights the key points of Dataquest's latest North America-based price survey and forecast. The year 1989 continues as a period of declining semiconductor prices and shorter lead times. Dataquest again recommends that users give CBICs a close look, together with gate arrays, for systems being designed today for production in the post-1990 period.

- **June Market Watch: Clearer Slowdown Signals as System Demand Weakens** (1989-31)—This month's Market Watch focuses on the dropping of book-to-bill ratios, continuing system demand slowdowns with manageable inventory levels, and steady prices. Dataquest believes that despite the inevitability of a slowdown, we should be thankful that capacity and inventory are low and prices and profits probably will not plunge severely.

- **DRAM-Supply Wild Card: Samsung to the Rescue?** (1989-32)—First-tier Japanese DRAM suppliers have reaped high profits with their strategy of managing supply to control prices. These companies have a plausible profit-maximizing strategy, but it hinges on the assumption that other manufacturers' production plans will slip. In following their strategy, Japanese suppliers will have to trade market share for profits, which means that they must ramp-up the 4Mb DRAM successfully in order to keep overall worldwide DRAM market dominance. Dataquest believes that Korean and U.S. suppliers eventually may prove that Japanese manufacturers do not have as tight a control over the DRAM market as they think.

- **U.S. Memories Inc.—A Strategic Response to DRAM Technology Dependence** (1989-33)—Events in 1988 demonstrated how DRAM technology dependence can cut system manufacturers' revenue and profits. A group consisting of U.S. DRAM users (Digital Equipment and Hewlett-Packard) and semiconductor suppliers (AMD, Intel, LSI Logic, and National Semiconductor), in alliance with IBM, have proposed the formation of a company to be known as U.S. Memories Inc. Dataquest recommends that North American DRAM users immediately investigate the possibility of participation in U.S. Memories Inc.

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- **Systems–Demand Slowdown Sparks Sharp Drop in Worldwide 1Mb DRAM Prices** (1989–34)—An expanding 1Mb DRAM supply from a growing number of suppliers hit a midyear demand slowdown that to DRAM suppliers looks like a second-half recession. Until worldwide system production/DRAM demand patterns change, Dataquest recommends that systems manufacturers on a worldwide basis aggressively negotiate for lower 1Mb DRAM prices.

- **July Procurement Pulse: Inventories/Orders Down, Memories on a Seesaw** (1989–35)—This month's Procurement Pulse explains what inventory order rate corrections mean to both semiconductor users and manufacturers. Dataquest expects low inventory levels (especially for non–DRAMs) to continue and to cause more spot orders, or at least more orders that require deliveries within three months. It is now a buyer's market.

- **July Market Watch: MOS Memory Joins Slowdown, Turns Business Increases** (1989–36)—This month's Market Watch examines increases in June's book–to–bill despite 0.99 ratio, decreasing system demand and inventory, and plunging indicator prices. Dataquest believes that the industry will see fluctuating, rather than continuously declining, order patterns from month to month as buyers adjust their inventory mix or respond to sudden production demands.

- **Semiconductor Price Survey: MPUs and 1Mb DRAMs Lead Way in Sharp Price Break** (1989–37)—Suppliers of 16–and 32–bit microprocessors (MPUs) and 1Mbx1 DRAMs have cut pricing aggressively in response to a recent slowdown in U.S. systems shipments. This newsletter highlights the key points of Dataquest's latest North America–based price survey and forecast. Dataquest reinforces its previous recommendation that systems manufacturers negotiate for better lead times. Dataquest again recommends that users give CDICs a close look vis–à–vis gate arrays for these products along with local customizing capability.

- **The Shape of Post 1992 Distribution in Europe** (1989–38)—Today, distribution represents 28.2 percent of the European semiconductor market; by 1993, Dataquest expects this to increase to 33.1 percent. This newsletter examines the current restructuring of the European distribution network and assesses the future shape of distribution in Europe after 1992. Dataquest believes that more global distributors will emerge in 1992, with a few U.S. distributors in the European market. The most dramatic change will occur when Japan–based trading houses forge links with some of their global distributors.

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- **August Procurement Pulse: The Orders–Down, Inventories–Up Seesaw Continues** (1989–40)*—This month's Procurement Pulse survey focuses on lower semiconductor orders along with slow system sales and the uncertainty of how long lead times will remain stable. Dataquest believes that the seesaw composed of inventory levels and order rates will continue to balance and that this trend should last through the end of the year.

- **August Market Watch: As the Market Slows, Advantage Goes to the Levelheaded** (1989–41)—This month's Market Watch reviews dropping book–to–bill ratios, further slowdown of computer inventory growth, up–down seesawing OEM semiconductor inventories, and declining prices. Dataquest believes that semiconductor manufacturers should go back to business basics—stay efficient, stay lean, and provide better service.

- **September Procurement Pulse: Orders Continue to Slide While Inventories Rise** (1989–42)—This month's Procurement Pulse survey continues to indicate slow semiconductor orders, lead times remain the same, and because of a business slump, inventories will continue to rise. Dataquest recommends that buyers need to communicate accurately their 6– to 12–month requirements while suppliers need to ensure timely delivery of parts as order levels decline.

- **Solutions to Systems Manufacturers' High–Speed ROM Supply Base Challenge** (1989–43)—Purchasing high–speed MOS mask ROM (sub–200ns) devices for use in leading–edge systems presents a special set of challenges and risks for supply–based managers in North America and Europe. This newsletter identifies the market factor behind this challenging reality and recommends specific courses of supply–based action for adapting to market realities.

- **GaAs PLDs Attack the Silicon TTL PLD Market** (1989–44)—GaAs programmable logic devices (PLDs) that operate 65 percent faster than equivalent silicon parts now are available as a superset of more than 30 of the most popular silicon PLDs. These and other GaAs PLDs are expected to have a major impact on the silicon PLD marketplace as the 1990s unfold. This newsletter discusses the availability and production worthiness of GaAs, the benefits of GaAs over silicon, and programming issues. Dataquest concludes that the availability of GaAs PLDs with TTL interface is accelerating the insertion of GaAs technology into digital systems.

- **September Market Watch: Buyers Put on the Brakes as Market Continues to Slide** (1989–45)—This month's Market Watch remains unchanged compared with last month's forecast. Book–to–bill continues to slip, computer bookings are down, inventories are up, and semiconductor prices are falling to new lows. Dataquest believes that the September indicators all point to the current slowdown as being more than a seasonal blip for both semiconductor suppliers and users.

* The number 39 (e.g., 1989–39) has been omitted.

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Research *Bulletin*

SEPTEMBER MARKET WATCH: BUYERS PUT ON THE BRAKES AS MARKET CONTINUES TO SLIDE

Market Watch is a monthly bulletin that is released after the SIA book-to-bill *Flash Report* and is designed to give a deeper insight into the monthly trends in the semiconductor market (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

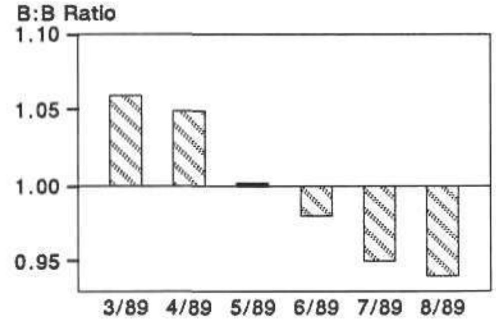


Figure 2
DOC Computer Demand

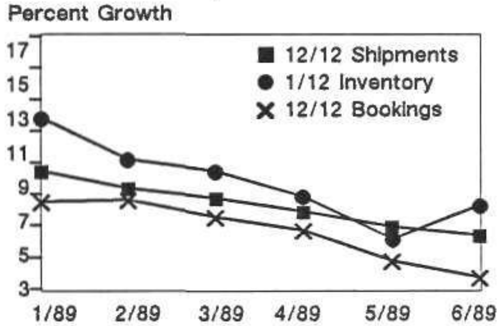


Figure 3
Semiconductor Inventory Level

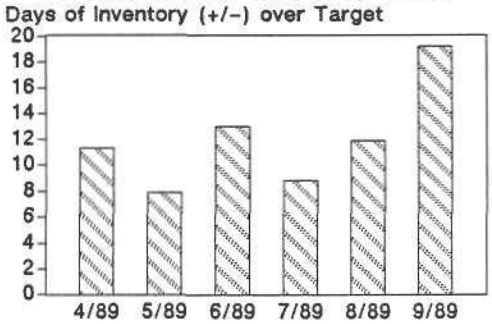
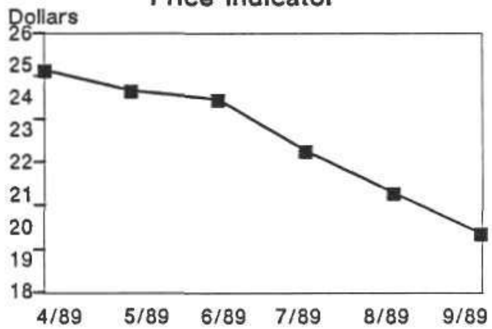


Figure 4
U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor
Trade Statistics
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September 1989

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BOOK-TO-BILL SLIPS FURTHER TO 0.94

The summer slump in semiconductor bookings and billings continues, but this seasonal slowdown is compounded by users experiencing comparably declining system sales growth. Dataquest believes that the current softness in the semiconductor market will continue for the next six months as a result of the fundamental decrease in electronic system demand.

COMPUTER BOOKINGS DOWN, SYSTEM INVENTORIES UP

System inventory levels have begun to rise again in the face of booking and shipment declines. The slowing system shipments, the rapidly falling booking rates, and an increase in system inventories all indicate that the computer industry will continue to cut costs. *At the current rate, the largest user of semiconductors in the United States—the computer industry—will barely show positive growth for 1989.* What this fact means for semiconductor suppliers is that there is no near-term relief from the current semiconductor booking decline.

OEM SEMICONDUCTOR INVENTORIES CONTINUE TO SPROUT UP

Semiconductor inventories dramatically rose above targeted levels this month, primarily because of DRAM stockpiles. This inventory buildup in memory will cause fewer new orders to be cut in the near term, thus accelerating the price decline that has been led by DRAMs and SRAMs. With no large increase in system demand foreseen, OEM cost-cutting continues to focus on inventory control and dependable delivery schedules. Declining prices, good quality, and efficient manufacturing now are considered essential.

SEMICONDUCTOR PRICES DIP TO NEW LOWS

Increased supplies of DRAMs and SRAMs and corresponding lower prices for these parts in the face of static demand were the main causes for the *5.7 percent price dive in September's price indicator.* Producers are trying to match supplies with fluctuations in demand, but the fab juggernaut cannot turn on a dime. Prices will decline; to keep costs down, inventories also must decline. Ideally, this adjustment will not be at either the supplier's or the user's expense. At this time, both users and suppliers have excess inventory, especially in memories. Users must continue to forecast their six-month needs accurately on a rolling monthly schedule in order to best avoid supply irregularities that lead to gluts and shortages that do not benefit anyone.

DATAQUEST ANALYSIS

September's indicators all point out that the current slowdown is more than a seasonal blip for both semiconductor suppliers and users. Dataquest expects the fourth quarter to be worse for suppliers than the third as backlog built in the first half finally erodes. With orders down, inventories up, and system demand shaky, we do not foresee a recovery to occur earlier than second quarter 1990. System OEMs will continue to focus heavily on cost-cutting measures (i.e., pricing, inventories, quality) that will negatively impact suppliers without their own cost-reduction plans in place. Dataquest believes that semiconductor suppliers must match the belt tightening now going on in their customer bases.

Mark Giudici
Victor de Dios

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Research Newsletter

GaAs PLDs ATTACK THE SILICON TTL PLD MARKET

GaAs programmable logic devices (PLDs) that operate 65 percent faster than equivalent silicon parts are now available as a superset of more than 30 of the most popular silicon PLDs. These and other GaAs PLDs are expected to have a major impact on the silicon PLD marketplace as the 1990s unfold. This newsletter examines some of the important issues involved in this aspect of the evolution of IC technology.

AVAILABILITY AND PRODUCTION WORTHINESS OF GaAs

The history of GaAs development in many ways parallels that of silicon ICs. The reproducibility of GaAs VLSI technology already is established by the accumulated experiences of several major U.S. defense suppliers, as well as commercial suppliers of GaAs ICs. Available gate arrays, standard cell logic, and static RAMs now contain 25,000 to 100,000 transistors per chip. U.S. defense contractors supplying complex digital ICs (digICs) include McDonnell Douglas, Rockwell, and Texas Instruments. Commercial suppliers of GaAs VLSI chips include Gazelle, GigaBit Logic, TriQuint, and Vitesse.

The GaAs digIC production difficulties experienced in the early and mid-1980s were resolved by improvements in wafer technology and device worst-case design techniques and by the application of silicon volume production methodologies to GaAs chip fabrication and testing operations. GaAs gate array manufacturers now are offering volume deliveries of sub-100-picosecond, 10,000-gate arrays with emitter-coupled logic (ECL) interface at per-gate pricing at or below that of silicon ECL. Availability of GaAs is no longer an issue in new designs.

BENEFITS OF GaAs OVER SILICON

At a given set of design rules, GaAs E/D MESFET technology offers a superior speed-power product of approximately three to five times that of silicon. This allows IC designers to trade off speed and power to optimize circuit operation at a more efficient point than that achievable with silicon. In TTL-interface designs, speed improvements in silicon now dictate that faster input and output transitions be used, because internal gate speeds are rapidly approaching the limits of silicon technology. Silicon chip designers have taken this approach in some of the latest designs, which results in increased ground noise, I/O signal reflections, and crosstalk, each of which may cause logic malfunctions.

GaAs internal gates can operate several times faster than silicon at the same power level, allowing significantly faster chip throughput speeds. This gives the IC designer greater flexibility in maintaining the relatively slow I/O rise and fall times dictated by a transistor-transistor logic (TTL) or CMOS environment.

GaAs properties also allow the design of chips that can operate above 250° Celsius (versus 125° Celsius for silicon). GaAs circuits have the additional property of greater radiation hardness than that achievable in silicon. However, these properties are relatively unimportant compared with raw speed and speed-power product in the design of ICs intended for commercial computer, communication, and workstation applications.

GaAs PLDs

The first GaAs PLDs, the GA22V10-10 and GA22V10-12, were announced by Gazelle Microcircuits, Inc. in mid-1988. These devices are pin-compatible replacements for the popular 24-pin

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TABLE 1
PLDs Replaceable by the GA23SV8

Part Type	Array Inputs	Registers	Product Terms	Fixed Inputs	Fixed Outputs	Bidirectional I/Os
23SV8	23	14	135	9	0	8
23S8	23	14	135	9	0	8
18V8	18	8	72	10	0	8
18P8	18	0	72	10	0	8
16V8	17	8	64	10	0	8
16R8	16	8	64	8	8	0
16R6	16	6	64	8	6	2
16R4	16	4	64	8	4	4
16L8	16	0	64	10	2	6

Source: Gazelle Microcircuits, Inc.

22V10 PLDs, which have been available in silicon for more than five years. The Gazelle chips are produced from wafers supplied by TriQuint or some other foundry and are factory configurable by laser programming technology.

In June 1989, Gazelle announced the GA23SV8, a 20-pin superset of 32 of the most widely used silicon PLDs. The 166-MHz maximum clock frequency makes this device the fastest TTL sequencer presently available in commercial volume. Table 1 identifies several of the TTL PLDs included in the superset, most of which are pin compatible and all of which are functionally compatible with the GA23SV8.

THE PROGRAMMING ISSUE

The Gazelle PLDs are programmed at the factory at present. This programming probably is acceptable for most prototype situations and many production environments, but it restricts the user's control over design security. Factory programming by the chip vendor also increases turnaround time and cost when engineering changes or product improvements are made to the system design, although overnight mail may relieve some time constraints. In the silicon TTL world, bipolar masked ROMs were limited in popularity and acceptance for these reasons, and field-programmable PROMs served as the workhorse technology until field-programmable PLDs became available. This issue will be a constraining factor in determining the extent to which GaAs PLDs will penetrate the silicon TTL and CMOS PLD markets.

DATAQUEST CONCLUSIONS

The availability of GaAs PLDs with TTL interface is accelerating the insertion of GaAs technology into digital systems. Together with GaAs gate array and standard cell technologies, this technology will find broad applications in workstations and other high-performance hardware. The acceptance of GaAs PLDs presently is limited by the constraint of factory programmability. However, Dataquest believes that the solution to customer programmability of GaAs PLDs is only months away, and that introduction of such GaAs chips soon will have a significant impact on the growth rate of the $900 million silicon PLD marketplace.

Mark Giudici
Gene Miles

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Research Newsletter

SOLUTIONS TO SYSTEM MANUFACTURERS' HIGH-SPEED ROM SUPPLY BASE CHALLENGE

EXECUTIVE SUMMARY

Purchasing high-speed MOS mask ROM (sub-200ns) devices for use in leading-edge systems presents a special set of challenges and risks for supply-base managers in North America and Europe. This Research Newsletter examines the factors that make ROM procurement so challenging. On a strategic level, Dataquest recommends that system manufacturers carefully track the major applications that determine ROM product developments. On a practical level, Dataquest recommends that users of high-speed ROMs either form a one-time programmable (OTP) ROM bank or establish a customizing minifab arrangement with ROM suppliers as possible solutions to this challenge.

PREVIEW

Tables 1 and 2 depict the worldwide ROM business from the contrasting viewpoints of North American/European users and Japanese suppliers, respectively. Table 3 translates Tables 1 and 2 into reality for North American and European users and shows the higher premiums compared with Japan pricing. Dataquest then outlines solutions to this procurement challenge.

FORCES DRIVING THE ROM MARKETPLACE

As shown in Tables 1 and 2, large-storage Japanese applications drive ROM demand and thus the product development of Japan-based ROM suppliers. Slow-speed ROM, which serves these applications, dominates production. On a worldwide basis, a limited number of major Japanese and non-Japanese users of slower-speed ROM are adequately served by the existing ROM supply base.

TABLE 1
Challenges for North American and European Users of High-Speed Mask ROM

Realities	Dataquest Recommendations
Japan-based suppliers dominate the ROM business	Forge close long-term arrangements with ROM suppliers in Japan
Japanese suppliers of ROM are driven by Japanese applications: storage of large operating systems and programs; laptop computer software	Track Japanese applications that drive ROM product development and match system life cycles with ROM product cycles in terms of speed/package and related specs
Service orientation of the ROM business puts non-Japanese users at a competitive disadvantage with local Japanese users	Forge long-term supplier ties but also anticipate risk by building a bank of OTP ROMs
	Align with current ROM suppliers or new entrants from North America or Japan that offer a customizing minifab capability.

Source: Dataquest
September 1989

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TABLE 2
Japanese ROM Suppliers' View of Non-Japanese User Market

Market Reality	Result for Users
Growth through maturity stages of product life cycle	
EPROM: 9.5 years Mask ROM: 5.0 years	ROM suppliers forge long-term relations with limited number of major users because of short ROM life cycle
Market share of 1Mb ROM shipments, 1988	
North America: 6.0% Japan: 94.0%	Japan-based suppliers like Matsushita, Ricoh, Sharp, and Toshiba control supply
Regional consumption of all ROMs, by region, 1988	
North America: 20.0% Japan: 60.0% Europe: 12.0% Rest of World (ROW): 8.0%	High-volume Japanese applications such as disk drives, electronic typewriters, laptop computers, and video games drive ROM product supply
Estimated ROM consumption by speed, 1988	
< or = 200ns: 93.0% > 200ns: 7.0%	Slower-speed applications (as above) dominate supply/demand decisions

Source: Dataquest
September 1989

TABLE 3
Typical Price Premiums Paid by North American and European Users of ROM

Device Speed	Premium
> or = 200ns	4-8% over Japanese price for equivalent speed device
< 200ns	10-40% over Japanese price for equivalent speed device
< 200ns	40-60% over Japanese price for device that operates at > or = 200ns

Source: Dataquest
September 1989

Negative Results for North American and European Users of High-Speed ROM

For current or prospective North American and European users of higher-speed ROM, however, the product mismatch in terms of ROM speeds/specifications causes several supply base headaches: component/system supply constraints, noncompetitive pricing, and overall disruption in planning system life cycles and production. Table 3 illustrates the stiff price premiums paid by North American and European users of high-speed ROM.

RECOMMENDATIONS

As outlined in Table 1, Dataquest makes an interrelated series of recommendations to North American and European systems manufacturers in order to solve the ROM procurement challenge.

Assumptions

These recommendations are built upon two assumptions: the current Japan-based ROM supplier base will continue to focus on supplying slower-speed devices, while new entrants—whether from Japan, North America, Europe, or ROW—will be responsive to meeting demand for high-speed ROM in exchange for long-term user/supplier arrangements.

Slow-Speed ROM Users

For slow-speed ROM users, Dataquest recommends the following supply base management activity. First, monitor on an ongoing basis the trends in Japanese applications such as disk drives, electronic typewriters, laptop computers, and video games that drive ROM product development. Next, users should match applicable system life cycles

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with the mainstream ROM product cycles in terms of speed, packages, and related specs. Finally, users should forge close long-term arrangements with major ROM suppliers in Japan.

In addition to forging these long-term supplier ties, Dataquest also recommends that users prepare for possible risk by building a bank of OTP ROM.

High-Speed ROM Users

For these users, Dataquest recommends two separate courses of action. One course is the formation of an internal bank of OTP ROM as an immediate practical hedge against the critical spot shortages and erratic pricing of high-speed devices. Users must pay a premium for OTP ROM over ROM pricing, but the stiff premium for high-speed ROM over slower-speed ROM is not expected to narrow rapidly over time.

Another possible course of action is for users to enter into a local minifab arrangement with ROM suppliers that have long-term aims on memory/gate array markets. Dataquest recently identified a significant market development that may become a long-term trend: Japan-based manufacturers of semiconductor memory/gate arrays are building global fab networks. In the network, a main "mother" fab (e.g., Japanese location) produces wafers that then are shipped to a worldwide net of "local" minifabs (e.g., European, North American locations). The minifabs then custom-produce SRAMs and gate arrays, as well as other memory chips, in accordance with the local customers' needs.

For users who need high-speed ROM, gate arrays, and SRAM, this emerging development—whether in alliance with familiar Japan-based ROM suppliers or newer entrants such as Gould-AMI—could prove a key long-term solution to this procurement challenge. Users should expect to support capital expenditures. Otherwise, high-speed ROM will remain a long-term procurement headache.

DATAQUEST CONCLUSIONS

North American and European users of high-speed ROM continue to experience procurement difficulties. This newsletter has identified the market factors behind this challenging reality and recommends specific courses of supply-base action for adapting to market realities.

Ronald Bohn
Victor de Dios

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Research *Bulletin*

SEPTEMBER PROCUREMENT PULSE: ORDERS CONTINUE TO SLIDE WHILE INVENTORIES RISE

The *Procurement Pulse* is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

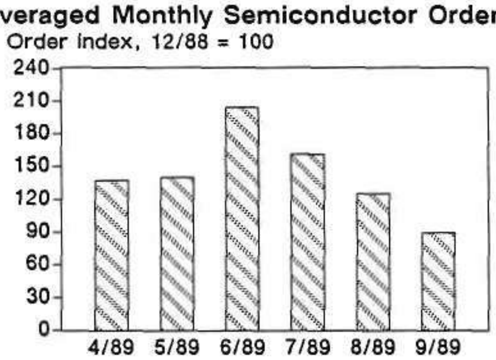


Figure 2
Averaged Semiconductor Lead Times

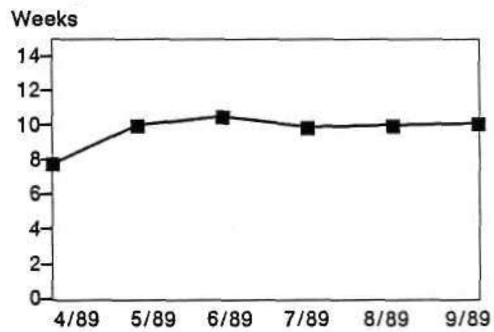


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

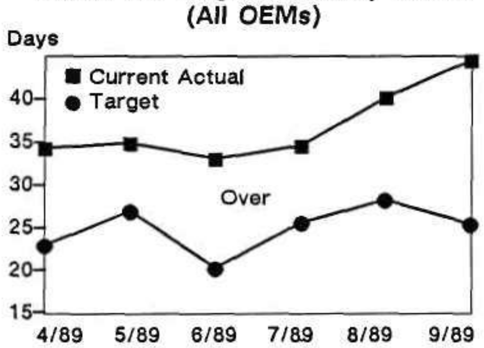
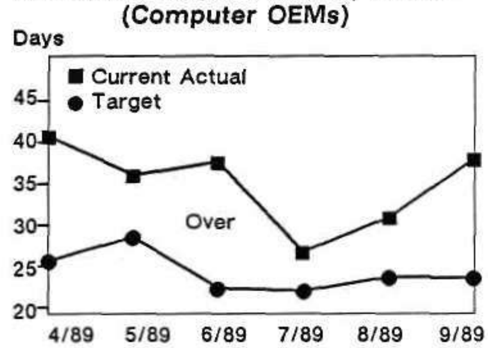


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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SEMICONDUCTOR ORDERS SLIP FURTHER AS SYSTEM SALES DIP

Respondents to this month's survey plan to lower their September orders by 29 percent compared with last month's response (see Figure 1). This third straight month of order reductions directly correlates with the stagnation of overall electronic sales that has been reported in the last two months of Dataquest's monthly *Market Watch*. Current sales levels are about equal with those of last year, but expectations are mixed regarding the next six months. Last month, no negative growth was expected, and the highest forecast was 20 percent. Currently, the forecast for system sales ranges from a negative 2 percent to a positive 10 percent. Inventory-control measures are keeping semiconductor orders in line with system sales forecasts, which means lower orders for the near term.

AVERAGE LEAD TIMES REMAIN THE SAME—2.5 MONTHS

As seen in Figure 2, overall lead times have risen by one day to 10.3 weeks over last month's 10.1 weeks. Purchasing managers expect more responsiveness to delivery schedules than they are getting at present in the current buyer's market. Although few respondents are having some difficulty in getting ASICs, some high-speed DRAM and SRAM devices, and surface-mount standard logic parts, 75 percent of respondents have no problems in procuring *any* semiconductors at this time. Supplies of all commodity ICs appear to be readily accessible, except for surface-mount standard logic parts; this situation is due to a combination of poor forecasting and lack of surface-mount capacity planning. This bottleneck is expected to continue for the next 3 to 4 months as schedules readjust to the current extended lead times of 8 to 10 weeks.

INVENTORIES AGAIN RISE AS BUSINESS SLUMP OUTPACES ORDER REDUCTIONS

In spite of static inventory targets, actual levels of semiconductor inventories rose for the third straight month, as seen in Figures 3 and 4. The bright side of the picture is that non-DRAM inventory levels, both target and actual, have declined for all OEMs to 22.0 and 36.0 days, respectively, and to 22.6 and 35.2 days, respectively, for computer OEMs. This means that DRAM inventory levels are the primary cause of the current overstocked inventory situation. Since DRAM supplies are abundant, faster price declines can be expected as orders slow for devices that were on allocation early this year. Actual inventory levels (including DRAM/WIP) rose to 38.2 days from 31.3 days for computer OEMs and to 44.8 days from 40.3 days for overall OEMs.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

As inventory levels of DRAMs rise relative to system sales levels, Dataquest expects the current abundance of commodity memory to turn to over-abundance as order rates are reduced. The current shortage of SOIC standard logic parts highlights what occurs when short- and long-range forecasts are inaccurate or not taken seriously. When availability, quality, and price are not the primary concerns, procurement often is determined by delivery and customer service. In this market, buyers need to communicate accurately their 6- to 12-month requirements while suppliers need to ensure timely delivery of parts as order levels decline. We expect the inventory-level/order-rate seesaw to remain unbalanced toward lower order rates for the next three months.

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Research *Bulletin*

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AUGUST MARKET WATCH: AS THE MARKET SLOWS, ADVANTAGE GOES TO THE LEVELHEADED

Market Watch is a monthly bulletin that is released after the SIA book-to-bill Flash Report and is designed to give a deeper insight into the monthly trends in the semiconductor market (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

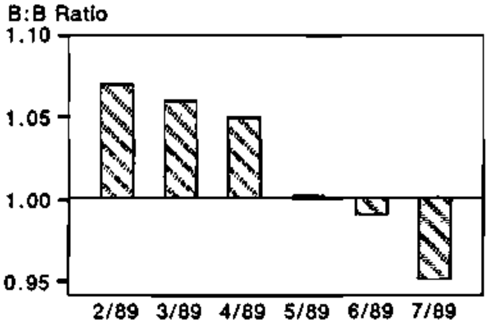


Figure 2
DOC Computer Demand

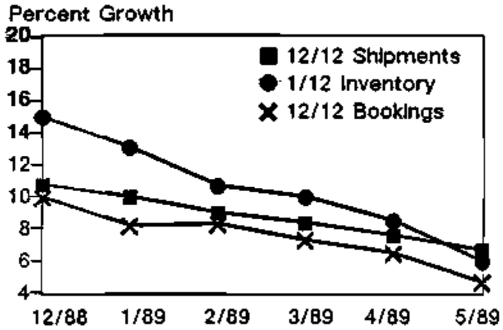
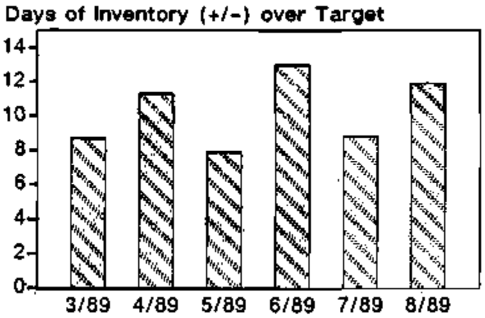


Figure 3
Semiconductor Inventory Level



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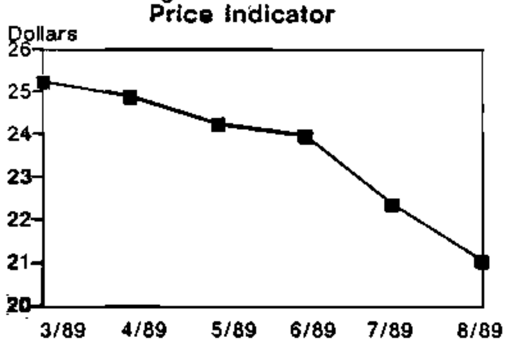
U.S. Weighted Semiconductor Price Indicator



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World Semiconductor
Trade Statistics
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August 1989

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BOOK-TO-BILL DROPS TO 0.95

The long-expected summer slowdown is upon us; the industry barometer, the SIA book-to-bill ratio, dropped to 0.95 for July. Dataquest believes that this slowdown is more than a seasonal pattern and will extend beyond the summer months, with definite signs of a weakening market ahead. Now the MOS memory market has followed, experiencing a slower sales growth and a more price-competitive market.

COMPUTER INVENTORY GROWTH SLOWS FURTHER

The growth of computer orders and shipments continues to decelerate as computer makers focus on cutting costs and improving efficiencies. For the first time this year, the rolling 12-month growth of computer inventories dropped below shipment growth. Inventory typically has slower growth than orders and shipments. With the loosening up of product in Q4 1988, however, computer inventories rose dramatically and have maintained high growth for nine months. Dataquest expects computer inventory growth to drop further and fall below that of orders, which will mean a more constrained semiconductor market.

OEM SEMICONDUCTOR INVENTORIES ARE ON AN UP-DOWN SEESAW, AND PRICES CONTINUE TO DIVE

As we observed in the July Market Watch, semiconductor users will rely more heavily on spot market buys and order product close to date of scheduled production to minimize holding costs. With the uncertainty in the systems markets, inventory control appears to be as important as acquiring lower prices. Orders and inventories over target are expected to resemble a sawtooth pattern in the coming months.

Spurred by the increasing competitiveness and loosened availability of MOS memories and DRAMs in particular, Dataquest's price indicator, based on a basket of 25 key products, plunged another 5 percent in August. The basket's price decline primarily was driven by DRAMs, SRAMs, and certain microprocessors. Manufacturers' inventories of these components are reported to be swelling. However, Dataquest cautions against speculations on a recurrence of the 1985 downward price spiral. Today's production levels, inventory levels, and nature of the demand slowdown are not similar to those of 1985, and we expect a milder and more orderly price decline.

DATAQUEST ANALYSIS

August's indicators further confirm our expectations of the nature of the current semiconductor industry slowdown. Semiconductor users are pursuing rational actions in meeting the uncertainty in their markets. Semiconductor suppliers should do the same. Unlike 1985, 1989's weakened demand did not take anyone by surprise. Current capacity is not excessive, and OEM inventories are limited. Dataquest believes that semiconductor manufacturers should go back to business basics—stay efficient, stay lean, and provide better service.

Mark Giudici
Victor de Dios

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Research *Bulletin*

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AUGUST PROCUREMENT PULSE: THE ORDERS–DOWN, INVENTORIES–UP SEESAW CONTINUES

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

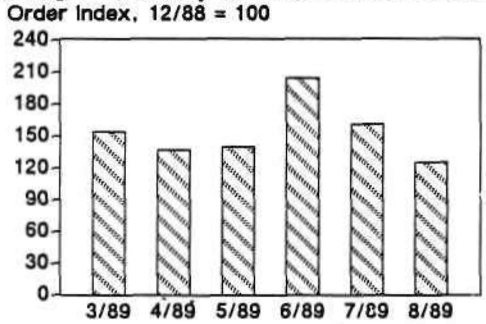


Figure 2
Averaged Semiconductor Lead Times

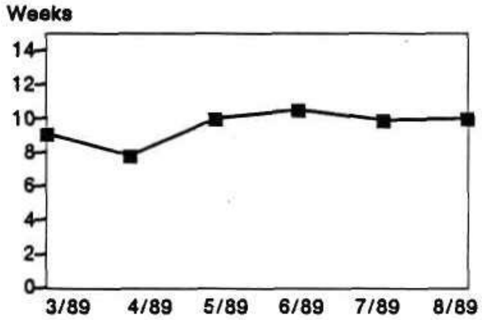


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

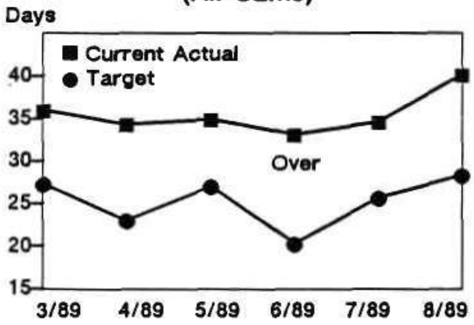
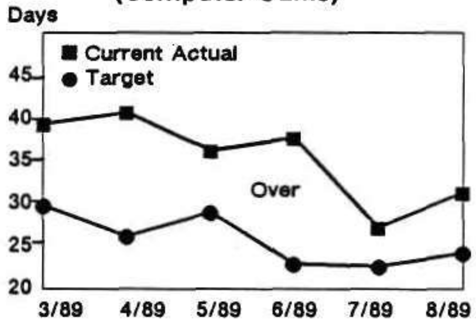


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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Source: Dataquest
August 1989

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SEMICONDUCTOR ORDERS AGAIN DROP, MATCHING SLOW SYSTEM SALES

This month's survey respondents plan to lower their August orders by 19 percent relative to last month's responses (see Figure 1). This drop and July's decline of 21 percent are the responses to the increased availability of semiconductors and the confirmation of a deceleration in system sales. Current sales levels are lower overall relative to last year, yet 61 percent of this month's sample respondents (66 percent last month) still see growth in sales ranging from 5 to 25 percent over the next six months. Buyers are keeping their component order rates in line with system sales. Component sales will continue to grow gradually, but in smaller increments and with increasing turns business due to improved semiconductor availability and slower system sales.

LEAD TIMES ARE STABLE—BUT FOR HOW LONG?

The relative stability of lead times at 10.1 weeks (see Figure 2) reflects how, up to now, the managed memory market and sole-sourced microprocessor suppliers have kept average lead times at a predictable level. According to some respondents, the products that continue to have longer lead times are 32Kx8 SRAMs and high-speed ROMs. Dataquest notes that major Korean and some Japanese memory suppliers have begun to break rank with the market, resulting in lower lead times for slower DRAMs. As competition heats up in the DRAM market in the upcoming months, lead times for faster parts also will decline.

LOWER ORDER LEVELS TRY TO CUT INVENTORY BULGE

Overall and computer inventory levels rose relative to last month's survey, as seen in Figures 3 and 4. Forecast lower order levels in August are expected to correct this situation. Computer OEMs are controlling inventories better than is the overall market, but non-DRAM/WIP inventory levels continue to keep target levels unreachable (computer non-DRAM/WIP inventory target is 32.7 days versus 44.5 days for current inventory). Dataquest expects users to continue focusing on cost cutting by lowering inventories and demanding lower component prices. Improvements in communicating user forecast requirements to semiconductor suppliers now are needed. Actual inventory levels (including DRAM/WIP) rose to 31.3 days from 27.3 days for computer OEMs and to 40.3 days from 34.7 days for overall OEMs.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

The seesaw made of inventory levels and order rates continues to balance. Until accurate forecasting becomes universal, either the buyer or the seller will continue to hold the excess-inventory bag. On the positive side, inventories are still at historically low levels and should remain there. Slow systems sales growth will force buyers to balance their component mix with low inventory levels. Buyers should continue to review pricing and availability of key components with their suppliers on a quarterly basis in order to ensure the best price and delivery. Suppliers should continue to see relatively smaller but steady orders due to inventory control requirements and easy availability of parts. This seesaw balancing act should continue through the end of this year.

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THE SHAPE OF POST 1992 DISTRIBUTION IN EUROPE

SUMMARY

Today, distribution represents 28.2 percent of the European semiconductor market; by 1993, Dataquest expects this to increase to 33.1 percent. The whole structure of this sales channel currently is undergoing profound changes that will radically alter the way semiconductor vendors service the mass market. This newsletter examines the current restructuring of the European distribution network and assesses the future shape of distribution in Europe after 1992.

DISTRIBUTION TODAY

Each European country currently is dominated by a small group of locally based distributors: Diploma, STC, and Lex in the United Kingdom; Spoerle, EBV, and E2000 in West Germany; and Sonepar, Tekelec, and CGE in France. Until recently, these distributors operated in their local regions with the help of "country-exclusive" agreements given to them by their major principal franchises. With the advent of 1992 legislation, such gentlemen's agreements will become illegal.

In anticipation, major European distributors already have started their restructuring programs to take advantage of cross-border multinational markets in Europe after 1992. Examples of various joint ventures and acquisitions that have taken place recently are Metrology and Unitech, Spoerle and Arrow, and E2000 and Diploma. The year 1992 already is here for these companies. Examples of pan-European distributors are ITT Multicomponents, which already operates in 13 countries in Europe, and Sonepar, which operates in 5 countries. International operators such as Arrow, with its previously noted stake in Spoerle, and the Lex Group, with operating units in the United Kingdom, France, and West Germany, also are moving quickly. A newcomer on the international front is Canadian Future Electronics, which was recently franchised by Motorola in West Germany.

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Semiconductor manufacturers are facing increasing costs in servicing their major OEM customers with an increased amount of technical support; just-in-time (JIT) programs; and computerized order entry, tracking, and delivering systems. Therefore, they are continually reassessing their distribution networks in Europe to see which companies can better meet their needs in servicing the non-OEM market. The non-OEM market will become more important after 1992, as we expect an increase in the number of smaller companies addressing the newer emerging technologies such as graphics, local area networks (LANs), and industrial automation.

END-USER MARKET STRUCTURE

The challenge that manufacturers and distributors face is organizing themselves in a cost-effective manner to address the new market structure. Dataquest expects the European end-user market to segment itself into the following three major categories:

- Large non-European multinational OEMs operating in more than one European region
- Medium-size European OEMs operating in more than one European region
- Small companies operating in one region and addressing local niche markets

Distribution will have a major role to play in the latter two segments, with the first segment being addressed directly by the semiconductor manufacturer. Semiconductor vendors are complaining that distributors are not investing enough in technical support. On the other hand, distributors complain that because of reduced margins, their investments in technical support do not give sufficient return. The primary aim of larger manufacturers is to minimize the cost of sales by tightly controlling the number of direct sales persons and using distributors to maximize efficiencies. We expect the distribution network in Europe to segment itself into the following two major categories:

- Pan-European broad-line distributors
- Small, highly technical niche distributors

Pan-European Distributors

Pan-European distributors will operate in all major regions of Europe that carry a broad product line, but with a reduced number of principals. Each distributor will invest in a central warehouse to carry slow-moving items that can be dispatched to their European customers in 24 hours, while fast-moving items will be stocked in local regional offices, providing better service to customers. Pan-European distributors will benefit from economies of scale in obtaining better pricing and technical training support from their principals as a result of their increased purchasing power. They will be able to invest in more central and technical support engineers, who will be able to travel to major customer locations throughout Europe.

Pan-European distributors still will need to service their customers via local sales offices staffed by local nationals. As more medium-size OEM companies move their manufacturing facilities throughout Europe, we expect them to strike a closer long-term relationship with one or two pan-European distributors that can make up for shortfalls in short-term supply/demand from their principal semiconductor vendors. The fundamental issue that pan-European distributors will face is that of reduced margins. Today, most major distributors in the United States survive on very slim margins because they operate in an open competitive market. We expect other companies to merge, taking advantage of common overhead structures and thus increasing margins.

Specialist Technical Distributors

As submicron semiconductor technology becomes state of the art, the products become even more technically intensive. These products will require specialist support engineers for both hardware and software. As a matter of fact, we anticipate that more than 50 percent of future product development costs will be in providing design tools and support systems. (The rest will be spent on the actual silicon design.) Semiconductor manufacturers are in a quandary as their current OEM customers lack the initiative to readily take advantage of new emerging technologies, while small dynamic companies are the most eager to start using these innovative new technologies. Traditionally, small dynamic companies have been addressed via the distributor network. No easy solution to this quandary exists, but one possibility is for broad-line manufacturers to encourage many small specialist distributors.

Dataquest expects small distributors to become more technically specialized in order to survive against larger distributors. We would expect semiconductor manufacturers to reward specialist distributors with design-win protection, regular training of distributor application engineers, special introductory prices, and holding of stock at the manufacturer's warehouse. These will free specialist distributors to invest more in technical support, which will be necessary for the specialist distributors/ manufacturers partnership to work.

Uncertainty about Medium-Size Distributors

What about medium-size distributors? Their future does not look good, as they will face severe competition from large distributors that can always undercut prices. Small distributors will be able to offer better technical support to gain multichip systems business with added value from software and support tools. Broad-line distributors will focus on the business' commodity end; niche distributors will invest in technical support to achieve higher margins.

A medium-size distributor cannot coexist with conflicting requirements (i.e., reduced service costs and increased levels of technical support) and thus either will join with a pan-European company or will streamline and become a niche player. The future shape of the European distribution industry will be a mirror image of today's semiconductor market, where the top 15 vendors have approximately 80 percent of the market and the other 100 players coexist in small niche markets. Possibly, the smarter smaller companies will form partnerships with specialist design houses and with workstation and specialist software suppliers to offer specialist one-stop shopping and service under one roof.

DATAQUEST CONCLUSIONS

Dataquest believes that more global distributors will emerge in 1992, with a few U.S. distributors operating in the European market. Currently, a small group of locally based distributors dominates each region within Europe. We expect to see an increase in mergers, acquisitions, and joint ventures, which will fall into the following two distinct categories:

- A broad-line pan-European distributor operating across Europe through locally based sales offices

- Small niche technical distributors specializing in particular segments such as graphics, LANs, and digital signal processing

Dataquest expects to see further entry in Europe by North American distributors, which will result in more global distributors. The most dramatic change will occur when Japan-based trading houses forge links with some of their global distributors. Japan, which now is the largest producer of semiconductors worldwide, has experienced difficulties penetrating North American and European distribution networks. We expect the Japanese companies to consider a number of options to improve their presence in European distribution, including acquisitions and joint ventures.

Mark Guidici
Bipin Parmar

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Research *Newsletter*

SEMICONDUCTOR PRICE SURVEY: MPUs AND 1MB DRAMs LEAD WAY IN SHARP PRICE BREAK

SUMMARY

As shown in Table 1, the downward trend in semiconductor prices and lead times accelerated during late second/early third quarter 1989. Suppliers of 16- and 32-bit microprocessors (MPUs) and 1Mbx1 DRAMs have aggressively cut pricing in response to a recent slowdown in U.S. systems shipments. Dataquest reinforces its earlier recommendation that system manufacturers actively negotiate for better 1Mbx1 DRAM prices and lead times and we extend this recommendation to 16- and 32-bit MPUs, CMOS logic, and ASICs.

STANDARD LOGIC TRENDS

As stated last quarter, supply of standard logic products continues to exceed demand as of midyear 1989. Users can expect major suppliers of 74HC products to actively compete on pricing (see Table 1). Standard logic lead times range from four to eight weeks, with some improvement expected during the seasonal summer slowdown. Figure 1 illustrates the continued downward pressure on standard logic pricing.

The downward trend in pricing for standard logic cuts across all product families. Recently, pricing for the 74F family has declined rapidly. Users can expect the sharpest declines during the third quarter to occur in the 74HC, 74AS, and 10K ECL families. As noted in last quarter's SUIS newsletter 1989-30, entitled *Semiconductor Price Survey: Suppliers Aim to Manage 1Mb DRAM Price Decline*, pricing for newer bipolar families (such as 74AS and 74ALS) continues to decline aggressively as volume grows; however, mature bipolar product pricing also remains highly competitive.

MICROPROCESSOR TRENDS

In the MPU business, a recent slowdown in U.S. computer shipments translates into downward pricing pressure in commodity 8- and 16-bit segments, as well as the high-speed 16- and 32-bit markets. Lead times now range from 4 to 12 weeks, with the most dramatic improvement occurring in the 80286 arena. Users can expect some additional shortening of MPU lead times (see Table 1).

TABLE 1
Semiconductor Pricing and Lead Time Trends (North American Bookings)

	Pricing Trend		Lead Times	
Part	2nd Quarter	Forecast	Current	Trend
74HC Family	3.6% to 8.3% down	Flat to 3.9% down	6-8 weeks	1 week shorter
16-Bit MPU	3.3% to 22.0% down	Flat to 9.2% down	4-10 weeks	1 week shorter
1Mx1 DRAM	8.6% down	13.0% down	8-16 weeks	Steady to 1 week shorter
32Kx8, 100ns SRAM	2.1% down	5.5% down	20 weeks	Steady

Source: Dataquest
July 1989

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SUIS 1989 Newsletters: July-September 1989-37

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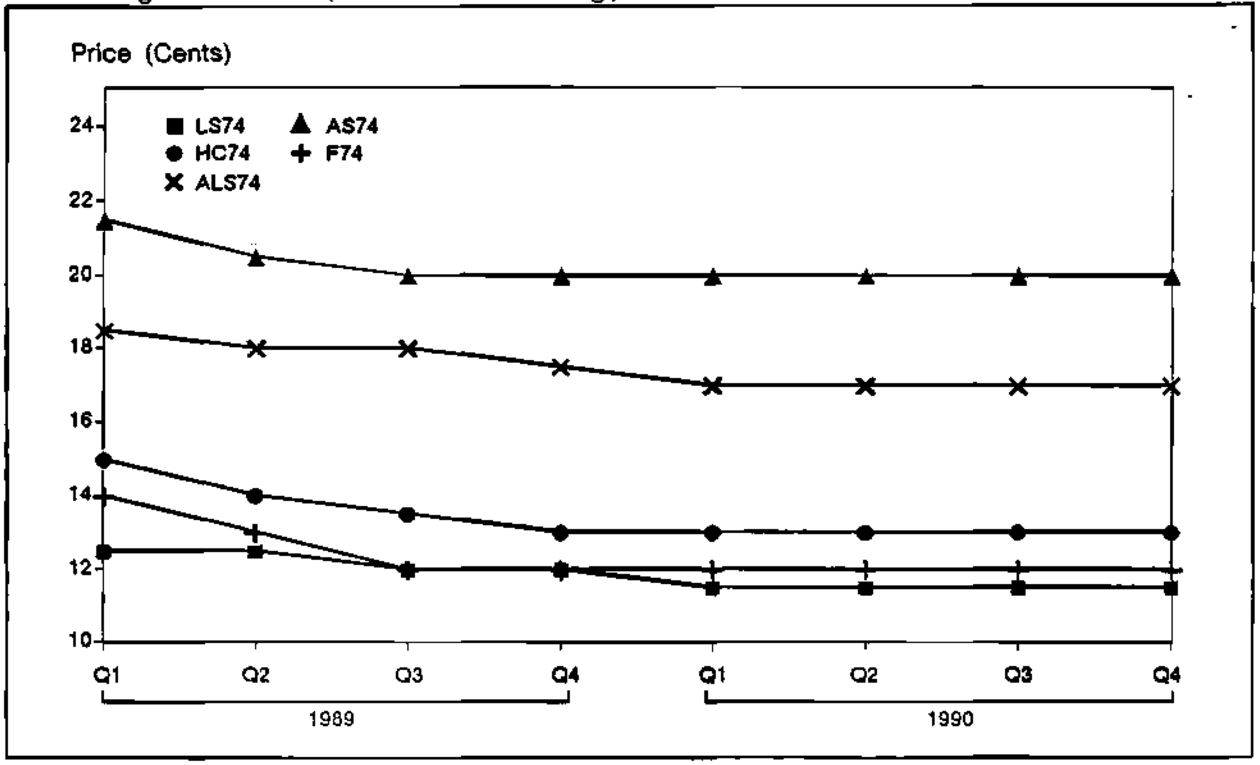
FIGURE 1
Standard Logic Price Trends (North American Bookings)



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Source: Dataquest
July 1989

High-Speed 286s Battle Low-End 32-Bit Products

The price battle between suppliers of high-speed 80286 devices and suppliers of 16 MHz 32-bit products intensified in view of a recent slowdown in North American shipments of computer systems. Pricing for the 10-MHz 80286 product dropped nearly 23 percent during the second quarter. During the third quarter, the average selling price (ASP) for this device should decline by 9.2 percent to a price of $15.52. Pricing for the 16-MHz 80386SX should erode by 12 percent in the third quarter to an ASP of $69.75. The downward trend in pricing for the 16-MHz 80386 has quickened and should move to a third quarter ASP of $174.50 in light of unconfirmed reports that output of this specific product will be phased down during 1990.

MEMORY TRENDS

Events in the DRAM segment continue to set the stage for many semiconductor product trends. A major midyear 1989 event in this business has been a recent worldwide plunge in pricing for 1Mbx1, 100/120ns DRAMs.

"Managing" the Megabit DRAM Market

As reflected in Figure 2, North American users of the critical 1Mb DRAM can expect a year-long price decline that should cause ASPs to drop to nearly $12.00 by the fourth quarter.

The megabit DRAM business is proving to be difficult for both suppliers and users to manage. Specifically, the rate of price decline for the critical 1Mb DRAM has accelerated in North America (see Figure 2 and Table 1) because of a recent discernible slowdown in U.S. computer shipments just as suppliers of 1Mb parts increased inventories. Similar demand and inventory patterns occurred in Europe, Hong Kong, South Korea, and Taiwan, and to a lesser extent Japan. Dataquest restates its recent recommendation that until system demand changes, users should aggressively negotiate for

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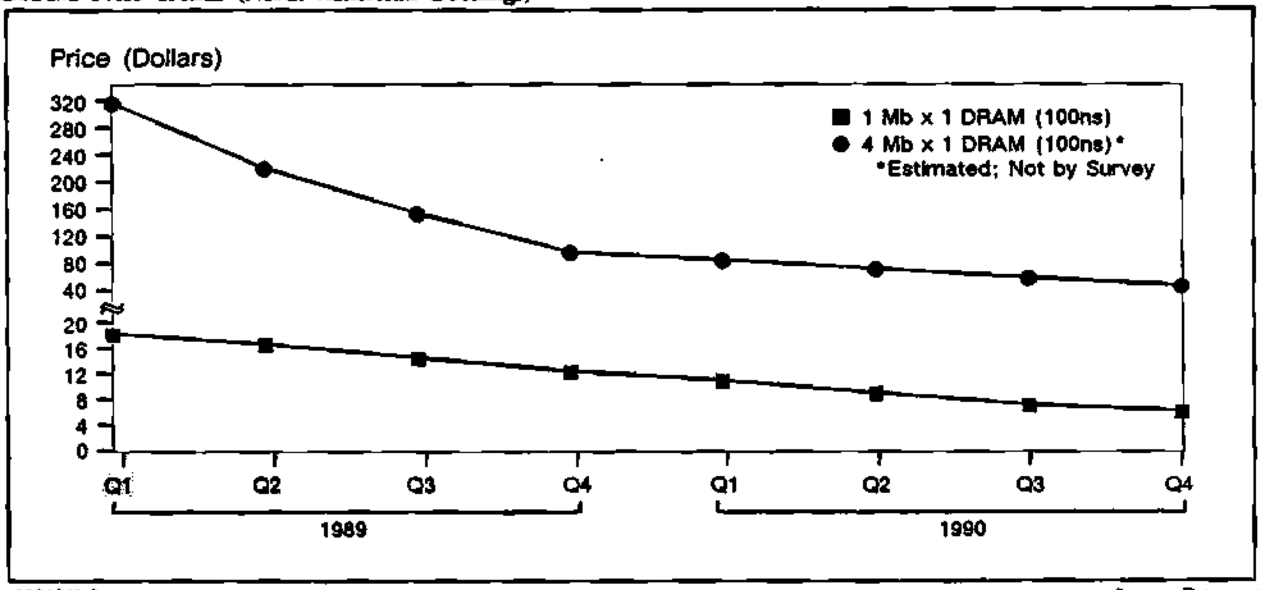
FIGURE 2
DRAM Price Trends (North American Bookings)



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Source: Dataquest
July 1989

lower 1Mb DRAM prices on a worldwide basis and also limit orders to delivery within three months.

Regarding the next generation of DRAMs, users can expect to pay an average price of $159.00 for small volume orders of 4Mb DRAMs during the third quarter of 1989 and $100.00 during the fourth quarter.

Relief in the 256K Segment?

Currently, Dataquest expects pricing for 256K DRAMs to remain at the high level of $3.77 for the rest of this year. Some early but uncertain signals of a downward break in pricing are causing Dataquest to advise users to monitor 256K DRAM price and lead time trends constantly over the short term.

Slow SRAM: A DRAM-Impacted Business

The supply and pricing of slow SRAMs remains a DRAM-driven function. As stated last quarter, users can expect a supply increase of slow 8Kx8 and 32Kx8 SRAMs. Pricing for the mature 64K device should continue to be relatively stable (in the $3.70 range); however, dramatic lead time improvements are occurring. Lead times for this product now range from 14 to 26 weeks versus the 26-week "allocation" scenario of early 1989.

Price declines associated with the 32Kx8 device's move down the cost curve have started. The ASP for this device is expected to drop from $9.55 in the second quarter to $9.02 in the third quarter, a 5.5 percent decline. Lead times remain steady at a long 20 weeks.

Fast SRAMs

Users of fast SRAMs can anticipate continuing declines in pricing and/or shorter lead times. The downward trend in pricing for 4Kx4, 35ns SRAMs and 64Kx1, 25ns SRAMs has quickened since last quarter. Pricing for 4Kx4, 45ns SRAMs and 16Kx4, 35ns SRAMs continues to decline as originally expected; however, lead times have shortened by one week.

Nonvolatile Memory

The nonvolatile memory business (ROMs, EPROMs, EEPROMs) remains in overall supply-demand balance. Lead times hold steady at 6 to 16 weeks.

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The recent entry of Gould AMI into the Mbit ROM market could spell relief for North American and European users of this product. ROMs are driven by demand from Asian electronic typewriter and video game manufacturers. These manufacturers use 150/200ns devices, which translates into a product mismatch in terms of speed for some North American and European users of this device. For these users, procurement of a higher-speed ROM (sub-150ns) carries a stiff price premium of as much as 50 percent over mainstream devices and an overall high level of supply base/pricing uncertainty.

ASICs

As noted in this newsletter series since the beginning of 1989, nearly all ASICs are declining in price this year and should continue to do so next year (see Figures 3 and 4).

The recent decision of the U.S. Department of Commerce and Japan's Ministry of International Trade and Industry (MITI) to monitor ASIC pricing might have an impact on Dataquest's price outlook; however, no clear signs can yet be discerned.

Dataquest analysts have spotted another development that might have an even greater long-term impact in the ASIC business than ASIC foreign market values (FMVs). Some Japanese semiconductor companies that supply both memory products (such as DRAMs and slow SRAMs) and gate arrays have begun to build fab networks that essentially enable users to custom-order memory/gate array requirements. Basically, a distant main fab produces wafers that are custom cut at local minifabs to meet a given user's specific needs. If so, users would have strong incentive to bundle memory/gate array purchases. Dataquest restates its prior recommendation that users give CBICs a close look vis-à-vis gate arrays in terms of total system cost-savings for systems being designed today for production in 1991 and 1992; however, the tantalizing prospect of custom memory/gate array procurement must also be given careful strategic consideration.

FIGURE 3
1989 ASIC Price Trends (North American Bookings)

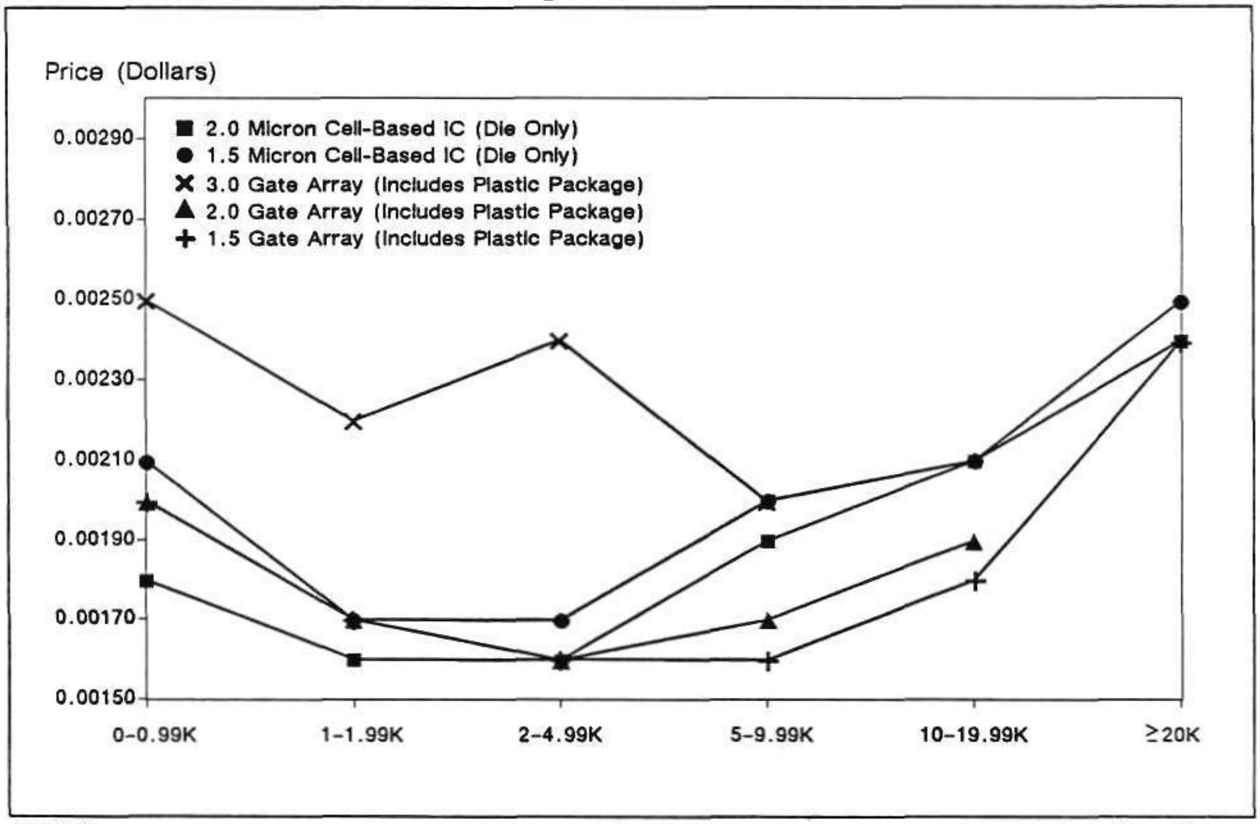

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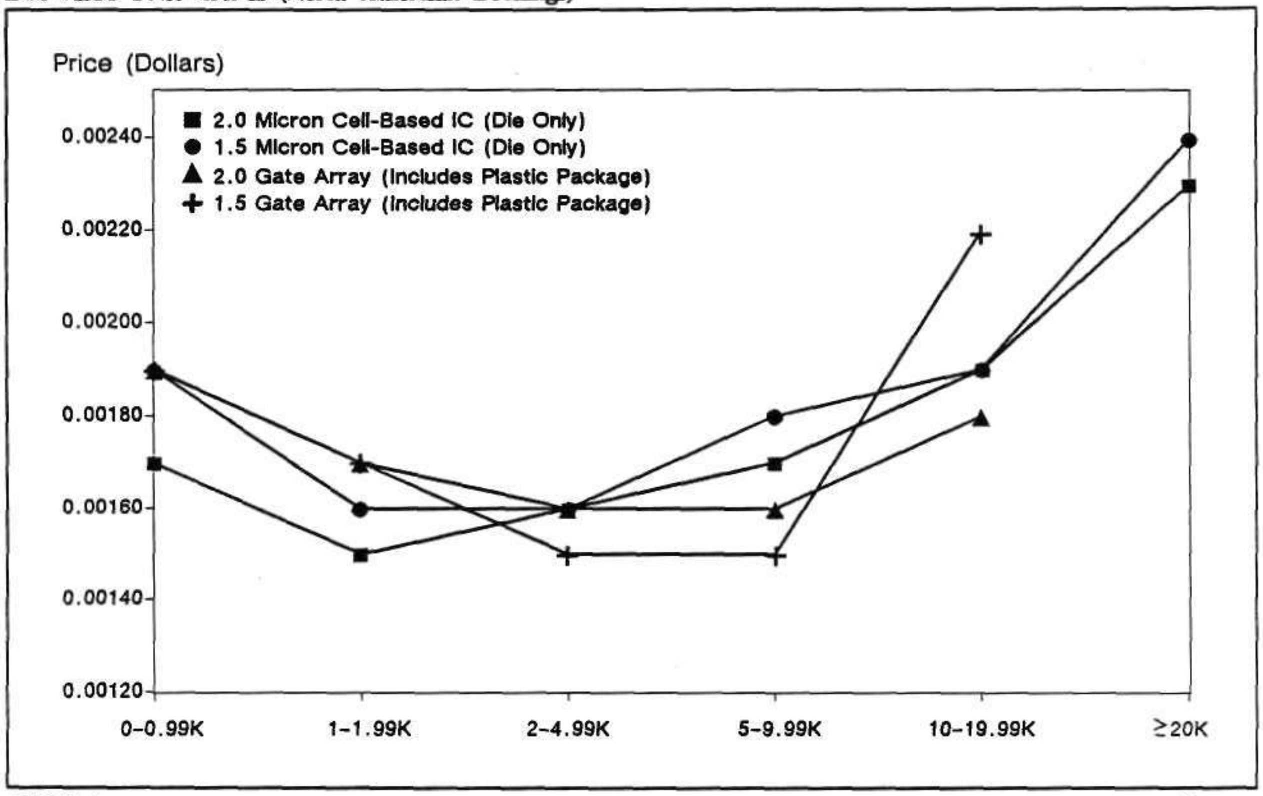
FIGURE 4
1990 ASIC Price Trends (North American Bookings)



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Source: Dataquest
July 1989

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The year 1989 continues as a period of declining semiconductor prices and shorter lead times. Under these conditions, Dataquest recommends the following:

- Dataquest reinforces its earlier recommendation that system manufacturers actively negotiate for better 1Mbx1 DRAM prices and lead times and now extends this recommendation to 16- and 32-bit MPUs, CMOS logic, and ASICs.
- ASIC users must develop contingency plans that take into account the impact of the FMV system on ASIC supply and pricing akin to the experience with memory products during 1987 and 1988.
- Dataquest again recommends that users give CBICs a close look vis-à-vis gate arrays for systems being designed today for production in the post-1990 period. Even so, Dataquest also recommends that users with systems that will have a strong memory/ASIC content should look for semiconductor manufacturers that combine worldwide fabs for manufacturing wafers for these products along with a local customizing capability.

Ronald A. Bohn

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Research *Bulletin*

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JULY MARKET WATCH: MOS MEMORY JOINS SLOWDOWN, TURNS BUSINESS INCREASES

Market Watch is a monthly bulletin that is released after the SIA book-to-bill Flash Report and is designed to give a deeper insight into the monthly trends in the semiconductor market (see Figures 1 through 4).

Figure 1

U.S. Semiconductor Book-to-Bill Ratio

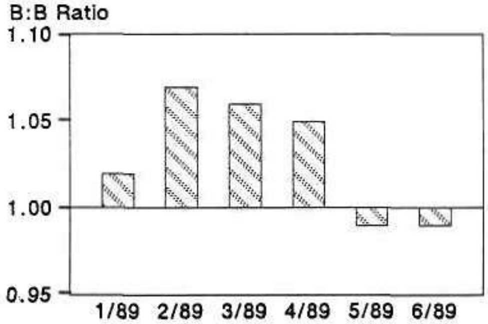


Figure 2

DOC Computer Demand

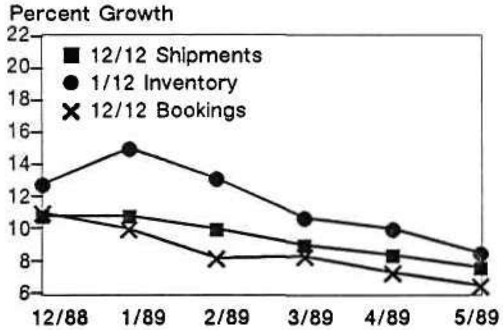


Figure 3

Semiconductor Inventory Level

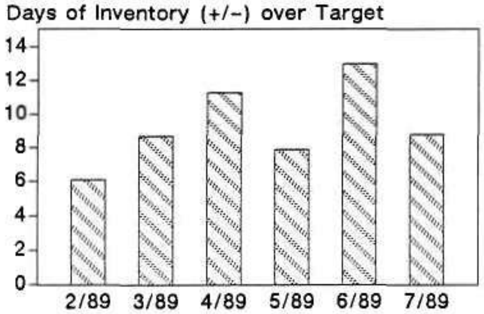
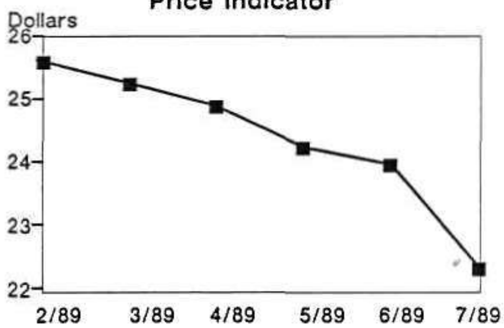


Figure 4

U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
July 1989

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JUNE RESULTS ARE UP; BOOK-TO-BILL STILL AT 0.99

Despite the SIA book-to-bill of 0.99 (see Figure 1), June bookings and billings increased. Dataquest's June Procurement Pulse survey foresaw the bookings increase. Because billings rose at a much higher rate (13.6 percent) than bookings, Dataquest suspects that the following are occurring: semiconductor manufacturers' order backlog is decreasing rapidly; turns business—orders placed and filled in the same month—is increasing as a percentage of total billings; and distributor inventory is growing.

SYSTEM DEMAND AND INVENTORY GROWTH STILL DECREASING

Computer order and shipment growth has dropped for the fifth consecutive month (see Figure 2). Computer shipment growth from June 1988 to May 1989 has increased by only 7.7 percent compared with the previous 12 months. Computer inventory growth again has decreased along with orders and shipments, indicating that OEMs are not being taken by surprise but are making prudent but gradual adjustments to lower growth expectations. This, in turn, has minimized sudden movements in semiconductor orders.

ACTUAL INVENTORIES DROPPING TO LOWER TARGET LEVELS

After 1989's first quarter, most OEMs have adjusted to their lower sales growth forecasts by reducing target inventory levels and reviving their just-in-time (JIT) programs. Generally, the semiconductor industry is now feeling the effects. Actual inventory levels, especially for non-DRAM products, have dropped dramatically in July and have approached target levels (Figure 3). Therefore, users will rely more on the spot market or on last minute orders against contracts that require quick delivery. Semiconductor manufacturers should expect turns business to increase as a percentage of total sales as users endeavor to keep inventories low.

PRICE INDICATOR PLUNGES

Dataquest's price indicator, based on a basket of key semiconductor products, has plunged significantly for the first time this year. The price indicator now is close to 7 percent below January levels. Certain products—1Mb DRAM, 80286, and 32Kx8 SRAM—were primarily responsible for the decrease. This indicator shows that MOS memory producers, once untouched by the woes of the rest of the industry, have begun to feel the bite of a competitive and weakening market.

DATAQUEST ANALYSIS

Dataquest recognizes the following trends: turns business is increasing as a percentage of sales; suppliers' order backlog is decreasing quickly; and distributor shelves probably are filling rapidly. MOS memory producers, still fairly well off, are no longer exempt from these trends—time for them to put away the caviar and bring on the hamburgers. However, because system sales still are growing and OEM inventory levels are low, Dataquest believes that the industry will see fluctuating, rather than continuously declining order patterns from month to month as buyers adjust their inventory mix or respond to sudden production demands. The market definitely is in a slowdown, but with low OEM inventory levels, it will hopefully be a short one.

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Mark Giudici

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Research *Bulletin*

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JULY PROCUREMENT PULSE: INVENTORIES/ORDERS DOWN, MEMORIES ON A SEESAW

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin explains what inventory order rate corrections mean to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

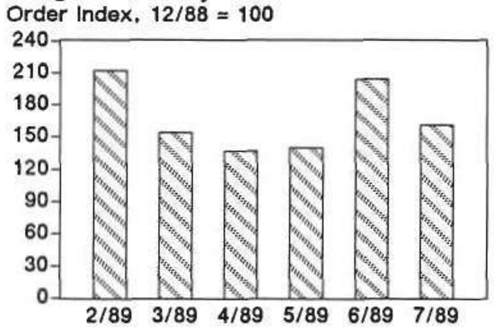


Figure 2
Averaged Semiconductor Lead Times

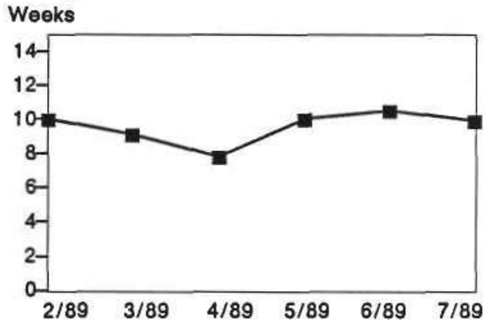


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

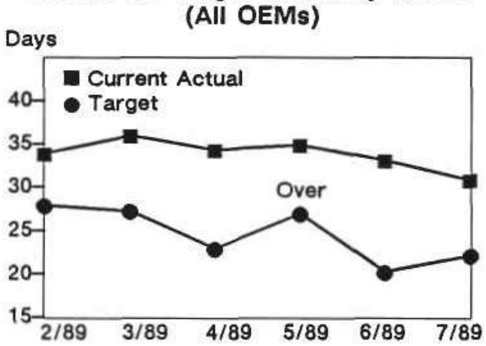
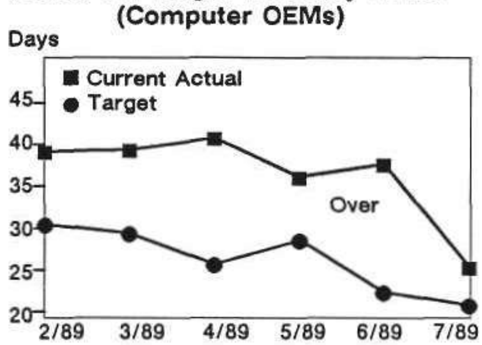


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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SEMICONDUCTOR ORDER LEVELS DROP TO CUT INVENTORIES

Semiconductor buyers in this month's survey expect to lower their July orders by 21 percent relative to last month's levels, as shown in Figure 1. Two-thirds of all respondents still see their systems sales growing from 5 to 30 percent in the next six months, with the remaining one-third expecting flat sales. As mentioned in last month's bulletin, the high order rate in June was an anomaly that resulted from a poor inventory mix that is now being corrected.

UNCHANGED LEAD TIMES HIGHLIGHT STEADY DEMAND

The average lead time of 10 weeks (see Figure 2) illustrates today's semiconductor market balance. DRAM purchases increasingly reflect a spot-market mentality. Short shipment windows and frequent but low orders are methods buyers currently are using to control costs. The availability of 80ns DRAMs and 32Kx8 SRAMs continues to be an issue for some buyers, but the situation is improving, with only 22 percent of our respondents noting any memory availability problems. Other semiconductor lead times remain at manageable levels for both users and suppliers.

OVERALL INVENTORY LEVELS FALL AS NON-DRAM INVENTORIES GET SLASHED

As Dataquest predicted, reductions in non-DRAM inventory have lowered the actual inventory levels of this month's respondents (see Figures 3 and 4). Non-DRAM/WIP actual inventory of computer OEMs dramatically declined to 19.2 days, down from 37.0 days! The overall OEM non-DRAM/WIP actual inventory levels also dropped from 36.7 days down to 27.0 days. Within the background of slower-growing system sales and easing of DRAM availability, Dataquest expects buyers to continue to focus on lower inventory levels and reductions in component prices. Actual inventory levels (including DRAM/WIP) fell from 37.7 to 26.0 days for computer OEMs and 33.2 days to 31.1 days for overall OEMs.

DATAQUEST ANALYSIS

Dataquest expects low inventory levels (especially for non-DRAMs) to continue and to cause more spot orders, or at least more orders requiring deliveries within three months. It is now a buyer's market. System sales are still growing, buyers need to watch their component mix as they maintain lower inventory levels to reduce dependence on large spot-market buys. Suppliers should expect fluctuating orders from month to month, an increased percentage of turns business, and therefore, more intense competition and price pressure. On a positive note, the low inventory levels should make this slowdown period shorter. When system sales pick up once again, semiconductor sales should quickly follow.

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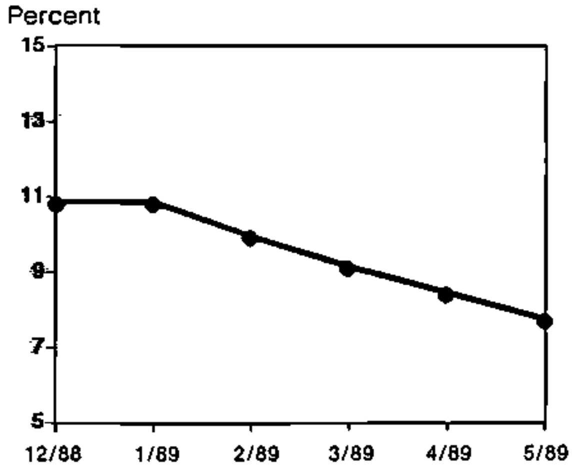
SYSTEMS–DEMAND SLOWDOWN SPARKS SHARP DROP IN WORLDWIDE 1Mb DRAM PRICES

EXECUTIVE SUMMARY

As clear signs of a slowdown in U.S. computer system production emerge (see Figure 1), 1Mb DRAM suppliers have responded with aggressive price cuts in North America and other world regions (see Figure 2). Briefly put, an expanding 1Mb DRAM supply from a growing number of suppliers has hit a midyear demand slowdown that to DRAM suppliers looks like a second-half 1989 recession. Until the system demand pattern crystallizes, Dataquest recommends that system manufacturers aggressively negotiate for lower 1Mb DRAM prices and limit orders to delivery within three months.

Figure 1

12/12 Rate of Change in Shipments of U.S. Computers and Office Equipment



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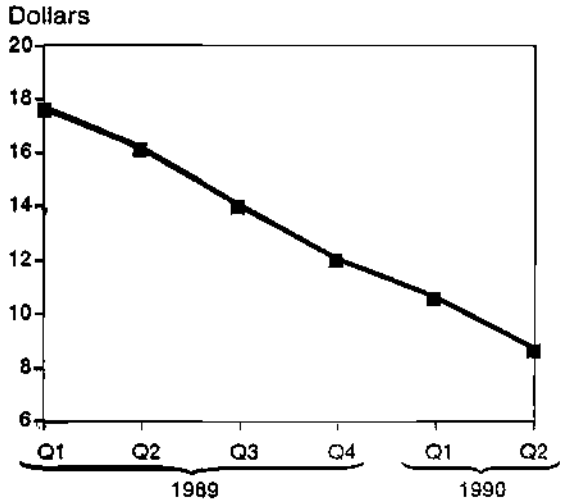
Source: U.S. Department of Commerce

Figure 2

1Mbx1 DRAM Price Trend North American Bookings



0004442-2

Source: Dataquest July 1989

TRENDS IN U.S. COMPUTER SHIPMENTS AND NORTH AMERICAN 1Mb DRAM PRICES

As shown in Figure 1, the rate of growth in U.S. shipments of computing equipment began to slow late in the first quarter of 1989. This slowdown continued during the second quarter, with June results not yet available.

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Earlier this year, Dataquest forecast a second-quarter 1989 downturn in North American bookings prices for 1Mbx1 100ns DRAMs (100,000-piece orders). The price declined from $17.75 in the first quarter to $16.22 in the second quarter.

CURRENT WORLDWIDE TRENDS

In response to a slowdown in demand by system manufacturers in North America, Japan, Korea, and Hong Kong, worldwide 1Mbx1 DRAM prices dipped as the quarter ended. Reasons for the slowdown vary by region: business uncertainty in China and Hong Kong, a 1989 recession in South Korea, and a temporary slowdown in Japan. Table 1 shows the sharp worldwide 1Mbx1 120ns DRAM price change at the end of June.

Table 1

Worldwide Bookings Price by Region for 1Mbx1 120ns DRAMs
(100,000 Pieces; in U.S. Dollars)

Date	Europe	Hong Kong	Japan*	Korea	Taiwan	United States
June 19, 1989	$16.50	$16.95	$13.23	$13.00	$13.50	$16.16
July 3, 1989	$14.20	$15.75	$13.48	$11.00	$13.50	$15.84

*Pricing affected by exchange rate fluctuation

Source: Dataquest
July 1989

EXCESSIVE 1Mb DRAM INVENTORY

One similar trend appears around the globe: a building inventory by suppliers of 1Mb DRAMs. The inventory increases have been noticed most dramatically in North America, South Korea, and Hong Kong, but no world region has escaped the development as of midyear 1989. For example, Dataquest analysts in Korea expect an excess inventory of 1Mb DRAMs during the third quarter, as reflected by the $11.00 bookings price. The apparently stable $13.50 price in Taiwan actually covers a price range of $11.00 to $16.00, another reflection of high inventory levels.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

As third quarter 1989 begins, users should look for these developments:

- Dataquest does not foresee a severe recession in North America, but users should expect a slowdown in U.S. system output for the rest of 1989.
- We expect some improvement this year in Japanese systems production but not in Korean.
- Under these market conditions—which suggest pressure on suppliers to reduce 1Mb DRAM inventory—North American users can expect the price to fall to $13.89 in the third quarter and to $12.11 in the fourth quarter, with similar pricing trends around the world.

Until worldwide system production/DRAM demand patterns change, Dataquest recommends that system manufacturers on a worldwide basis aggressively negotiate for lower 1Mb DRAM prices. In line with this recommendation, Dataquest also recommends that users limit orders to delivery within three months.

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Research *Bulletin*

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U.S. MEMORIES INC.—A STRATEGIC RESPONSE TO DRAM TECHNOLOGY DEPENDENCE

EXECUTIVE SUMMARY

Events in 1988 demonstrated how DRAM technology dependence can cut system manufacturers' revenue and profits. Now, a group of U.S. DRAM users (Digital Equipment and Hewlett-Packard) and semiconductor suppliers (AMD, Intel, LSI Logic, and National Semiconductor) have proposed the formation of a company to be known as U.S. Memories Inc. in alliance with IBM, the only company that currently produces and uses volume quantities of 4Mb DRAMs. The aggressive goal is to produce 4Mb DRAMs in volume quantities by the first half of 1991. Table 1 summarizes Dataquest's view on the risks and benefits for users associated with the venture.

Table 1

A User View of Proposed U.S. Memories Inc.

Prospective Benefits of Participation	Risks of Participation
• Some protection against shortages and perceived threat of foreign market control over price/supply	• Inability to meet 1991 production ramp plans
• Enhanced long-term competitiveness against foreign computer companies that produce DRAMs	• Inconsistent competitive prices
• Access to U.S.-based leading edge DRAM technology from IBM	• Two quality risks - Uncertain level of quality - Which standard to use?
• Some protection against government trade action that affects market price/supply	• Product mix mismatches (speed, organization, package)
• More accurate production forecasts	• Allocations to user/investors in times of product scarcity
	• Exposure of users' confidential order levels and part choices

Risks of Nonparticipation

- Periodic spot shortages and premium pricing
- More trade barriers to DRAM importation
- Competitive disadvantage compared with user investors in U.S. Memories Inc.

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June 1989

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RISK/BENEFIT ANALYSIS

As shown in Table 1, prospective North American 4Mb DRAM users must weigh harsh risks against prospective benefits. Dataquest's instant analysis—which will be developed more thoroughly in future newsletters—concludes that U.S. Memories Inc. is a sound approach that offers users direct access to leading-edge DRAM technology from a U.S.-based supplier, IBM.

Individual Levels of Benefit

U.S. systems manufacturers will be able to combine resources with U.S. chip manufacturers to build DRAMs. Their goal will be to reduce the competitive edge of foreign systems manufacturers that also make DRAMs. Users must realize that the benefits for each user participant, as outlined in Table 1, depend on the degree to which DRAMs supplied by U.S. Memories Inc. satisfy any single user's DRAM requirements. For example, users who can satisfy more than 50 percent of their 4Mb requirements through participation stand to gain more than users who meet 10 percent or less of their need through investment or involvement.

The Ultimate Benefit

Foreign DRAM suppliers and systems competitors have demonstrated their ability to manage DRAM supply and pricing in the past, and some aim to do so at this time. The ultimate benefit of the venture really flows to the North American electronics industry as a whole, in that U.S. Memories Inc. aims to break the dependence of U.S. systems manufacturers on DRAM suppliers that also are competitors in systems businesses.

DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

Dataquest suggests that North American DRAM users immediately investigate the possibility of participation in U.S. Memories Inc. At this time, our preliminary recommendation is that users do participate.

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Research Newsletter

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DRAM–SUPPLY WILD CARD: SAMSUNG TO THE RESCUE?

SUMMARY

First–tier Japanese DRAM suppliers have reaped high profits with their strategy of managing supply to control prices. As the threat of a market slowdown nears, several of these companies have indicated that they will continue to limit 1Mb DRAM production by shifting capacity to other scarce products, such as SRAMs or 4Mb DRAMs, in order to maintain the relatively high prices of 1Mb DRAMs. The question is whether or not the Japanese companies will succeed in this strategy. Dataquest believes that Korean and U.S. suppliers eventually may prove that Japanese manufacturers do not have as tight a control over the DRAM market as they think.

MANAGING PRODUCTION, CONTROLLING PRICE

When MITI instituted production cuts in the first half of 1987, many Japanese companies learned the lesson of managing supply to control prices. The irony is that the 1986 U.S.–Japan Semiconductor Trade Arrangement prompted these moves by MITI. Since then, production has been fairly limited by MITI based on demand measurements.

Today, however, several Japanese DRAM manufacturers have indicated that they will shift capacity to other scarce products (such as SRAMs) or new products (such as 4Mb DRAMs) if the market softens, in order to preserve the relatively high prices of 1Mb DRAMs. MITI has since dropped its production guidelines. DRAM procurers in the United States see quoted prices and directions from different Japanese companies that are suspiciously close, leading to a feeling of helplessness in the buying community.

Will the Japanese DRAM manufacturers succeed in implementing this strategy?

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ENTER THE WILD CARDS

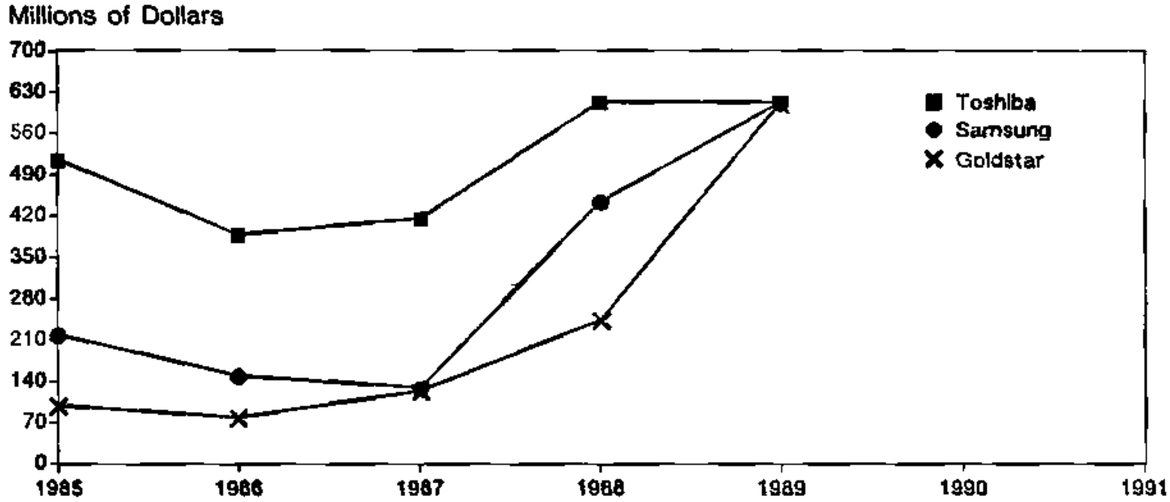
Toshiba has been in the forefront of the 1Mb DRAM market, outproducing others by two to one. Most Japanese companies have stopped trying to outpace Toshiba because of the dangers of excess capacity and the threat to 1Mb DRAM profits. Reports show that Toshiba plans to slow its production buildup in 1990.

The Japanese strategy's success depends on the level of control these companies exert over the 1Mb and 4Mb DRAM market and other factors.

As presented in Figure 1, Samsung's and Goldstar's capital spending have reached Toshiba's level. (Toshiba currently is the most aggressive Japanese manufacturer.) Reports predict that Samsung will have capacity up to 9 million units per month by the end of 1989, just a shade less than Toshiba, and has plans to increase production further while Toshiba slows its growth. Samsung's main challenge will be to increase production yield to 80ns parts and supply of product variations such as SIP/SIMM modules, and to qualify in a wider field of major OEMs.

Figure 1

Estimated Semiconductor Capital Spending



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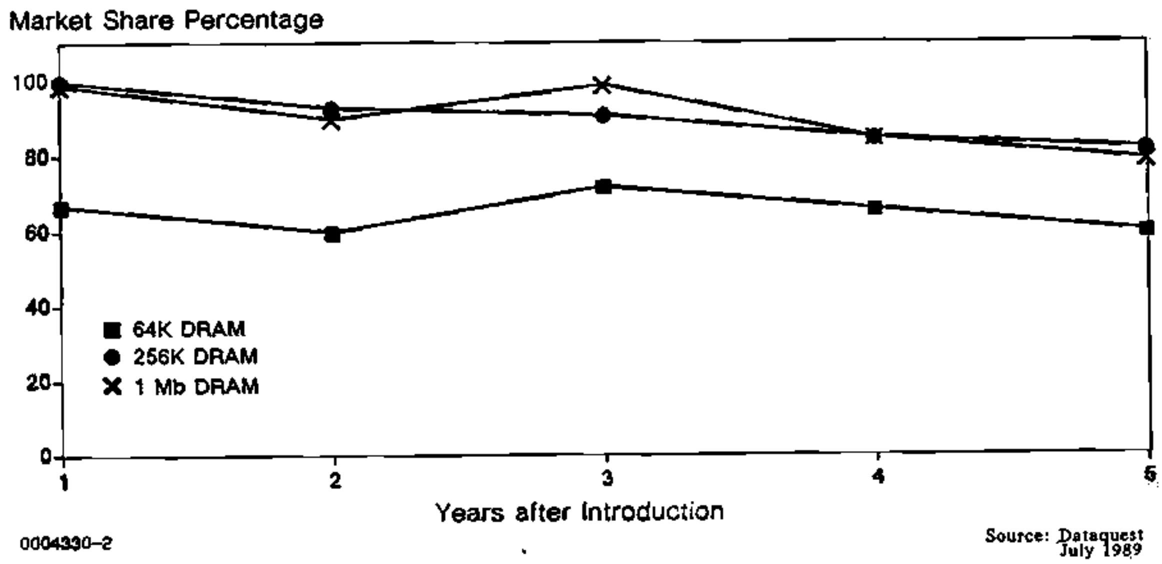
Source: Dataquest
July 1989

With the entry of the Korean manufacturers, a wider field of 1Mb DRAM suppliers will exist in 1990. Estimates show that Japanese manufacturers as a group will have the same control over the market, in terms of market share, as they did with the 256K DRAM (see Figure 2). The 1Mb DRAM estimates assume greater participation by Goldstar, Hyundai, Micron Technology, Samsung, Siemens, and Texas Instruments.

Figure 2

Estimated Japanese Companies' Worldwide Market Share



With such aggressiveness displayed by other manufacturers, the top Japanese companies should be cautious about their strategic assumptions of market control. Although they are threatened in the 1Mb DRAM market, Japanese manufacturers will find good refuge in the profitability of the 4Mb DRAM, which they are ramping quickly.

Can the top-tier Japanese companies shift enough 1Mb DRAM capacity to other products? If these companies do maintain control over the 1Mb DRAM market, they can effectively reduce 1Mb DRAM production by shifting capacity to 32Kx8 SRAMs and 4Mb DRAMs. Dataquest estimates show that if Japanese companies increase the shipments of 32Kx8 SRAMs by 50 percent more in 1990 and use existing 1Mb DRAM capacity to build all 4Mb DRAMs, then they would have effectively cut 1Mb DRAM production by about 20 percent in 1990. Nevertheless, after successfully doing this, they would have reduced their market share in 1990 and their future control over the 1Mb DRAM market. By that time, however, we would hope that their emphasis would have shifted to the 4Mb DRAM.

In keeping the 1Mb DRAM prices up at the cost of market share, these leading Japanese companies also can keep the prices of 4Mb DRAMs, a market that they control, relatively high. The profits that could have been gained from the 1Mb DRAM will be reaped from the higher prices of the 4Mb DRAM.

DATAQUEST ANALYSIS

Korean, European, and U.S. companies currently have the momentum to change the control over the 1Mb DRAM market held by the top-tier Japanese companies. However, they face challenges other than production ramps, such as improving 80ns yields, widening their product offerings, and meeting major OEMs' stringent qualifications.

The top-tier Japanese companies have a plausible profit-maximizing strategy, but it hinges on the assumption that other manufacturers' production plans will slip. In following their strategy, Japanese suppliers will have to trade market share for profits, which means that they need to successfully ramp the 4Mb DRAM in order to keep overall worldwide DRAM market dominance.

DRAM procurers that have had difficulty returning the 1Mb DRAM to its learning curve path will need to try to qualify a wider field of suppliers, especially knowing the aggressiveness of the production plans of Korean companies.

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George Burns

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Research *Bulletin*

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JUNE MARKET WATCH: CLEARER SLOWDOWN SIGNALS AS SYSTEM DEMAND WEAKENS

Market Watch is a monthly bulletin that is released after the SIA book-to-bill flash report and is designed to give a deeper insight into the monthly trends in the semiconductor market (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

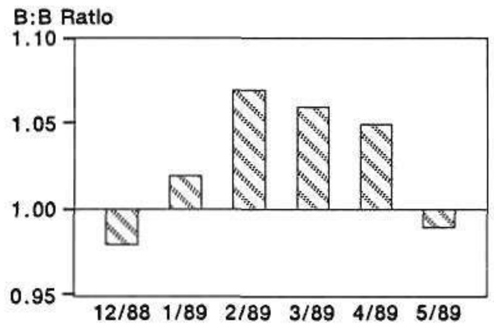


Figure 2
DOC Computer Demand

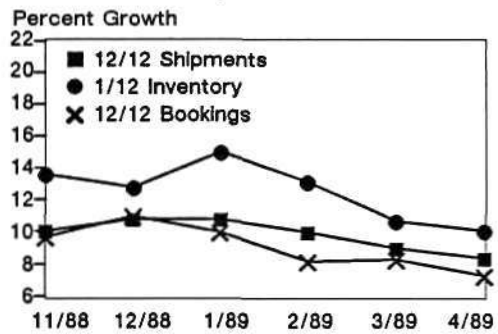


Figure 3
Semiconductor Inventory Level

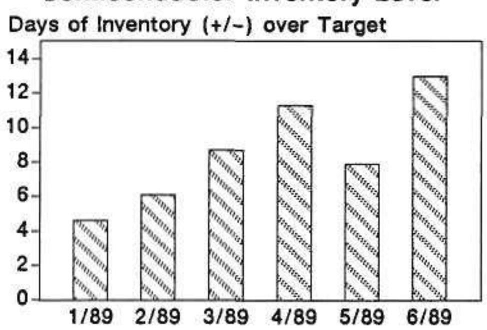
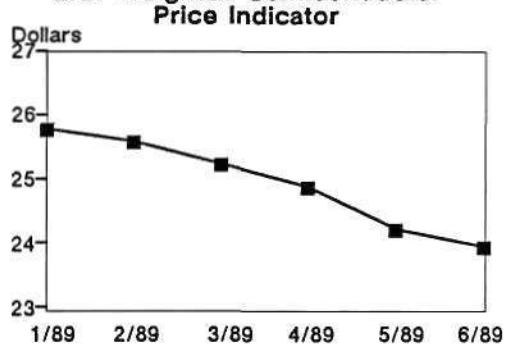


Figure 4
U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
June 1989

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SIA BOOK-TO-BILL RATIO DROPS TO 0.99

The industry's leading health indicator, the SIA book-to-bill ratio, has dropped below unity—perhaps the first clear sign of the slowdown Dataquest has been predicting for the second half of 1989. Despite strong first quarter bookings, nonmemory product sales were flat from Q4 1988 to Q1 1989, indicating that the slowdown may already have occurred for this segment. MOS memory sales, on the other hand, grew by 14.8 percent during the same period. Several Japanese companies saw strong bookings in May, especially for MOS memory devices, which is likely to boost the flash report figures when finalized.

SYSTEM DEMAND CONTINUES TO SLOW, BUT INVENTORY LEVELS ARE STILL WELL MANAGED

Computer demand is slowing down, as shown in Figure 2, with declining computer order growth threatening to slow further the already sluggish growth of computer shipments. A positive sign is that inventory growth is slowing even more rapidly than that of computer orders and shipments, reducing the possibility of severe price declines in the second half of 1989.

Despite the increase in inventory over target levels, actual inventory has remained fairly flat, as explained in the June Procurement Pulse newsletter. Semiconductor users have reduced target inventory levels, perhaps as a result of anticipated slowdowns in the system markets and easing of the DRAM shortage problem. The major emphasis of procurement managers today is to cut costs and return to just-in-time (JIT) schedules, which are standard in slow markets. Although actual inventories have remained flat, Dataquest's survey shows that non-DRAM inventory levels have risen dramatically. Non-DRAM manufacturers should be cautious of this trend.

PRICES ARE STILL STEADY

The price of Dataquest's basket of key products has not dropped very much since the beginning of the year. Most of the price declines are in microcomponents and selected memories, but prices of standard logic and linear devices, as well as key memory products, have been firm. Although affected by demand, prices decline faster in periods of excess capacity or inventory. The semiconductor industry does not have excess capacity, and OEM inventories are still fairly low. Dataquest does not expect to see severe price declines in this slowdown period.

DATAQUEST ANALYSIS

The MOS memory market has isolated itself from the patterns of the rest, persisting in its growth, while other product families are slowing down considerably. MOS memories, the major growth drivers in 1989, also will encounter a slowdown as computer demand weakens. Already, price pressures are increasing for the 1Mb DRAM. Semiconductor buyers are beginning to act with less optimism on future system sales growth. Despite the inevitability of a slowdown, we should be thankful that capacity and inventory are low and prices and profits will not plunge severely.

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SEMICONDUCTOR PRICE SURVEY: SUPPLIERS AIM TO MANAGE 1Mb DRAM PRICE DECLINE

SUMMARY

Trends for the first half of 1989 continue to mark this year as a period of declining semiconductor prices and shorter lead times (see Table 1). A major rumble is a concerted, if not coordinated, effort by several leading suppliers to manage the supply of 1Mb DRAMs by shifting production from this critical device to other products. This newsletter highlights the key points of Dataquest's latest North America-based price survey and forecast.

Table 1

Semiconductor Pricing and Lead-Time Trends
(North American Bookings)

	Pricing Trend		Lead Times	
Part	1st Quarter	Forecast	Current	Trend
74LS	Flat to 3.5% down	Flat to 4.5% down	4-8 weeks	1-2 weeks shorter
16-Bit MPUs	1.0-12.0% down	2.5-5.5% down	8-11 weeks	1 week shorter
1Mx1 DRAMs	1.1% down	6.0-12.0% quarterly declines	8-16 weeks	1-2 weeks shorter
4Kx4 35ns SRAMs	7.0% down	2.0-4.0% down	7-10 weeks	Steady

Source: Dataquest
June 1989

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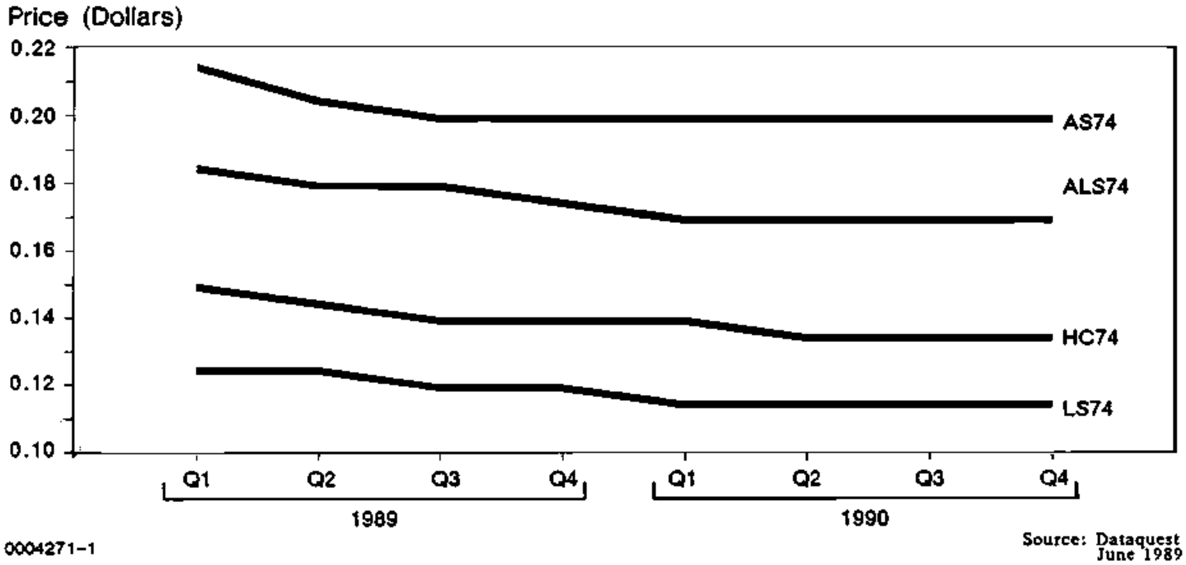
STANDARD LOGIC TRENDS

Supply of standard logic product has exceeded demand during the first half of 1989, with firm signs of a contraction in the supplier base for mature bipolar products. General lead times range from four to eight weeks. As a sign of demand slowdown, several major users of commodity logic have extended delivery dates on recently booked orders. Figure 1 illustrates the continued downward pressure on standard logic pricing.

Figure 1

Standard Logic Price Trends
(North American Bookings)



The downward trend in pricing for the mature bipolar and HCMOS products has quickened. Pricing for newer families such as the 74AS and 74ALS should continue to decline at an aggressive pace as volume grows. Dataquest recommends that users of mature bipolar logic plan for a supplier-base contraction and expect lifetime and last-time purchase offers from suppliers. North American and European users must realize select suppliers are now departing from this business.

MICROPROCESSOR TRENDS

Supply and Demand

In the microprocessor (MPU) business, the supply of commodity 8- and 16-bit devices shows signs of exceeding demand with concomitant downward pressure on pricing. Supply of high-speed 16- and 32-bit devices now moves into balance with demand. For example, lead times generally range from 8 to 11 weeks, a contraction of 1 to 3 weeks from earlier levels. The 32-bit product lead times have shrunk a full 2 weeks. Users can take advantage of steady price declines for mature products such as the 8-MHz 68000 and the 8-MHz 80186.

High-Speed 286 Battles Low-End 32-Bit

The price war between suppliers of high-speed 80286 devices and suppliers of 16-MHz 32-bit products has not abated. Manufacturers of high-speed 80286 devices are responding aggressively, with price cuts to counter the push by Intel/Motorola to move users from high-speed 16-bit MPUs into the low end of the 32-bit segment. With average selling prices (ASPs) for 32-bit MPUs declining at a rate of 5 percent per quarter (as much as 10 to 12 percent in the case of the 80386SX), users can expect suppliers of 80286 chips to respond with competitive 5 percent quarterly price cuts.

MEMORY TRENDS

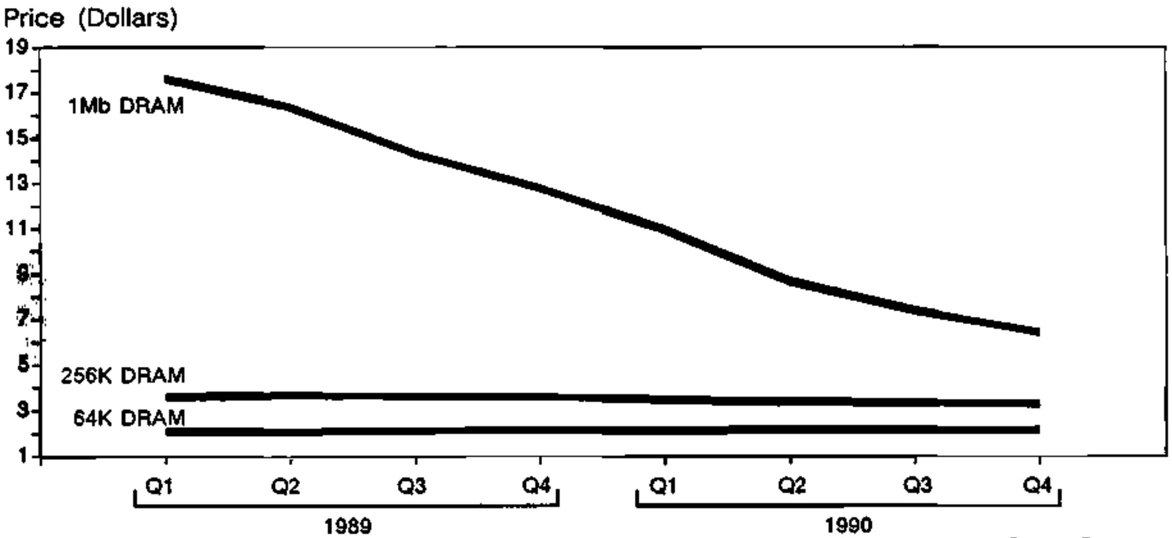
Events in the DRAM segment continue to set the stage for memory-price/lead-time trends. In fact, memory market pricing and supply developments have direct and indirect impacts on most semiconductor product trends.

Managing the Megabit DRAM Market

As reflected in Figure 2, North American users of the critical 1Mb DRAM can expect a year-long decline in price that will drop below $13 by the fourth quarter.

Figure 2

DRAM Price Trends
(North American Bookings)



0004271-2

Source: Dataquest June 1989

The price decline rate slowed because of the recently stated intention by first-tier suppliers of 1Mb DRAMs to manage this market by shifting production from this critical part to other semiconductor products should "one meg" DRAM profit margins narrow rapidly this year.

Dataquest recommends that 1Mb DRAM users take suppliers at their word on this issue as reflected in the current price forecast. Conversely, Dataquest believes that the managed market effort could boomerang on would-be market managers. For example, suppliers that cut their 1Mb DRAM supply might find themselves supplying a product such as 4Mb DRAMs far in advance of market demand. Currently, samples of 4Mb DRAMs are available at an ASP of $150 from an ever-growing supplier base.

Little Relief in the 256K Segment

As noted last quarter, North American and European users of 256K DRAMs can expect little immediate price or availability relief. Prices of 256K DRAMs rose during the first half of 1989 and should remain at the high level of nearly $3.80 for the rest of this year. Obtaining high-speed DRAMs (256K or 1Mb) continues to be a major procurement challenge.

Slow SRAM: A DRAM-Impacted Business

The supply and pricing of slow SRAMs remains a DRAM-driven function. Moving into the second half of 1989, users should see an increase in supply of slow 8Kx8 and 32Kx8 SRAMs. Pricing for the mature 64K devices should be stable at $3.72. Users can expect cost-curve price declines for the younger 256K part to start during the second half of this year, declining from the first quarter ASP of $9.75 to $8.62 by year-end 1989.

Fast SRAM

Fast SRAM trends are less affected by developments in the DRAM world than are slow SRAM trends. For users, this reality reinforces last quarter's fast SRAM price outlook: during 1989, 16K and 64K fast SRAM prices will decline as an expanding supplier base actively competes for users' sockets.

Nonvolatile Memory

The nonvolatile memory business (EPROMs, EEPROMs) should remain in overall supply-demand equilibrium. Pricing will be flat over the second half of this year for the mature 64K and 128K products. Users can expect somewhat uneven price declines for 256K, 512K, and 1Mb devices during the rest of 1989 as these devices move through the growth stage of the life cycle. Lead times hold steady at 6 to 16 weeks because of the relatively small size of this marketplace.

ASICs

Nearly all ASICs are declining in price this year (see Figure 3). The exception is the 3-micron gate array, an older product now being displaced from systems.

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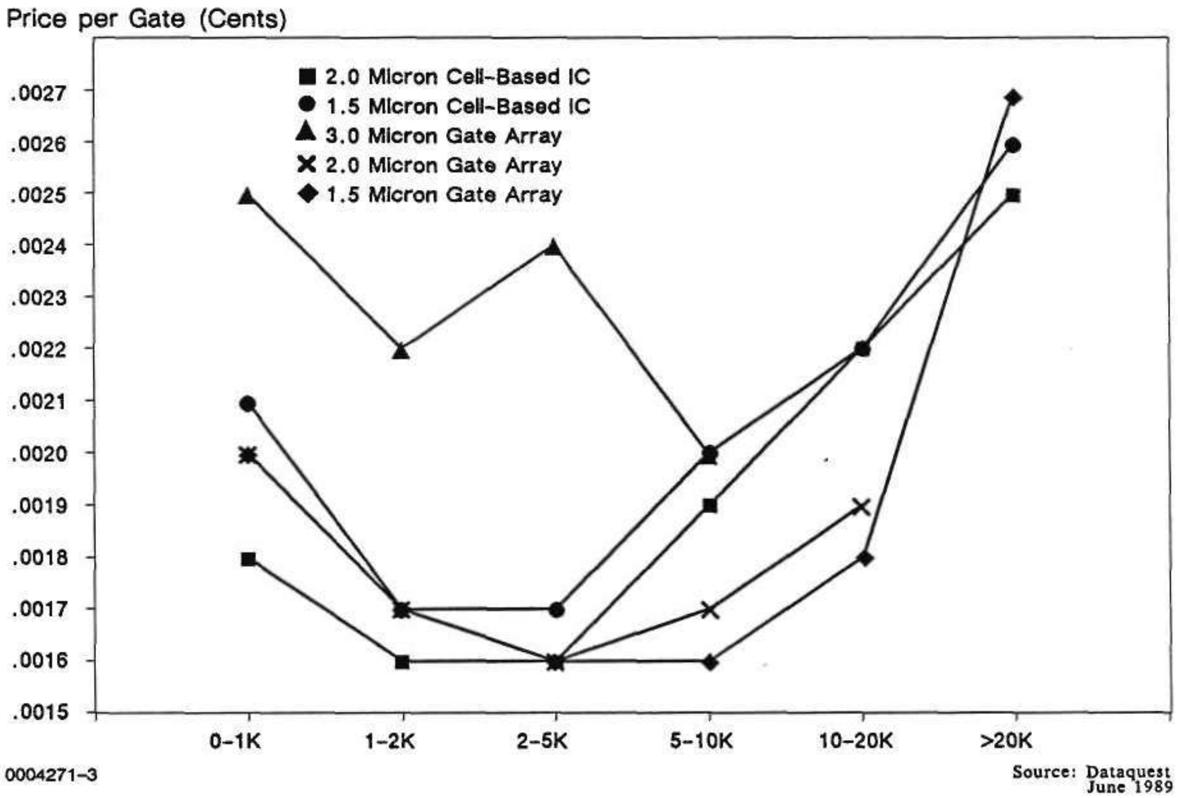
Figure 3

1989 ASIC Price Trends
(North American Bookings)



CMOS gate arrays are declining in terms of both price per gate and nonrecurring engineering (NRE) costs, with the trend now quite apparent in the 2.0-micron and 1.5-micron segments. A combination of gate array suppliers—first-tier companies, along with newer entrants—fully intend to aggressively compete against manufacturers on pricing of cell-based ICs and CMOS PLDs as part of the current intense war by ASIC companies for systems design-ins. On a long-term strategic basis, Dataquest still recommends that users take a close look at CBICs, versus gate arrays in terms of total system cost savings for systems being designed today for production during the 1991 to 1992 period.

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DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The year 1989 continues as a period of declining semiconductor prices and shorter lead times. Under these conditions, Dataquest recommends the following:

- Users of mature bipolar logic should make lifetime buys and use other procurement arrangements to ensure an adequate supply of parts for the full course of system life cycles, or they should design these devices out of systems.

- Users of commodity-type semiconductor products such as standard logic, 1Mbx1 DRAMs (100 to 120ns), 2.0- and 1.5-micron CMOS ASICs (10K gates or less), and mature 8- and 16-bit microprocessors should push for better pricing and shorter lead times on orders to be booked during the second half of 1989.

- Users of noncommodity DRAMs (e.g., high-speed devices of 80ns and below, x4 and x8 configurations, and ZIPs) should plan for erratic pricing patterns and spot shortages during the rest of this year.

- Dataquest again recommends that users give CBICs a close look, together with gate arrays, for systems being designed today for production in the post-1990 period.

Ronald A. Bohn

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Research Newsletter

SUIS Code: Newsletters 1989: July–September
1989–29
0004255

COST TRENDS—HIGH LEAD-COUNT PACKAGING

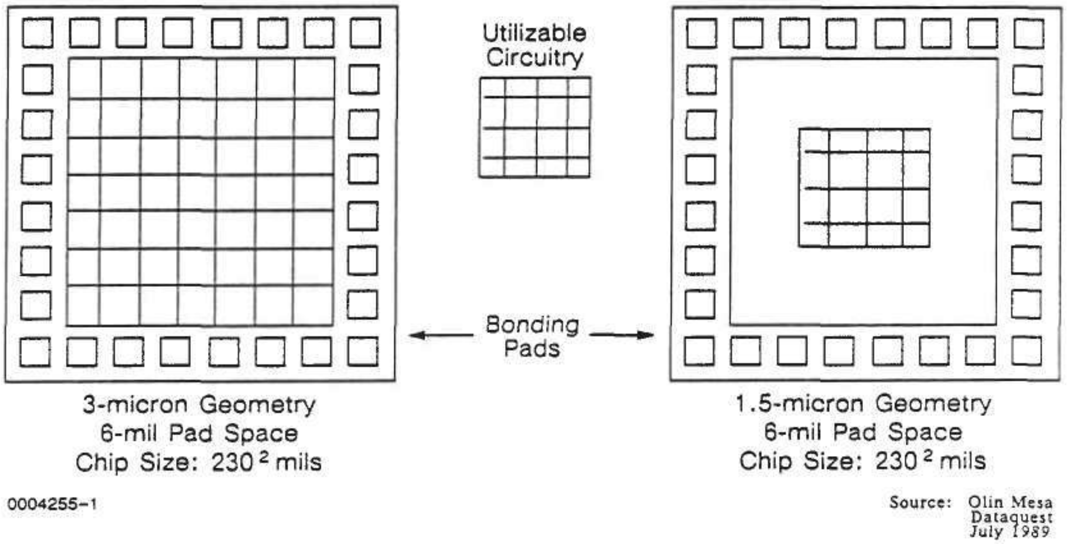
SUMMARY

As dice become more complex, their input and output (I/O) requirements increase. To minimize silicon costs and improve processing speed, feature sizes are being shrunk continually, to the point where traditional package assembly using wire bonding is no longer cost-effective. The dice become bond-pad limited as shown in Figure 1 (i.e., as geometries shrink, bonding pads limit the functionality of the chip because of the bond pad size that surrounds the circuitry). Tape-automated bonding (TAB) then becomes the preferred cost-efficient assembly technique.

This newsletter analyzes high I/O package assembly costs and how design component engineers need to work with procurement to decrease system assembly costs.

Figure 1

Example of Bond Pad Limitation
(132-Pin I/O Circuit)



0004255-1

Source: Olin Mesa
Dataquest
July 1989

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WIRE BONDING VERSUS TAB

Wire bonding is the most cost-effective package assembly technique when bond pad pitch (the distance between adjacent interconnect pads) is not limited by die size. It is the preferred assembly method up to approximately 132 leads, at which point the bond pad pitch begins to reach the practical limit of 5 mils. Above this, higher I/O requirements, combined with shrinking die size, make it difficult to wire bond and produce high-yield, high-quality parts. The limitations of wire bonding compared with die size in plastic packages are shown in Table 1.

Table 1

Wire Bond Limitations for Plastic Packages (6-mil Bond Pad Pitch)

Lead Count	Lead-Frame Die Pad Size (Square Inch)	Maximum Wire Length (Inch)	Minimum Die Size (Square Inch)
68	0.260	0.140	0.110
84	0.300	0.140	0.150
100	0.290	0.140	0.140
132	0.380	0.140	0.230

Source: Dataquest
July 1989

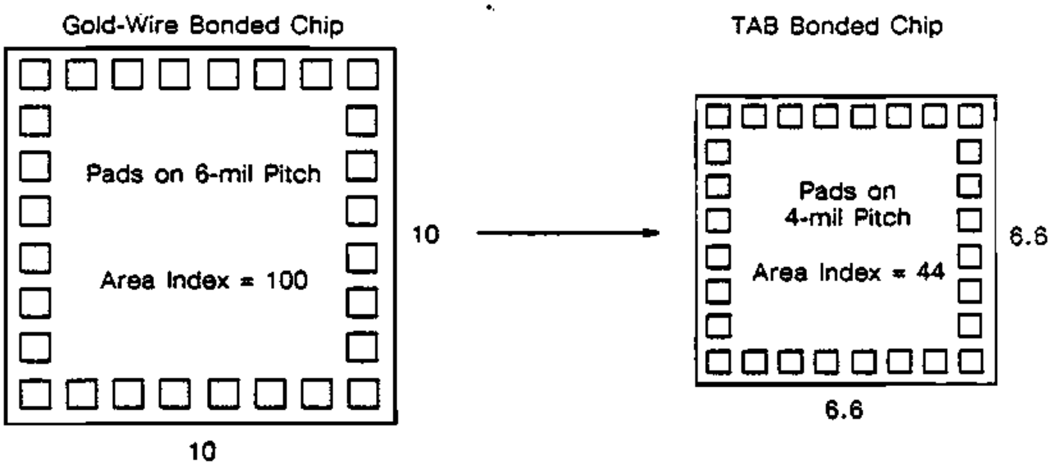
TAB, on the other hand, allows for the use of tighter tolerances and pitches. Paradoxically, the cost per lead decreases with TAB as lead counts increase. As the lead count rises above 132 leads, TAB offers even more cost advantages.

For the first step in cost savings, TAB allows the bond pad pitch to shrink from a typical 6 mils to 4 mils. For a 132-lead device, this doubles the number of gross dice per wafer, which halves the chip cost. This effect is illustrated in Figure 2.

The cost savings continue as lead counts increase. Table 2 compares silicon costs for bond-pad-limited integrated circuits at 132 and 300 leads, for both wire-bonded and TAB-assembled dice. Wafer fabrication costs of $500 and bumping costs of $100 per wafer are used for the analysis.

Figure 2

Silicon Chip Area Savings



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Source: Olin Mesa

Table 2

Silicon Cost for Bond-Pad-Limited Die

Lead Count	Pad Pitch (mil)	Bond	Die Size (Square Inch)	Gross Die per Wafer	Net Die per Wafer	Yielded Die Cost (Dollars)
132	6	Wire	0.230	509	254	$ 1.96
132	5	TAB	0.183	725	398	$ 1.50
132	4	TAB	0.150	1,104	662	$ 0.91
300	6	Wire	0.468	90	22	$22.22
300	5	TAB	0.393	132	39	$15.15
300	4	TAB	0.318	218	76	$ 7.86

Source: Olin Mesa
Dataquest
July 1989

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In the second cost-savings step, dice can then be assembled in a variety of packages, as follows:

- Ceramic pin grid arrays (CPGA)
- Plastic pin grid arrays (PPGA)
- Leaded or leadless ceramic chip carriers (LDCC or LCCC)
- Ceramic quad flat packs (CQFP)
- Plastic quad flat packs (PQFP)
- TAB-In-Package (ceramic or plastic)
- TAB-On-Board (TOB)

Assembly of the silicon in some of these packages shows that as little as 15 percent of the device cost is determined by the die cost, compared with 85 percent of the package cost (see Table 3). Table 3 also shows that the greatest cost savings results from eliminating the package. With a 132-lead device, TAB-On-Board (TOB) costs approximately $4.00, while a plastic quad flat package (PQFP) costs about $7.00 and a plastic PGA around $13.00. These costs include the dice, wafer bumping, inner-lead bonding, and encapsulation. Test, burn-in, board assembly, or board costs are not included.

Table 3

Silicon Cost versus Packaged Device Cost
(U.S. Assembly)

Lead Count	Package Type	Bond	Silicon Cost (Dollars)	Total Cost (Dollars)	Percent Silicon Cost
132	PQFP	Wire	$ 1.96	$ 7.01	28%
132	PPGA	Wire	$ 1.96	$12.87	15%
132	PQFP	TAB	$ 0.91	$ 7.01	13%
132	PPGA	TAB	$ 0.91	$12.68	7%
132	TAB/PCB	TAB	$ 0.91	$ 4.19	22%
300	CPGA	Wire	$22.22	$61.64	35%
300	CPGA	TAB	$15.15	$53.65	28%
300	TAB/PCB	TAB	$ 7.86	$21.26	37%

Source: Olin Mesa
Dataquest
July 1989

Analysis of these costs for the PPGA and TOB packages reflects cost benefits for TAB, as shown in Table 4:

Table 4

Cost Comparison
PPGA versus TOB

Cost	PPGA	TOB
Die Cost	10%	20%
Bumping Cost	-	4
Package Cost	50	1
Wire or Tape Cost	2	40
Bonding Cost	10	15
Overhead/Labor	28	20
Total	100%	100%

Source: Olin Mesa
Dataquest
July 1989

DATAQUEST CONCLUSIONS

Many packaging choices are available above 132 leads, both ceramic and plastic. TAB appears to be the least-expensive package assembly method, with TOB--die that are mounted directly on the PCB--being the lowest cost TAB option. As lead counts increase, packaging can represent more than 85 percent of the total device cost. As die feature sizes shrink, more high lead-count ICs become bond pad limited. Emphasis on reducing the costs of systems now must focus on the packaging area as well as on the silicon. Design, component, and process engineers must work together at the beginning of the project development cycle to optimize the system for cost and performance. Procurement managers must become involved early on to understand how package cost affects the total system.

Mark Giudici
Jim Walker

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October-December

The following is a list of the newsletters in this section:

- **October Procurement Pulse: Order Pickup + Inventory Control = Industry Optimism** (1989-46)—This month's *Procurement Pulse* discusses rising semiconductor orders, lead times, and inventory levels due to the industry's emerging optimism. Dataquest expects the semiconductor industry to bottom out for the first quarter of next year. If the industry turns around in the late first or early second quarter of next year, availability (or lack of it) and benefits of good supplier relations again will be issues that take top priority.
- **October Market Watch: A Worse Fourth Quarter but Positive Signs Emerge** (1989-47)—This month's *Market Watch* examines the inevitability of a bleak fourth quarter due to declining demands. Computer order and shipment growth continues to weaken, signaling continued poor demand.
- **The Bare Facts about Flash** (1989-48)—Flash technology, first announced by Toshiba in 1985, represented a $2.1 million market in 1988. Flash architecture is built around a single transistor cell with electrical programming and fast bulk/chip erase and is available in plastic and surface-mount packages. This newsletter compares the performance trade-offs of flash with other nonvolatile products, discusses price-per-bit comparisons with other MOS memory products, and looks at current potential applications for flash technology.
- **November Procurement Pulse: Market Optimism Spreads Although Orders and Inventories Shrink** (1989-49)—The semiconductor order seesaw dips once again. Although the outlook for the next six months continues to brighten, lead times are slightly higher, and inventory levels are down. Dataquest observes that overall semiconductor availability is good and dependable. Dataquest recommends that users and suppliers continue to foster close communications.
- **Semiconductor Price Survey: Prices Decline as Product Life Cycles Shift** (1989-50)—The downward trend in semiconductor prices continues during the third quarter of 1989, but major news did not focus solely on pricing. The *apparent* prospect of an early 1Mb-to-4Mb DRAM crossover during 1990; the life cycle shift in the 32-bit microprocessor segment from 16-MHz speed devices to 20- or 25-MHz products; and extended lead times for standard logic in surface-mount packages mark significant third quarter trends for semiconductor users.
- **Market Watch: More Positive Signs as the Year Winds Down** (1989-51)—This month's *Market Watch* focuses on the improved SIA book-to-bill ratio, improving computer demands, low inventories, and pricing. Dataquest concludes that the first quarter of 1990 will be stronger and the second half of the year will depend greatly on the U.S. economy's continuing health and the success of new computer products.
- **European Semiconductor Procurement Survey** (1989-53)—Dataquest periodically conducts procurement surveys of the leading semiconductor purchasing locations in Europe. The information is used to provide key industry indicators such as regional, product, and application forecasts and trends. This newsletter covers important procurement trends with difference market sectors and highlights major issues currently facing procurement executives and semiconductor marketing managers.

- **December Procurement Pulse: Order Rates, Inventories, Prices, and Market Outlook All Decline** (1990-54)—This month's *Procurement Pulse* discusses the downward slide of semiconductor order rates. Although order rates are declining, an inventory cushion of approximately one month ensures that steady, but possibly smaller, order levels will continue. Dataquest notes that closer user/supplier communication will make flexibility easier to cope with in meeting the customer's needs.
- **December Market Watch: The Market Exits the Year Gracefully Without a Stumble** (1989-55)—The optimistic signs that we have seen for the past two months are tempered somewhat by our most recent survey data, which forecasts a mixed short-term future. Mixed signals of book-to-bill ratios, computer demand stabilizing, and inventory levels and prices dropping all indicate that growth of the electronics market in the 1990 is still dependent on the overall health of the economy and the end user.

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Research *Bulletin*

DECEMBER MARKET WATCH: THE MARKET EXITS THE YEAR GRACEFULLY WITHOUT A STUMBLE

Market Watch is a monthly bulletin that is released after the SIA book-to-bill *Flash Report* and is designed to give a deeper insight into the monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

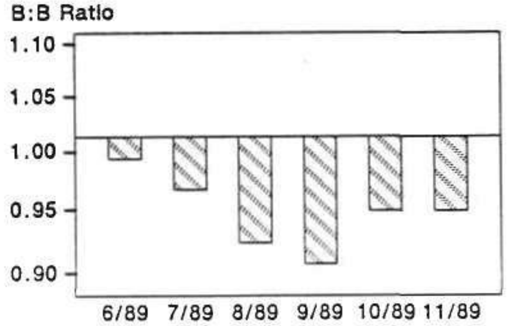


Figure 2
DOC Computer Demand

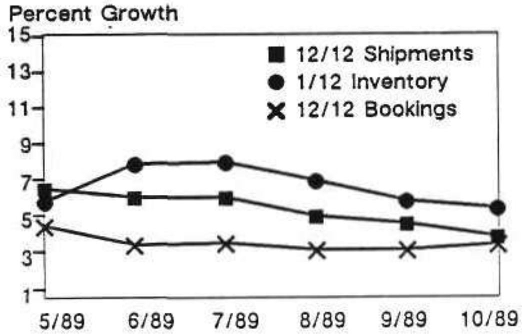


Figure 3
Semiconductor Inventory Level

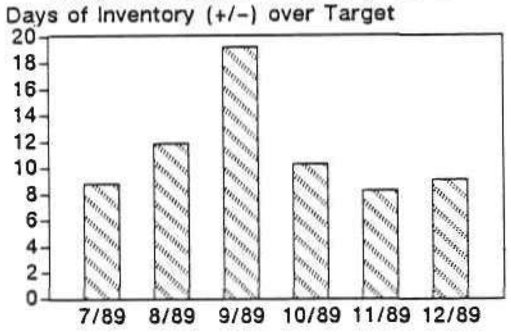
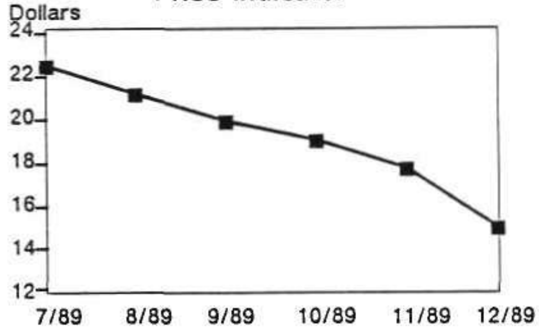


Figure 4
U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
December 1989

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BOOK-TO-BILL STABILIZES AT 0.93

The steady book-to-bill ratio confirms what we have been noting in the market for the past six months; steady demand and lower ASPs are combining to stabilize the market. Although November bookings are 1.8 percent off of October's average, this is a 2.2 percent increase over November 1988. As of this November, total *year-to-date (YTD) semiconductor billings are 12 percent above those of the same time period one year ago* in spite of the recent price erosion of MOS memory. Because of the ASP declines, Dataquest expects the book-to-bill ratio to remain below parity for the next few months, even with steady unit shipments.

COMPUTER DEMAND ALSO STABILIZES, WITH SHORT-TERM SIGNALS IMPROVING

Although the long-term trend lines show steady booking, shipment, and inventory activity in the computer market (see Figure 2), the short-term picture is brighter. *Both computer bookings and shipments have increased over last month's levels* as new computer offerings begin to grow in sales. The 3/12 booking rate-of-change indicator has risen for the second consecutive month (7.8 percent versus 6.4 percent). Continued growth in this index is a preview of the annualized growth rates shown in Figure 2. Computer industry competition remains fierce, however, with many companies expecting lower earnings in the near future. This situation of steady, slowly growing system sales tempered with strong competition is forcing cost controls on all aspects of the system business. Lower semiconductor inventories and price declines are integral parts of this cost-cutting environment.

INVENTORY LEVELS CONTINUE TO DROP—GOOD NEWS!

Although the gap between actual and targeted inventory levels appears to have widened, both targeted and actual levels declined according to our latest monthly procurement manager survey. The good news is that with actual inventory levels averaging 30.4 days, any end-market demand fluctuation will be readily picked up by component suppliers. Another good news item is that targeted inventory levels also have dropped, reflecting continued confidence in the ability of semiconductor suppliers to meet user needs. As mentioned earlier, the steady incremental pickup of computer business is being absorbed quickly by an abundant semiconductor market. While system demand continues to chug along, we expect semiconductor suppliers to receive constant feedback on user requirements in order to keep inventories under control.

PRICES SLIP FURTHER

Although system demand is constant, the supply of semiconductors continues to exceed current needs; this situation results in steady price declines. Most of the ASP erosion is in the DRAM, SRAM, and microprocessor markets, where demand has not kept pace with semiconductor capacity increases. *The current memory production cutback program by major suppliers will not be felt until late in January or early in February—if at all.* The only market perturbation may come in higher spot market prices, leaving contract pricing untouched and short lead times intact.

DATAQUEST CONCLUSIONS

The optimistic signs that we have seen for the past two months are tempered somewhat by our most recent survey data forecasting a mixed short-term future. What is evident is that the semiconductor and end-use electronics industries are more in lockstep with each other now than at any time in the past five years. Although currently not a boom period by any means, we believe that buyers will react quickly to any increase in system demand because inventories currently are so low and any incremental business will require new orders.

Dataquest continues to see signs that the first quarter of 1990 will be stronger than this quarter in terms of semiconductor shipments. Nevertheless, continued stability and growth of the electronics market in 1990 is still dependent upon the overall health of the economy and of the end user—both of which are sending mixed signals.

Mark Giudici
Victor G. de Dios

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Research *Bulletin*

DECEMBER PROCUREMENT PULSE: ORDER RATES, INVENTORIES, PRICES, AND MARKET OUTLOOK ALL DECLINE

The *Procurement Pulse* is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

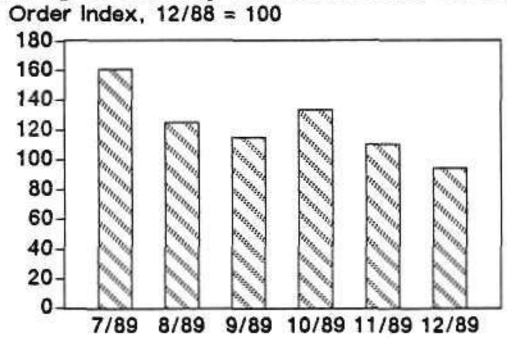


Figure 2
Averaged Semiconductor Lead Times

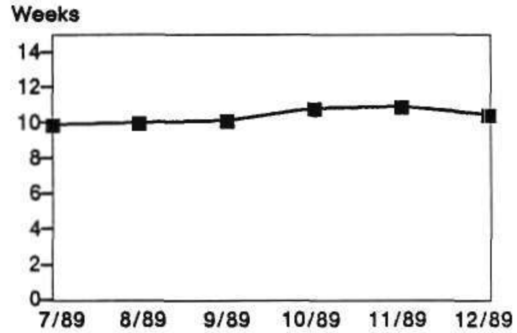


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

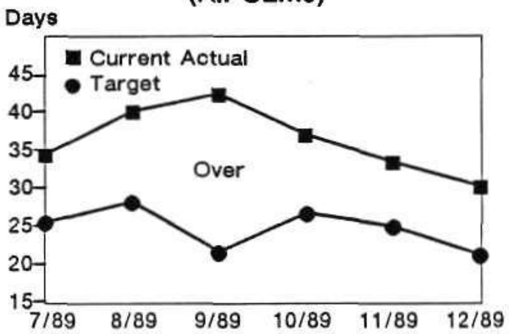
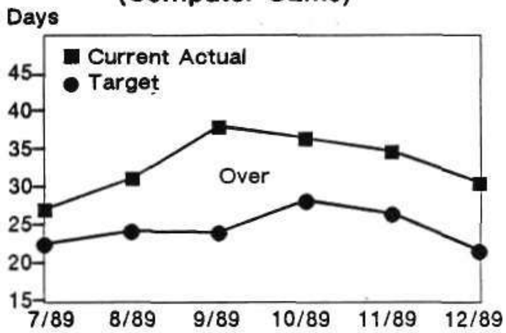


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



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December 1989

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THE SEMICONDUCTOR ORDER RATE SEESAW TURNS INTO A DOWNWARD SLIDE

The respondents to this month's survey *expect to order 32.4 percent fewer semiconductors in December* compared with November, as shown in Figure 1. Continued emphasis on cost controls and end-of-year financial housekeeping combined with the benefits of readily available components have *reduced order levels below those of a year ago* (12/88) for the first time this year. Compared with last month's optimistic outlook, this month's responses to the next six months of system sales ranges from a negative 20 percent to a high of 20 percent with a mean of 4 percent. It is important to note that only 18 percent of those surveyed expect to see negative growth; this decline would be primarily in the defense industry. As mentioned in earlier bulletins, components availability allows users to cut order rates and still supply their production lines with sufficient material while simultaneously reducing inventory costs.

LEAD TIMES DIP BUT STILL HIGHER THAN EXPECTED

Lead times took an effective two-day decline over last month's levels, coming in at 10.6 weeks as seen in Figure 2. The cumulative effects of long-term contracts and spot allocations of specific surface-mount logic devices have effectively countered the abundance of memory and other commodity logic devices. Standard logic (DIP) and standard speed (100 to 120ns) DRAM lead times still average four to eight weeks and will remain low for the next few months as demand appears to decline.

MIRRORING ORDERS, BOTH TARGET AND ACTUAL INVENTORY LEVELS DROP

Figures 3 and 4 reflect how inventory control measures have become ingrained so that inventory levels match order rates. Interestingly, for the first time, the computer and overall OEM inventory levels are within a half-day difference of each other (overall OEM target/actual equals 21.3/30.4 days and computer OEMs target/actual equals 21.8/30.7 days, respectively). Because of the abundance of DRAMs, the inventory target versus actual situation without DRAMs is within one day of the total inventory levels. Overall OEMs target/actual without DRAMs is 19.9/29.8 days and computer OEMs target/actual without DRAMs is 20.0/30.0 days, respectively). Although order rates are declining, an inventory pad of approximately one month ensures that steady, but possibly smaller, order levels will continue.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

Dataquest predicts that the trend of lower order rates and inventory levels will continue. Although the outlook for the next six months is not expected to be extraordinary, steady growth is expected and should be complemented by readily accessible ICs. In the current buyers' market, strategic procurement planners must continue to focus on long-term supplier relationships. At this time, production cutbacks of Japanese DRAMs are not being felt because of high supplier inventories that are being run down. A possible spot market increase in DRAM prices may occur by February because of the production controls now implemented. Contract buyers will not experience any perturbation and will continue to see good availability through the first half of 1990. Dataquest notes that the ability to remain flexible to customer needs is what differentiates suppliers in the current market, and close user-supplier communications make flexibility easier to cope with.

Mark Giudici
Victor de Dios

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Research *Newsletter*

EUROPEAN SEMICONDUCTOR PROCUREMENT SURVEY

SUMMARY

Dataquest periodically conducts procurement surveys of the leading semiconductor purchasing locations in Europe. The information from these surveys is then analyzed to provide key industry indicators such as regional, product, and application forecasts and trends. This newsletter covers a number of important procurement trends within different market sectors and highlights major issues currently facing procurement executives and semiconductor marketing managers. Table 1 summarizes the results obtained in Dataquest's most recent survey.

THE MARKET SEGMENTS

Data Processing Segment

When asked to specify, in local currency terms, the percentage of increase in their semiconductor purchases from 1988 to 1989, the majority of respondents indicated a range between 25 and 60 percent. For 1989 to 1990, the growth expectation varies from 0 to 5 percent. The decline in growth rate stems first from a decline in the average selling price of MOS memory products and second from an increase in inventory levels within the PC sector. Most of the large users, especially those concentrating on PC production, indicated that their actual inventory levels were five to six weeks higher than their targeted inventory levels. The major culprit causing this excess inventory level is memory, which represents more than 50 percent of these companies' semiconductor purchases in dollar terms. No new large orders have been placed for DRAMs over the last few months, and our analysis indicates that many buyers are hedging for the best prices before they place more DRAM orders. Very little double ordering is occurring because most buyers are not rescheduling their delivery dates. The market for PCs grew by more

TABLE 1
European Procurement Survey Key Results

Segment	Target Inventory Levels	Semiconductor Spending 1989-1988	Semiconductor Spending 1990-1989	Key Concerns
Data Processing	5-6 weeks over	+25%-60%	0%-5%	Memory inventories and prices
Communications	2 weeks over	+10%-15%	5%-10%	Increased complexity of ASICs memory prices
Transportation	2-3 weeks under	+5%-10%	+10%	Discrete, opto
Industrial	3 weeks over	5%-10%	Flat	On-time delivery, distribution shakeup
Military	OK	20%	5%	Reduction of military memory suppliers
Consumer	High	10%	Negative	Slowdown in consumer spending

Source: Dataquest
December 1989

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than 50 percent in the first half of 1989. The inventory build-up is due to suppliers catching up on long-term agreed contract delivery dates and prices. We expect inventories to be used up by the fourth quarter of 1989.

One sign of major concern facing this sector is that most Japanese vendors are cutting back on 1Mb DRAM capacity in favor of 256K SRAMs and 4Mb DRAMs. This situation could cause some hiccups in supply of 1Mb DRAMs, especially when 4Mb DRAMs become widely available in 1990.

Communications Segment

The major central office equipment manufacturers indicated a growth of 10 to 15 percent in semiconductor purchases in 1989 over 1988. However, this growth is expected to decline to 5 to 10 percent in 1990. This segment is also a very large user of ASIC devices. Dataquest believes that full-custom ASICs will still dominate over standard cell and gate array devices in terms of purchasing dollars spent in 1990.

The next biggest expenditure should be for memories, followed by microcontrollers. Inventory levels in these products are two weeks over targeted levels and are expected to remain the same in the near future. The datacommunication sector showed some signs of weakness, with some buyers indicating very little growth in 1989 over 1988 and a minimal increase of 5 percent in 1990.

Issues that caused procurement managers in the telecommunications sector most concern were pricing, on-time delivery, and quality of incoming goods—ranked in that order.

Transportation Segment

Most survey respondents indicated that they are two to three weeks below their targeted inventory levels of three to four weeks holdings. The majority of them participate in just-in-time programs with their key vendors. Comparatively speaking, they spend a large portion of their purchasing dollars on discrete and optoelectronics products, followed by linear devices and microcontrollers. Exceptionally, most buyers indicated that they were budgeting for a 10 percent growth in 1990 in contrast to other segments that indicated a gradual slowdown in semiconductor purchase dollars. This growth is being driven specifically by the greater use of electronic systems and components in the mass market range of automobiles.

Major issues ranked by transportation buyers were on-time delivery, pricing, quality, and accurate forecasting of demand. Interestingly, a number of buyers intimated that they relied upon making up to 5 percent of their purchases via distributors in order to make up for shortfalls in delivered quantities from major vendors.

Industrial Segment

As in the transportation segment, discrete and optoelectronic devices enjoy a relatively high proportion of the total semiconductor expenditure in the industrial segment. These devices make up more than 50 percent of the purchased devices in dollars, followed by linear, memory, and standard logic. Most respondents indicated that between 20 and 35 percent of their purchases were via franchised distributors. Despite this fact, most of the microcontrollers and ASICs are purchased directly from semiconductor vendors.

Inventory levels in this segment are three weeks over targeted levels. Overall, industrial segment buyers anticipate that their 1990 spending will be flat compared with 1989 despite buoyant market conditions in the test, instrumentation, and medical markets.

Military Segment

Most military buyers indicated a slowdown in their purchasing power in 1990, with some stating a positive 20 percent growth in 1989 over 1988. Inventory levels do not seem to be a major problem because of the availability of standard parts from distributor shelves and the long lead times required for some military parts.

Major concerns are the shrinking base of military high-density memory suppliers and the switch from bipolar to CMOS devices. A large percentage of dollars is spent on memory products, followed by ASICs, linear, microcomponents, and standard logic. A number of respondents intimated that a high proportion of their memory spending is taken up by specialized hybrid configurations. Among their ASIC expenditures, 80 percent were in the PLD segment, with standard cells becoming more popular.

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Consumer Segment

Within the consumer segment, procurement executives indicated concern about the overall economic situation. Most economists are forecasting a reduction in GNP during the first half of 1990. In the United Kingdom in particular, high interest rates have affected the amount of disposable income in circulation, leading to a reduction in order intake. Inventory levels at present are high, and total spending in 1990 could be reduced by up to 10 percent over 1989. Key concerns in this sector were just-in-time, quality, and pricing.

DATAQUEST CONCLUSIONS

Dataquest's overall analysis shows that it will take time for excess inventory to be used up, resulting in slow growth in 1990. We believe that the brightest sectors will be transportation, telecommunications, and industrial; the data processing, military, and consumer segments will show some decline.

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Bipin Parmar

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Research Bulletin

MARKET WATCH: MORE POSITIVE SIGNS AS THE YEAR WINDS DOWN

Market Watch is a monthly bulletin that is released after the SIA book-to-bill *Flash Report* and is designed to give a deeper insight into the monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

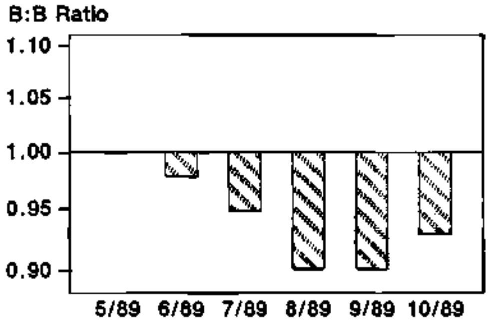


Figure 2
DOC Computer Demand

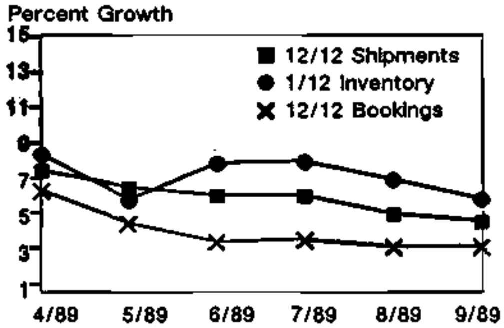


Figure 3
Semiconductor Inventory Level

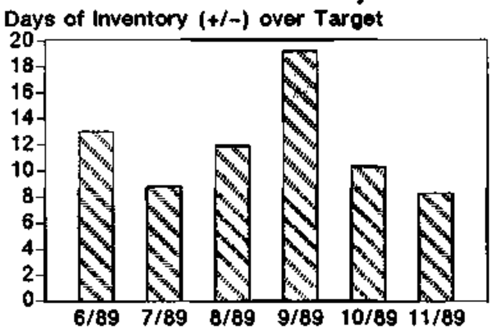
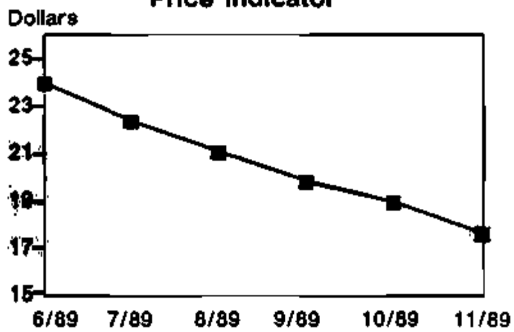


Figure 4
U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
November 1989

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BOOK-TO-BILL BOUNCES BACK TO 0.93

For the first time in at least six months, the SIA book-to-bill ratio improved to 0.93 in October from 0.90 in September. Shipments fell 10 percent from September, which is slightly better than the 11-year average 12.5 percent decline in October revenue. What is encouraging is that orders grew well despite the ongoing rapid descent of MOS memory prices; this growth implies strength in other product areas.

Important questions beg for answers: What is causing these market developments? Will this pickup be sustained?

COMPUTER DEMAND IMPROVING

Part of the change is driven by end-use demand. Computer orders, the premier leading indicators of the semiconductor industry, have stopped declining in growth. Computer shipments now are pacing orders in growth, suggesting a more stable demand for semiconductors. *But what is most significant is that the computer book-to-bill ratio achieved parity in September.*

New computer introductions contribute heavily to the improvement in computer orders. Many of these machines were announced even prior to Comdex. Computer manufacturers inevitably will spur more semiconductor demand as they build these new products to fill their distribution channels, but new products do not necessarily mean increased revenue. How well and how quickly these new products are accepted in the market will determine how long the improvement in semiconductor demand will be sustained.

These new products also have raised buyer optimism, measured in terms of system sales outlook for the next six months, as well as increasing target inventory levels. Details are in the November *Procurement Pulse*.

LOW INVENTORY HELPS SEMICONDUCTOR INDUSTRY

Since April, we have described the slowdown as being less severe because inventory levels will be kept low. The benefits of that now are becoming apparent. The semiconductor industry will reflect improvements in the computer market with very brief lags because of dropping inventory levels of computer manufacturers.

Our surveys show that the gap between actual and target semiconductor inventory levels in user shelves has dropped even more—to about 8 days in November—which is characteristic as the year winds down. With inventory levels lower and orders increasing at the end of 1989, the first quarter of 1990 should show an improvement over this quarter.

PRICES CONTINUE TO SLIDE

So far, prices have not reflected the mild market improvements. Prices dropped another 7 percent in November, primarily because of continued dips in DRAM and 16-bit microprocessor prices. MOS memory prices have declined by 7 percent since October, while microprocessor prices on the whole fell by 8 percent.

DATAQUEST CONCLUSIONS

Last month, Dataquest glimpsed some positive signs, but we suggested waiting until the results of November and December supported the trend. So far, November has reinforced that trend and has added more optimism to the industry with improvements in computer orders, semiconductor orders, and inventory levels.

Dataquest believes that the first quarter of 1990 will be stronger than this quarter in terms of semiconductor shipments, but the forecast strength of the second quarter and the second half of the year will depend greatly on the U.S. economy's continuing health and the success of new computer products in the resale market.

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Research Newsletter

SEMICONDUCTOR PRICE SURVEY: PRICES DECLINE AS PRODUCT LIFE CYCLES SHIFT

SUMMARY

As shown in Table 1, the downward trend in semiconductor prices continued during the third quarter of 1989, but major news did not focus solely on pricing. Extended lead times for standard logic in surface-mount packages, the *apparent* prospect of an early 1Mb-to-4Mb DRAM crossover next year, and the life cycle shift in the 32-bit microprocessor segment from 16-MHz devices to 20-MHz or 25-MHz products mark significant third quarter trends.

STANDARD LOGIC TRENDS

Extended Lead Times for Surface-Mount Packages

As stated last quarter, supplies of standard logic products continue to exceed demand but now with a major exception. Because of poor demand/supply forecasting on the part of both users and suppliers, suppliers on the whole have not been able to meet a second-half 1989 move by several major users toward surface-mount devices. Users of this product face extended lead times of four to six weeks over the lead times for the dual in-line package (DIP).

Dataquest views the supply constraint as that of a limited supply of surface-mount packages and *not* as a limited supply of standard logic die. Dataquest expects the demand imbalance to improve during early 1990, perhaps by the first quarter, should suppliers quickly shift capacity to surface-mount packages. Suppliers have been reluctant, however, to add capacity because of negative 1990 market prospects, so the supply constraint could persist till the third quarter of next year.

TABLE 1
Semiconductor Pricing and Lead Time Trends (North American Bookings)

	Pricing Trend		Lead Times	
Part	3rd Quarter	Forecast	Current	Trend
74HC	0-8.0% down	1.2%-3.0% down	4-10 weeks	Steady
	Add 3%-10% for surface mount		Add 4-6 weeks for surface mount	
74AC	0.8%-3.2% down	0.8%-5.8% down	8-10 weeks	Steady
	Add 5%-10% for surface mount		Add 4-6 weeks for surface mount	
32-bit MPUs	2.3%-14.9% down	2.0%-10.3% down	5-10 weeks	Steady
1Mx1 DRAM 100ns, DIP/SOJ	22.9% down	19.2% down	8-16 weeks	Steady
4Mx1 DRAM 100ns, DIP	36.4% down	40.3% down	8-20 weeks	1-2 weeks shorter

Source: Dataquest
November 1989

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Downward Trend in Standard Logic Pricing

As shown in Figure 1 and Table 1, users can expect continued downward pressure on standard logic pricing. The downward trend in pricing for standard logic cuts across all product families; however, as shown in Table 1, users of surface-mount devices can expect to pay a premium of 3 to 10 percent over DIP prices. Lead times for products in DIP should be steady.

Users Shift to Advanced CMOS (AC) Family

Based on client inquiries and inputs, some users are shifting to the AC family of standard logic from the HC or other families. Several major suppliers of AC devices are ramping up production, so users can look to steady price declines for this product during the fourth quarter of 1989 and next year, as shown in Table 1 and Figure 1.

MICROPROCESSOR TRENDS

In the microprocessor (MPU) marketplace, general lead times now range from 4 to 10 weeks. Lead times should remain steady (see Table 1).

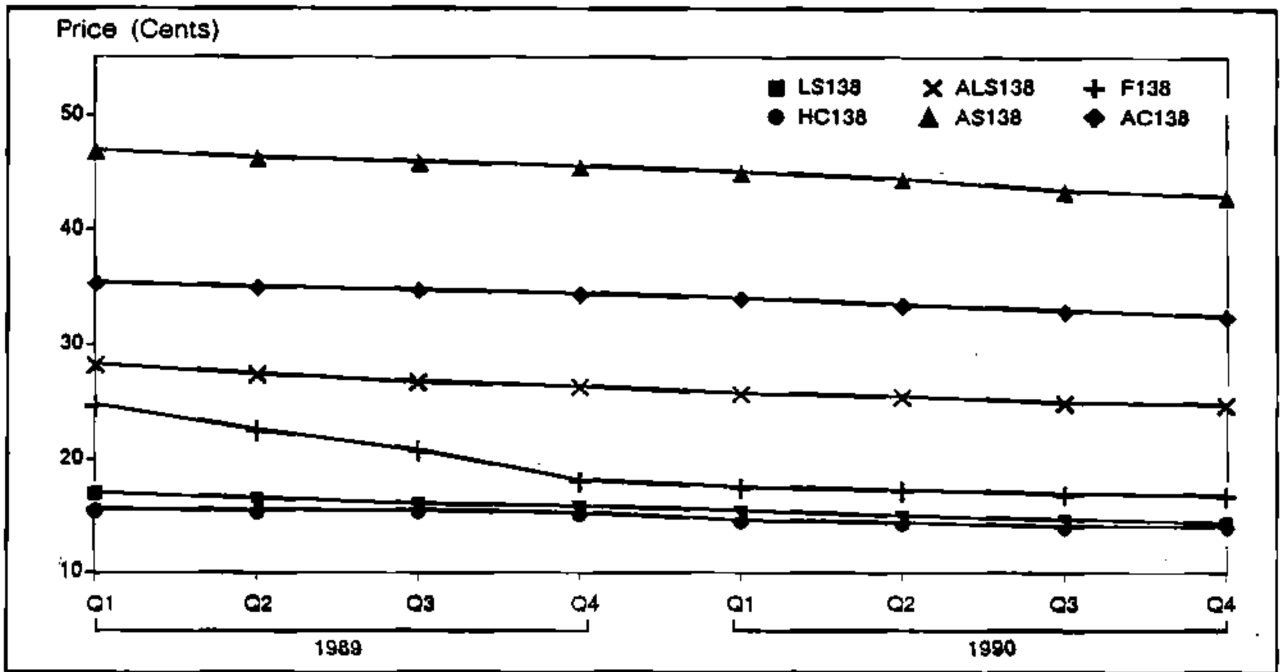
High-Speed 80286s versus the 80386SX

Users can expect suppliers of higher-speed 80286 microprocessors (12 MHz and faster) to continue a fierce pricing battle against Intel's 80386SX products. For example, Dataquest anticipates that the average selling price (ASP) for the 16-MHz 80386SX products should decline by 10.3 percent in fourth quarter 1989 and drop to an ASP of $62.55. By contrast, pricing for the 12-MHz 80286 products should decline by 10.5 percent during the fourth quarter and fall to $19.26.

The Changing Stages of 32-Bit Microprocessor Life Cycles

The second half of 1989 represents a general change in the life cycle stage for 32-bit microprocessors that operate at 16 MHz, 20 MHz, and 25 MHz. For example, the 16-MHz 80386—which currently is a sole-sourced product—is at the decline stage. Pricing for this device should stabilize during 1990 as supplier support shifts from this product to the 20- or 25-MHz 80386. Pricing for the 16-MHz 68020—which Dataquest expects to erode by

FIGURE 1
Standard Logic Price Trends (North American Bookings)



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5.4 percent during the fourth quarter of 1989 to an ASP of $87—should be relatively flat next year. In contrast, pricing for the 25-MHz 68020—which Dataquest expects to erode by 5.4 percent during the fourth quarter also to an ASP of $154—should decline 4.0 percent per quarter next year as this product moves through the growth stage of its life cycle.

A Wild Card in the 80386 Supplier Base?

Recently, AMD publicly revealed its effort to manufacture the 80386 family of products, either through arbitration with Intel or by reverse engineering. Intel promised to protect its property interest carefully to the full extent of the law. If AMD achieves its objective, the life cycle of the 80386 family (perhaps including that of the 16-MHz version) would be extended. A more aggressive 1990 pricing scenario thus would be likely.

The 80486 Delay

Preliminary reports indicate that the error in the floating-point element of this state-of-the-art product should be easily corrected. First reports also indicate a slight delay of several weeks in shipments.

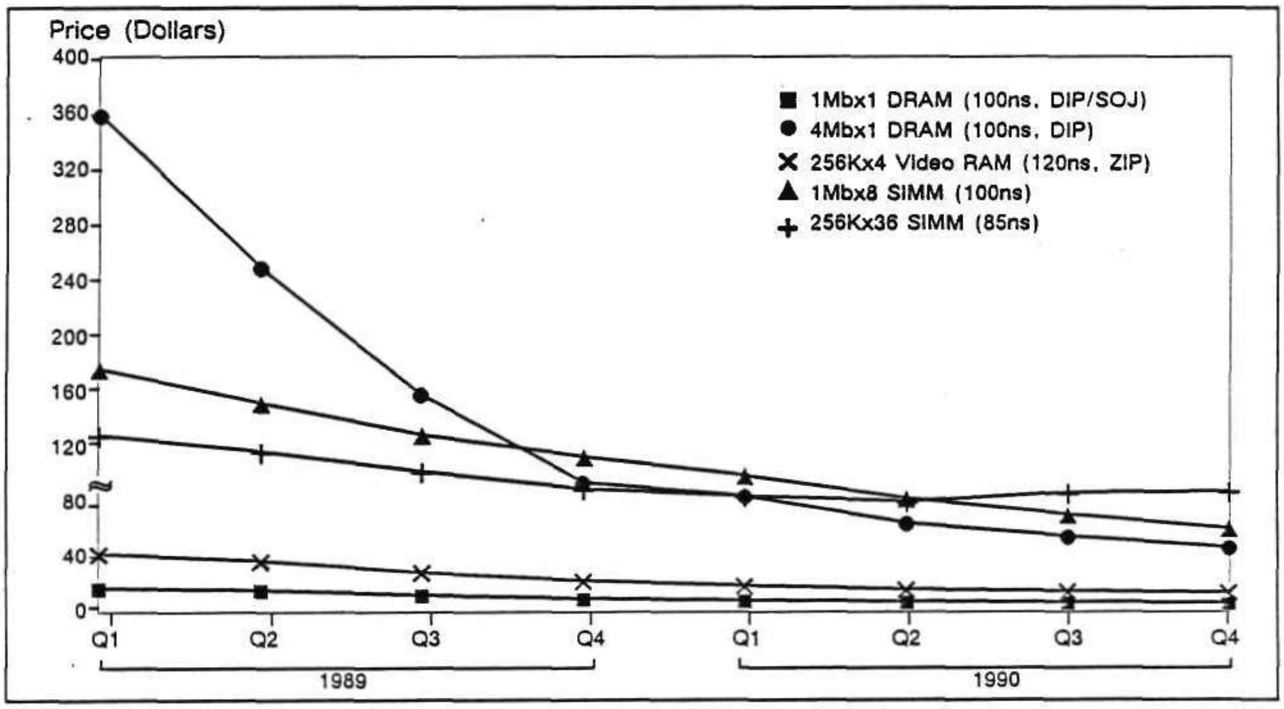
MEMORY TRENDS

Dramatic events in the DRAM segment continue to set the stage for many semiconductor product trends. A major second-half 1989 event in this business has been a recent plunge in pricing for 4Mbx1 DRAMs and 1Mb DRAMs.

Any Management of the Megabit DRAM Market?

Once again, the megabit DRAM business proves difficult to manage for both suppliers and users. As reflected in Figure 2 and Table 1, North American users of 1Mbx1 DRAMs can expect a sharp decline in price during the second half of 1989 that should drop the ASP to $10.10 *or less* by the fourth quarter. During the first quarter of 1989, Dataquest forecast that the fourth quarter ASP for this device would be $10.10. The results of Dataquest's pricing survey reveal several tiers of anticipated 1Mb DRAM pricing—bands running from

FIGURE 2
DRAM Price Trends (North American Bookings)



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Source: Dataquest
November 1989

$8.00-$10.00, $10.00-$11.00, and $11.00-12.00—behind this forecast 1Mb DRAM price of $10.10 for the fourth quarter.

An Early Crossover from 1Mb DRAMs to 4Mb DRAMs?

A major factor stimulating the downward surge in 1Mb DRAM pricing has been the effort by a small group of 4Mbx1 DRAM suppliers to win early design-ins for this next-generation product. As expected, pricing for this product declined by 36.4 percent during the third quarter to a price of $159. The rate of decline for the 4Mb DRAM recently accelerated in North America (see Figure 2 and Table 1), so Dataquest has revised its original pricing estimate for the fourth quarter of 1989 *downward*—from $100 to $95.

Many SUIS clients have expressed a mixture of glee and concern regarding the prospect of an early (i.e., pre-1991) crossover to the 4Mb device. Dataquest has been conservative in making its 1990 4Mb DRAM (as well as 1Mb DRAM) price forecasts in order to avoid giving any false signal of a second-half 1990 price crossover. If *each* of the five to seven prospective suppliers of 4Mb DRAMs can achieve *each* of its 1990 production, yield, pricing, and market goals, *some* major users of DRAMs might make the crossover by late 1990 at the earliest. Most will not, even under these most optimistic of circumstances. If *any* of the prospective suppliers of 4Mb DRAMs fail to meet their 1990 objectives—and Dataquest believes this scenario to be the most likely case—the possibility of a 1Mb-to-4Mb DRAM price crossover next year will become nil.

Slow SRAMs: Pricing Eases and Lead Times Shorten

For users, the current ample supply of DRAMs translates into increased capacity for production of slow SRAMs. As forecast last quarter, users saw a growing supply of slow SRAMs (i.e., 8Kx8, 120 to 150ns; 32Kx8, 100ns) during the third quarter. Users can expect the same pattern during the fourth quarter of 1989. For example, lead times for the 64K devices narrowed during the third quarter to a range of 8 to 18 weeks. Lead times should shorten by one to two weeks during the fourth quarter. Pricing for 8Kx8 devices has eased and should decline nearly 3 percent during the fourth quarter to a price of $3.64. Pricing for 32Kx8 slow SRAMs continues to move downward as expected. The ASP for this device is expected to drop from a third quarter price of $9.02 to a fourth quarter price of $8.67, a quarterly decline of 3.8 percent. Lead times now range from 10 to 20 weeks—they improved dramatically during the third quarter for most users. Lead times should shorten by two weeks or more by the fourth quarter.

Fast SRAMs: Pricing Declines as Supply Base Expands

Users of fast SRAMs can look forward to continuing declines in pricing. Most suppliers of semiconductor memory eye the potentially lucrative fast SRAM business as a global business opportunity—which means new entrants and increased competition—while current suppliers respond to user demand and market shifts through a combination of product price cuts and new product introductions. Lead times should remain steady in the range of 7 to 12 weeks.

Downward Trend in 16K, 64K Fast SRAM Pricing

The downward trend in pricing for 16K and 64K SRAMs (25ns, 35ns) should continue steadily as these devices move through the growth stage of their life cycles. During the fourth quarter, Dataquest expects pricing for devices that operate at 35ns to decline at quarterly rates ranging from 1.7 percent (4Kx4, 35ns) to 11.7 percent (16Kx4, 35ns). Pricing for devices that operate at 25ns are expected to decline at similar rates that range from 2.5 percent (2Kx8, 25ns) to 9.5 percent (64Kx1, 25ns).

The Ramp-Up in Production of 256K Fast SRAMs

Users of 256K fast SRAMs can anticipate sharp declines in pricing for these devices during the fourth quarter of 1989, as well as throughout 1990. Dataquest expects the price of 64Kx4, 25ns products to drop from $30.00 during the third quarter of 1989 to $25.00 during the fourth quarter. By the fourth quarter of 1990, the price for this part should fall to $16.00. Pricing for the 32Kx8, 35ns products should move in a similar style as production ramps up during the next several quarters: a

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decline from a third quarter 1989 price of $26.05 to a fourth quarter price of $23.00, and then to a price of $15.18 during the fourth quarter of 1990.

Nonvolatile Memory

The nonvolatile memory business (i.e., ROMs, EPROMs, EEPROMs) has been affected during the second half of 1989 by a pattern of increased supplier competition in the face of somewhat weaker demand conditions.

Movement in the EPROM Market

For example, pricing for EPROMs in densities of 256K and greater tumbled unexpectedly during the third quarter as supplier competition increased. Lead times shortened and now typically range from 4 to 12 weeks. Lead times for 256K EPROMs are somewhat shorter—a range of 4 to 8 weeks—because of a wider supply base, while lead times for 128K products are slightly longer—8 to 12 weeks—because of a narrower supply line. Users can expect further reductions in lead times during the fourth quarter.

Relief for Users of High-Speed ROMs?

Pricing for ROMs held steady during the third quarter (except for 4Mb-density parts) and should continue to do so during the fourth quarter. Lead times for ROMs continue to range from 6 to 16 weeks for products with densities of less than 1Mb and 10 to 16 weeks for those with densities of 1Mb and above.

Users of high-speed devices that operate at less than 200ns might find relief in the near future. At least one North American supplier—IMP—has clearly marked this segment as vital to its short- and long-term strategic objectives. Based on inquiries to Dataquest, other suppliers also are examining opportunities in this business.

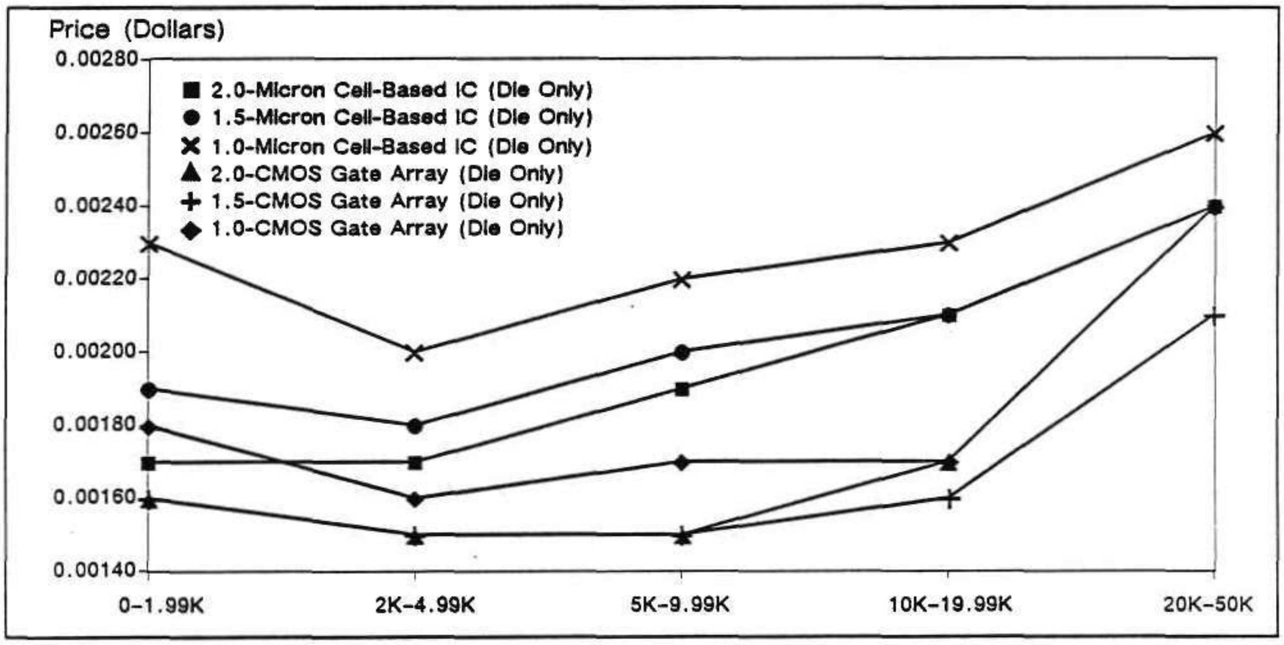
ASICs

As noted in prior forecasts, the ASIC supplier base remains a competitive arena. A comparison of Figures 3 and 4 shows that ASICs should decline in price from the level of 1989 during 1990. No clear signs have been discerned of any market impact from the decision by the U.S. Department of Commerce and Japanese Ministry of International Trade and Industry (MITI) to monitor ASIC pricing through the fair market value (FMV) system.

Supplier-by-Supplier Pricing Differentials

As in the DRAM marketplace, where Dataquest's pricing survey discloses several tiers of 1Mb DRAM pricing, the ASIC pricing survey also

FIGURE 3
1989 ASIC Price Trends (North American Bookings)



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reveals a wide range of prices. Dataquest restates its forecast of a continued overall decline in gate array, cell-based IC, and PLD pricing, but we advise buyers that a range of technical factors such as packaging, testability, and application can make supplier-by-supplier pricing comparisons a challenging task. Another factor that complicates users' straightforward analysis of ASIC price trends is a recent trend in which some suppliers are building a worldwide network of fabs for manufacturing wafers for memory and ASIC products *along with* a "local customizing" capability.

The Testability Challenge

Among ASIC technical issues that are affecting pricing, Dataquest views the prospect of inadequate testing tools as a potential threat to the anticipated long-term migration of some users to gate arrays and CBICs of gate counts of 40,000 gates and above. Inadequate testing means increased user risk and, consequently, reduced demand. The testability issue could affect the post-1989 supply/demand/pricing scenario in the higher-density segment of the ASIC marketplace.

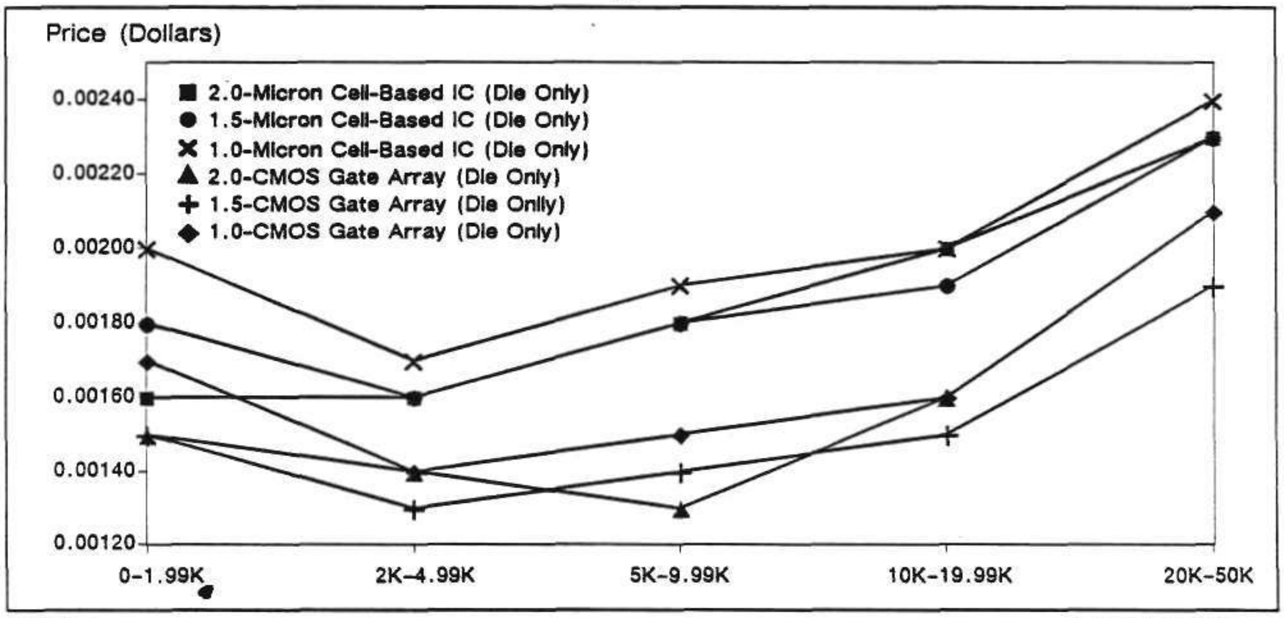
DATAQUEST CONCLUSIONS AND RECOMMENDATIONS

The fourth quarter of 1989 should be a period of declining semiconductor prices and relatively steady lead times. Market conditions have weakened in North America as the year 1990 approaches. Under these conditions, Dataquest recommends the following:

- Dataquest reinforces earlier recommendations that system manufacturers actively negotiate for better 1Mbx1 DRAM prices and advises buyers to carefully analyze *all* risks before making an early jump to the 4Mbx1 products.
- Users of standard logic should make 1990 contracts on the basis of aggressive pricing terms for newer CMOS products such as the AC and FAST families, but on less aggressive terms—given the prospect of sudden 1990 contraction in the supplier base—regarding older bipolar and CMOS families. Users of surface-mount devices must plan for extended lead times and premium pricing patterns during the next two quarters.
- Users of 32-bit microprocessors should begin the migration now from 16-MHz devices to 20- or 25-MHz products. Dataquest expects pricing for the 20- and 25-MHz parts to decline steadily during 1990 and then converge by early 1991. By contrast, barring an expansion in the supplier base, pricing for 16-MHz devices should be stable after this year.

Ronald Bohn

FIGURE 4
1990 ASIC Price Trends (North American Bookings)



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Research *Bulletin*

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0005481

NOVEMBER PROCUREMENT PULSE: MARKET OPTIMISM SPREADS ALTHOUGH ORDERS AND INVENTORIES SHRINK

The Procurement Pulse is a monthly update of critical issues and market trends based on Dataquest's monthly survey of major OEM semiconductor procurement managers. This bulletin explains what inventory and order rate corrections mean to both semiconductor users and manufacturers.

Figure 1
Averaged Monthly Semiconductor Orders

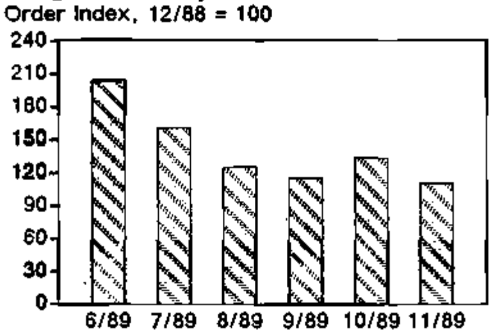


Figure 2
Averaged Semiconductor Lead Times

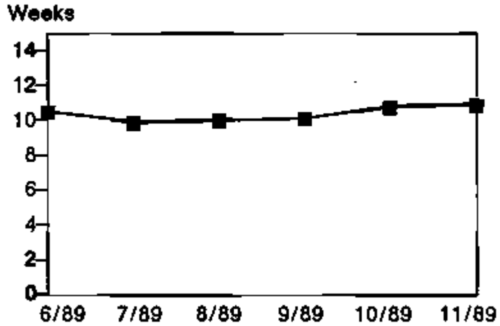


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

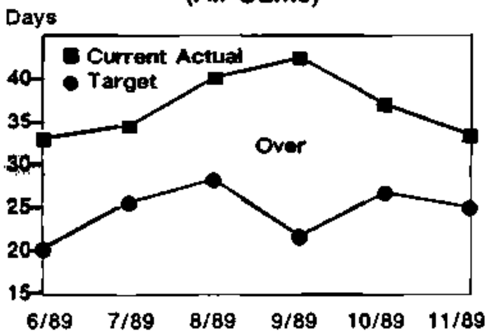
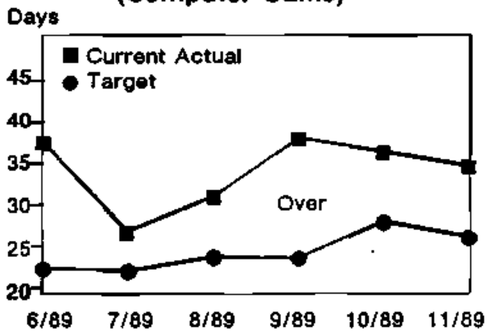


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



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November 1989

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THE SEMICONDUCTOR ORDER SEESAW DIPS ONCE AGAIN

This month's survey respondents expect to order 17.3 percent fewer semiconductors in November than in October, as shown in Figure 1. End-of-year financial housekeeping and continued concern over above-target inventory levels have kept order rates in check. The outlook for the next six months continues to brighten as purchasing managers expect to see system sales grow an average of 8.2 percent over October's six-month estimate of 5.4 percent. The range of negative 5 percent to positive 20 percent growth has not changed, but one-half of the respondents now expect growth of 8 percent or more during the next two quarters. Adequate semiconductor supplies allow users to trim costs and respond quickly to changing system demand. Dataquest expects this order behavior to continue through the next six months as suppliers continue to adjust to the demand slowdown.

LEAD TIMES SLIGHTLY HIGHER—SMT LOGIC STILL A BOTTLENECK

Figure 2 shows how lead times have increased an average of one day over last month's 2.5-day increase for the same reason as last month—the stretch-out of surface-mount standard logic lead times. Lead times now have lengthened to as long as 18 weeks for certain SMT parts from some suppliers. Besides the SMT logic situation, all other semiconductor lead times are reasonable (an average of four to eight weeks) and can be expected to remain so. DRAM and SRAM lead times continue to improve as supplies increase, in contrast to flat demand.

GOOD NEWS! INVENTORY TARGETS REMAIN FLAT WHILE ACTUAL LEVELS FALL

Figures 3 and 4 show that computer manufacturers and all OEMs generally have kept their inventory targets flat and have reduced inventory levels in response to slow but steady system sales and seasonal end-of-year accounting cost cutting. The targeted inventory level has been kept to within a 20- to 28-day guardband for the past six months, reflecting corporate concern over inventory costs. The target-to-actual inventory difference overall and for computer OEMs now is practically the same, at 8.5 and 8.3 days, respectively. Actual inventory levels (including DRAM/WIP) dropped to 34.9 days for computer OEMs and 33.6 days for the overall sample.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

Dataquest observes that both order rates and inventory levels are down. Overall semiconductor availability is good and dependable. System sales are not growing at hyper rates; rather, they are chugging along in steady, low, single-figure percentages. Aside from an isolated product-specific problem, this dependability is the correct way for strategic supply base management to work. Price declines have become a given, with many users having monthly price reviews. By looking at the total cost of supply, however, a lower price is but one variable that has to be examined. The increased optimism for system sales in the next six months combined with the supply controls now in place should allow for quick upward adjustment to demand (when it occurs) for users who retain their strategic supplier base. With the current spate of computer company financial woes in the news, the question is whether or not the increased optimism is centered around new product offerings that will sustain growth. We believe that the aggressive pricing now seen in the DRAM area will fuel new product offerings faster than we thought six months ago. We recommend that users and suppliers continue to foster close communications now so that any change in demand can be relayed quickly and accurately, thus avoiding future availability problems.

Mark Giudici
Victor de Dios

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Research Newsletter

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THE BARE FACTS ABOUT FLASH

INTRODUCTION

Flash technology, first announced by Toshiba in 1985, represented a $2.1 million market in 1988. Flash is an emerging nonvolatile memory technology currently supported by six entrants, with four potential suppliers on the horizon. Flash architecture is built around a single transistor cell with electrical programming and fast bulk/chip erase, in plastic and surface-mount packages.

This newsletter compares the performance trade-offs of flash in comparison with other nonvolatile products, discusses price-per-bit comparisons to other MOS memory products, and looks at current and potential applications for flash technology. A learning curve and life cycle analysis have been used to develop Dataquest's flash market forecast for the next five years. During that time frame, the assumed growth of the flash is based on its ability to compete successfully in the nonvolatile memory market. To remain competitive and gain market share, flash suppliers must strengthen their products' performance relative to competing technologies. The price will have to drop from its current level for the products to be competitive. A form of standardization in place of the current functional differentiation must be established in order for second-source availability to evolve and user acceptance of a new and emerging product area to develop.

PERFORMANCE TRADE–OFFS

Already a fragmented market in terms of density, speed, and price, the nonvolatile memory hierarchy, with the addition of flash, now has multiple product offerings. Each nonvolatile memory technology in Figure 1 is shown in ascending order of performance, with each member offering a significant advantage over the other technology. In this hierarchy, the most desirable memories have the highest prices and lowest bit shipments, as would be expected. The respective revenue shares for all nonvolatile products shown in the figure represented $3.2 billion in 1988.

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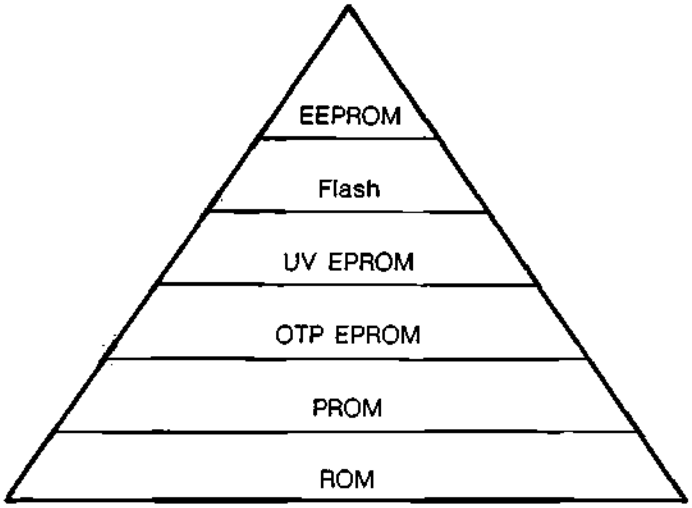
Figure 1

Nonvolatile Hierarchy



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Source: Dataquest
October 1989

It has been speculated that hierarchical cannibalism is possible when one memory technology usurps the market of a technology next to it in the hierarchy. This can occur when a new technology is introduced at near price parity with an older technology, but at much lower bit shipments. The new technology then needs to garner only a small fraction of the bit shipments of the older technology to double and redouble its bit shipments. Through the economies of scale, the new technology can run rapidly down its learning curve and lower its relative price substantially, until eventually it captures the bulk of the older technology's market.

In the late 1970s, cannibalism occurred when bipolar PROMs replaced bipolar ROMs. The one-time programmable (OTP) EPROM also was projected as the ultimate replacement to the UV EPROM. However, it never quite gained acceptance as a viable technology replacement to the strongly entrenched UV EPROM product. The OTP's reputation is permeated with black marks and obstacles, including questionable reliability, manufacturer inability to support the product with second-sourcing, poor customer acceptance, and declining EPROM prices. The full-featured EEPROMs, often the preferred system memories with 5-V system power and byte-alterable features, also were projected as EPROM replacements in the early 1980s. Although the EEPROM market experienced strong growth in 1983 and 1984, the price recessions of the early 1980s pushed EPROM prices down the learning curve, and the EEPROM growth generated was not substantial enough to drive the process technology that would allow prices to drop faster than they actually did. There also was very little if any standardization in EEPROM devices, with each vendor functioning as its customers' sole source. As a result, device prices were not as tightly coupled to one another for EEPROMs as were the prices for the commodity-type EPROM products.

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As Figure 1 shows, flash is sandwiched between the EEPROM and UV EPROM family of products. Vendors of their respective flash EPROM/EEPROM products currently speculate that flash could erode some portion of both the UV EPROM and the EEPROM families during the mid-1990s. As the largest supplier of flash products at present, Intel currently has positioned the price of its flash EPROMs far above the UV EPROM price, establishing a separate, defensible position for its flash EPROM and UV EPROM market niches. In this type of situation, the majority of users will buy the superior technology only when the relative performance of the product (programming reliability and application compatibility) is absolutely required.

The maximum performance features and functionality trade-offs of the various technologies currently being shipped in the nonvolatile hierarchy are described in Table 1. Although reprogrammability always has been one of the major strengths of the superior nonvolatile products, reliability (endurance and data retention), and cost per bit have become strong criteria for the user selection process.

Table 1

Nonvolatile Memory Trade-offs

	Mask ROM	Bipolar PROM	Fast EPROM	OTP ROM	UV EPROM	Flash EPROM	Flash EEPROM	EEPROM
User-Programmable	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reprogram-mable	No	No	Yes	No	Yes	Yes	Yes	Yes
Programming Voltage	5V	21V	12V	12V	12V	5V/12+V	5V/12+V	5V
Programming Algorithm	-	-	Required	-	Required	Required	Required	-
In-Circuit	No	No	No	No	No	Yes	Yes	Yes
Write/Erase Options	No	No	Chip	No	Chip	Bulk	Bulk	Byte
Endurance Cycles	-	-	-	-	-	100-10K	1K-10K	10K-100K
Performance	120ns	35ns	35ns	150ns	150ns	90ns	170ns	35-200ns
Highest Density	16Mb	128K	1Mb	4Mb	4Mb	1Mb	1Mb	4Mb
Plastic Package	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Transistor	-	-	1-T	1-T	1-T	1-T	1-T	1&2-T

Source: Dataquest
October 1989

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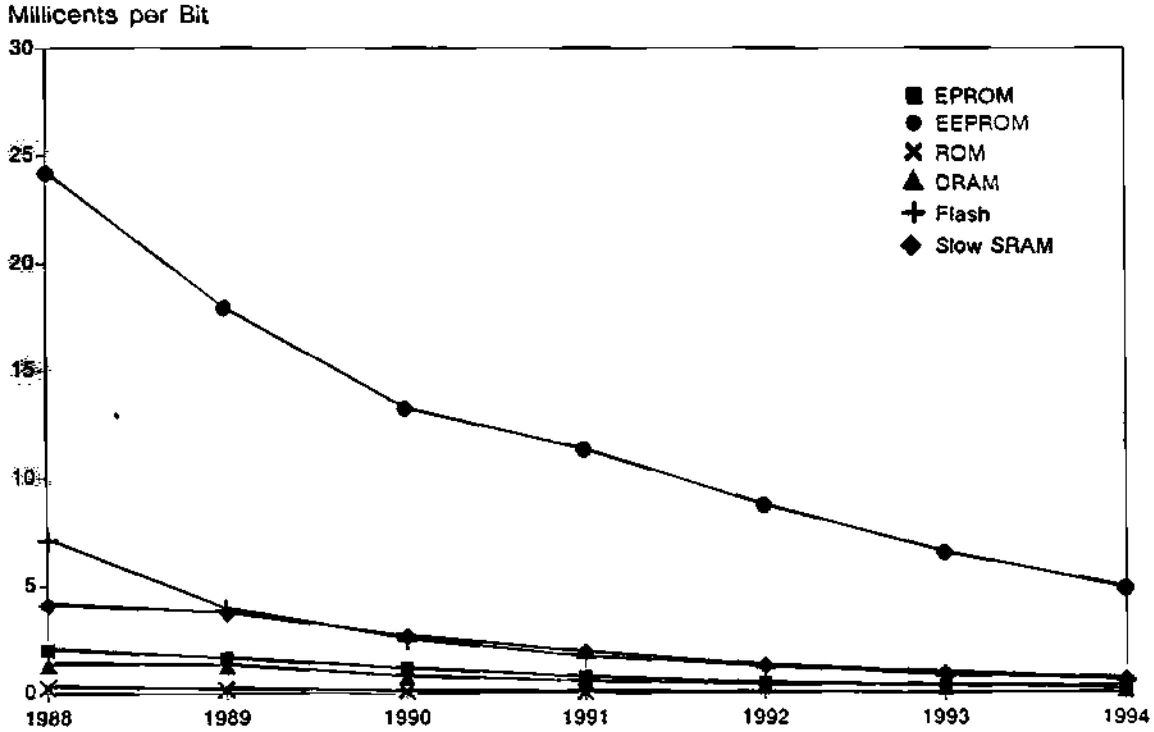
Relative price performance, in terms of price-per-bit changes over time, is also a measure of the relative superiority of one technology over another. Figure 2 illustrates the estimated price-per-bit changes for all MOS memory devices. Price-per-bit information for 64K and above densities only has been used to get a fairly sound representation of how the flash might position itself over time against other memory alternatives. A critical factor for growth and end-user stimulus for product selection of the flash will be driven by vendors' abilities to price their flash products competitively against other alternative technologies.

Figure 2

MOS Memory Price-Per-Bit Comparisons



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Source: Dataquest
October 1989

TECHNOLOGY DEVELOPMENTS

From the first 256K flash EEPROM, introduced by Toshiba, flash developments have appeared from both the EPROM and EEPROM sectors, with densities ranging from 64K through 1Mb, with 2Mb and 4Mb designs in the development stages. Flash construction implements an EPROM-like process design. The cell is programmed via hot electron injection. The erasure is accomplished using the Fowler-Nordheim tunneling of electrons between the floating gate and the drain. Typically, it takes one second to erase the entire memory.

Two major announcements have been made during the last six months. Texas Instruments (TI) and Waferscale Integration (WSI) have introduced flash devices that offer 5V power supply, which is typical of the power supply required by the EEPROM. This is a distinct path away from other flash EPROM/EEPROM device announcements, where 12V power supplies, typical to the EPROM, are required for programming and erasure. Intel, TI, and WSI also have announced that their flash products can achieve maximum endurance capabilities of 10,000 program cycles, which is typical of the minimum write cycles for EEPROMs. An industry definition of endurance is the ability of a nonvolatile memory to withstand repeated data alteration while all parameters remain in specification. The end of endurance life is when any parameter fails specification as a result of data alteration.

APPLICATIONS

The ultimate success of the flash depends on the vendor's ability to create a demand for the flash products by defining new applications, and/or the performance ability of the flash to displace other alternate nonvolatile products in existing applications. To date, most flash products have been designed into new applications. Some of these new applications are as follows:

- Automotive – Power train–for in-system code programming and reprogramming
  – Data/fault logging–for system analysis
- Telecom – Switching equipment databases
  – Portable telephones/radios
- Industrial – Test and medical instruments

STRATEGIC ISSUES

The nonvolatile memory industry currently is a mature industry with an overabundance of producers. As such, it comprises two very distinct types of companies with varying abilities to sustain new product development. Very large companies such as Intel, TI, and Toshiba (with potential development from AMD and Hitachi) all have abundant capital and engineering resources and sufficient market dominance to permit significant new product development, such as the flash, that will extend the nonvolatile product horizon. Many smaller companies, such as SEEQ, WSI, and, possibly, Atmel, are very single-product directed, and they could leverage off basic technology developments of the major companies for their market growth. If flash EPROMs and EEPROMs offer significant performance and price advantages as a competing technology, they may jeopardize other nonvolatile product markets over time.

In polling some of the very large U.S. and European nonvolatile users, Dataquest has found that two major user concerns have yet to be addressed by flash EPROM and EEPROM vendors: standardization and cost of upgrade. The only standard for the flash at this time is the JEDEC standard (32-pin) pinout. Standardization of the electrical features (programming algorithm) will be a major difference between all manufacturers of the various flash EPROM and EEPROM devices. Because flash technology is still emerging and all participants are offering flash EPROMs and EEPROMs in different programming algorithms, standardization could develop in two ways. As more vendors enter the market and vie for market share, they will compete in a price and performance arena, eventually combining forces with other competitors and displacing multiple-functional differentiation with second-source availability. Standardization can also occur when and if large-scale producers such as Intel, TI, or Toshiba ramp up their flash lines into full-scale production and force standardization by volume produced and shipped. At this point in the flash EPROM and EEPROM neophyte stage, current producers will have to lock in their users to their specific product because of the varying programming algorithms. The second area of user concern is cost of upgrade. Users currently view flash EPROMs and EEPROMs as yet another nonvolatile memory. Although their design engineers see some potential for design-in of flash, its value as an EEPROM replacement at the electronic data processing (EDP) sector is minimal. Although flash also has potential as an EPROM replacement at the EDP and instrumentation sectors, the current cost (time and expenses) of requalification is prohibitive.

Ultimately, we believe that the largest end-use segments for the flash will come from the automotive and telecommunications sectors. This may or may not come at the risk of UV EPROM displacement over time. The automotive market is expected to be the largest consumer of nonvolatile devices through the early 1990s. This is timed exactly at the point of development and ramp up of the flash EPROM and EEPROM market. Although there are other potential high growth sectors in the EDP segment, the growth of flash technology should still come from the vendors' abilities to define new applications and new buying segments in their markets. As yet, the multiplicity of nonvolatile products only has added to buyer confusion regarding the relative advantages of one nonvolatile product over another. Technological advancement, price/performance ratio, and vendor support will determine the true success of the flash market.

Mark Guidici
Mary Olsson

Dataquest

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Research *Bulletin*

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OCTOBER MARKET WATCH:
A WORSE FOURTH QUARTER BUT POSITIVE SIGNS EMERGE

Market Watch is a monthly bulletin that is released after the SIA book-to-bill Flash Report and is designed to give a deeper insight into the monthly trends in the semiconductor market and an analysis of what to expect in the next six months (see Figures 1 through 4).

Figure 1
U.S. Semiconductor Book-to-Bill Ratio

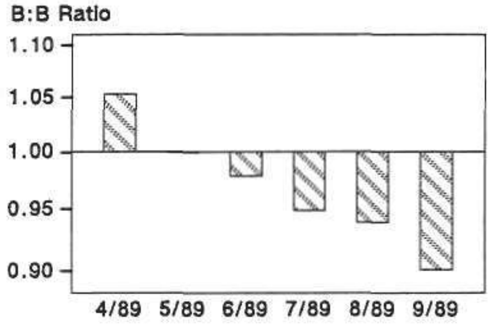


Figure 2
DOC Computer Demand

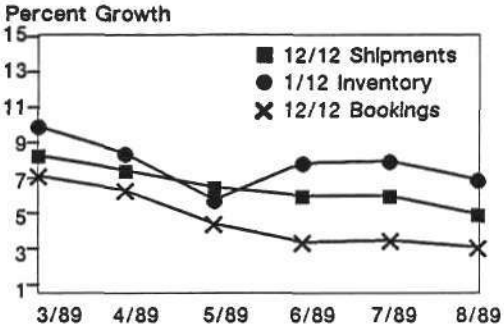


Figure 3
Semiconductor Inventory Level

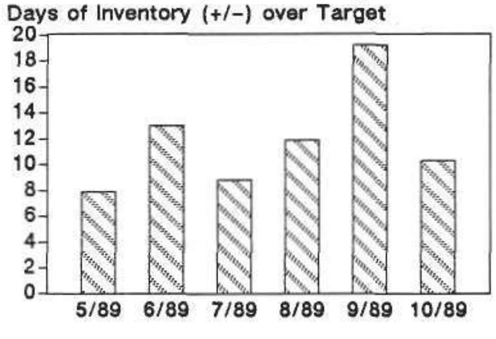
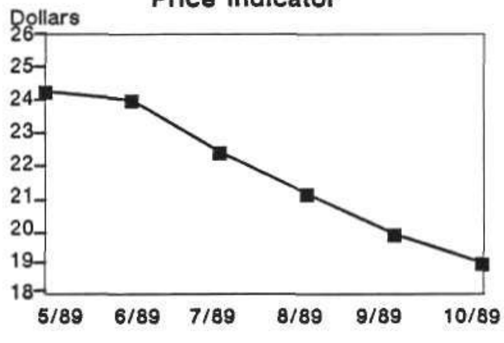


Figure 4
U.S. Weighted Semiconductor Price Indicator



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Source: U.S. Department of Commerce
World Semiconductor Trade Statistics
Dataquest
October 1989

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BRACE YOURSELF FOR A WORSE FOURTH QUARTER

The fourth quarter promises to be even weaker because of poor orders in the third quarter. The September SIA book-to-bill of 0.90 made the final statement of a market that has indeed "gone south" and will continue to do so for at least the next two quarters. MOS memory, accounting for 37 percent of the North American market, exacerbates the situation with rapid price drops in DRAMs and SRAMs.

On a positive note, semiconductor revenue stayed flat in the third quarter, declining by only 0.5 percent (Dataquest estimates) or 0.1 percent (WSTS estimates). With the third-quarter price-driven decline in MOS memory revenue, other IC products appear to be more resilient than in the second quarter. MOS memory market ASPs are making the aggregate market numbers worse just as they made them look better early in the year.

DEMAND CONTINUES TO DECLINE; SOME HOPEFUL SIGNS APPEAR

Computer order and shipment growth continues to weaken, signaling continuing poor demand. However, for the first time in five months, computer order growth dropped only slightly compared with shipment drops, indicating that the computer book-to-bill ratio has reversed its downward trend. This ratio is still below unity, but the change in direction is a welcome sign. (See the October SAMonitor for more details.) On the negative side, computer inventories have continued to outgrow orders and shipments since June. Inventories are about twice shipment levels, still bordering on being manageable.

INVENTORY LEVELS STILL UNDER CONTROL; PRICES STILL SLIDING

OEM semiconductor inventory levels over target have dropped slightly since September. Again, these swings in inventory levels will continue as OEMs continue to implement just-in-time and inventory control systems. DRAM inventory levels continue to grow faster than non-DRAM. With computer order growth starting to stabilize, Dataquest foresees increased OEM target inventory levels and improved buyer optimism about system sales in the next six months. (Consult the October Procurement Pulse for more inventory analysis.)

Prices of Dataquest's basket of 25 key products dropped by 4.0 percent in October compared with 5.7 percent in September. Although DRAM and SRAM prices continue to fall quickly, we see more stable pricing in microprocessors and EPROMs. We will add a list of new products to our basket next month, having tracked their prices since September. Amazingly, microprocessor prices actually increased in October compared with last month—another healthy sign of a possible market turn.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

When Dataquest began Market Watch in April, we saw several hints of a rapidly approaching slowdown, despite the strong market at that time. We appear to be at the crossroads again as we begin to see subtle clues of a stronger market that may bounce back mildly by the second quarter of 1990.

Dataquest believes that several factors are buoying up the North American market. European and Japanese markets remain strong and are fueling continued U.S. electronic equipment production. The U.S. economy is sound; economic forecasts have wiped out the possibility of a 1990 recession. During the next two months, we will explore the leading indicators to determine if we can anticipate a recovery in the first half of 1990.

Victor de Dios
Mark Giudici

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Research *Bulletin*

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OCTOBER PROCUREMENT PULSE:
ORDER PICKUP + INVENTORY CONTROL = INDUSTRY OPTIMISM

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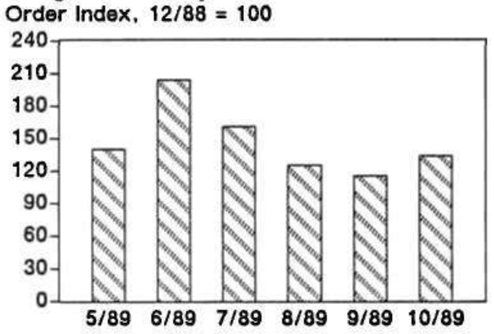

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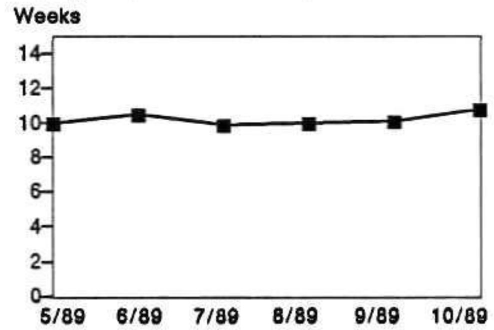
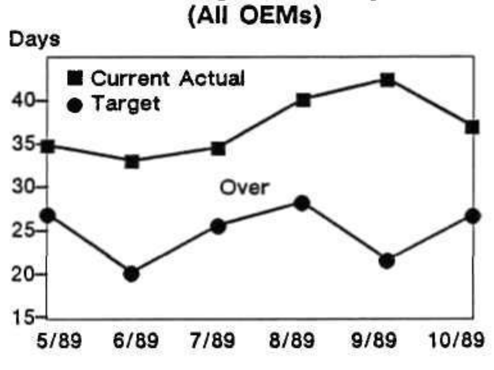


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)



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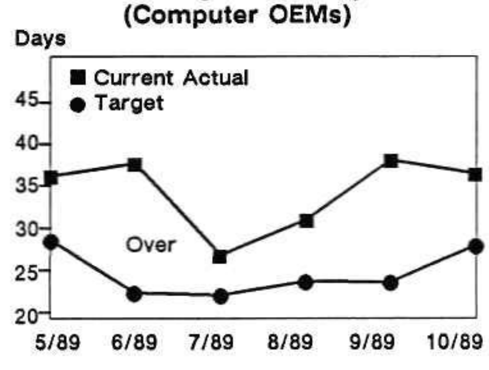

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SEMICONDUCTOR ORDERS RISE TO MATCH SYSTEM GROWTH EXPECTATIONS

Figure 1 shows that this month's respondents expect to order 16 percent more semiconductors in October than in September in anticipation of new system sales and a perceived need for safety stock to support the new products. This turnaround in order levels after three months of consecutive decline indicates a higher level of optimism regarding system sales in the next six months. Last month, procurement managers expected six-month growth to average an increase of 4.5 percent (ranging from a decline of negative 2 percent to an increase of positive 10 percent). This month, they expect an average increase of 5.4 percent (ranging from negative 5 percent to positive 20 percent). As a result of tight system and component inventory controls, it appears that upticks in system demand will be felt quickly in semiconductor order rates.

LEAD TIMES INCH UPWARD—SMT STANDARD LOGIC THE CULPRIT

Lead times have risen by 2.5 days on the average since our last survey, as seen in Figure 2, primarily due to the rapid increase in surface-mount standard logic lead times that have stretched out as long as 10 to 12 weeks. Because of unanticipated demand and little or no reserve SOIC manufacturing capacity, lead times for these parts have jumped by 4 to 6 weeks from bookings made as recently as a month and a half ago. Prices for these parts currently are unchanged but expected to rise slightly by the end of the year because additional SMT capacity is not planned to come on-line for the next six months. Other product lead times remain stable or are falling—especially for SRAMs and some specialty DRAMs.

INVENTORY TARGET LEVELS RISE AS INDUSTRY OPTIMISM EMERGES

Figures 3 and 4 show that both computer manufacturers and all OEMs in general have raised their inventory targets and lowered their actual inventory levels. As new systems gear up for production, anticipated needs of safety stock are being reflected now in overall raised targeted inventory levels. Procurement managers continue to cut inventories and have slashed the target-to-actual difference for overall and computer OEMs to 10.3 and 8.2 days, respectively. Non-DRAM inventory is below 5 percent of actual inventory levels of both the computer and overall OEM respondents, reflecting the current nonissue of memory availability. Actual inventory levels (including DRAM/WIP) dropped to 36.6 days from 38.2 days for computer OEMs and to 37.2 days from 42.6 days for overall OEMs.

DATAQUEST ANALYSIS AND RECOMMENDATIONS

The order-rate/inventory-level seesaw continues. The current outlook appears to have a rosy tint of optimism as the procurement community expects the next six months to grow at rates higher than forecast relative to the past three months. Dataquest expects the semiconductor industry to bottom out by the first quarter of next year. Aside from SMT standard logic, semiconductor availability is excellent and prices continue to decline predictably. The current supply-demand situation may lead some buyers to demand short-sighted unrealistic price cuts that could sour long-term supplier-user relationships. Buyers need to forecast their six-month needs accurately now. If the industry turns around in the late first or early second quarter of next year as it appears that it will, availability (or the lack of it) and benefits of good supplier relations again will be issues that take top priority.

Mark Giudici
Victor de Dios

Newsletter Index

1988–1989 SUIS Newsletter Index

The 1988 SUIS Newsletter Index is a quick reference guide to the SUIS newsletters. It is structured as follows:

- Titles are organized by both subject and company.
  - The first part is a company list, e.g., LSI Logic.
  - The second part is a subject list, e.g., Memory.
- The newsletter month and year follow each title listing in the index. Refer to the month tab to locate a specific newsletter.

This index is updated quarterly.

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January-March

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Research Newsletter

SUIS Code: 1988–1989 Newsletters: January–March
1988–12

CHIP SETS: TRENDS AND BENEFITS

SUMMARY

January's announcement of several ICs that would allow PC manufacturers to build 100 percent-compatible clones of IBM's complete new line of personal computers—smaller, faster, and with more features than the originals—stands as continued evidence that there are few areas safe from infiltration by these value-added VLSI parts known as chip sets.

Chip sets are showing up everywhere: in peripherals, in graphics systems, in telecommunications, and in military electronic equipment, among other areas. Dataquest estimates that, in just a few short years, chip sets have grown into a $0.5 billion annual business and will top $1.0 billion by 1990.

While some debate remains over what constitutes a chip set, the following is Dataquest's definition:

> One or several VLSI chips, available off-the-shelf, that integrate (and usually optimize) some or all of the logic, interface, memory, and/or processing functions for a specific system, architecture, or interface protocol.

Regardless of a device's precise categorization, it is clear that ICs that meet this definition are in high demand.

Chip sets were born of the electronic equipment industry's (actually driven by the end user's) seemingly insatiable demand for smaller boxes with higher performance at lower cost. Chip sets can provide these benefits, and more, to OEMs—but, of course, not without some potential pitfalls, as described in the section of this newsletter entitled "Rewards and Risks of Chip Sets."

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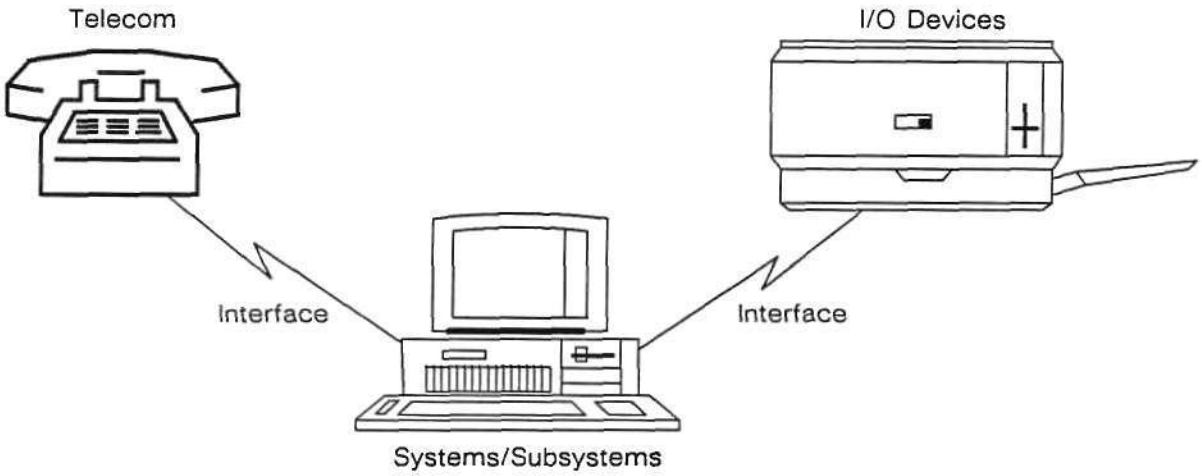
EXISTING CHIP SET APPLICATIONS AND SUPPLIERS

To date, personal computer system logic, graphics, and disk drive controllers have accounted for the vast majority of chip set revenue. Other applications (see Figure 1) gaining popularity include interface boards (allowing various add-on products or incompatible systems to communicate with the host system), input and output devices (printers, scanners, and facsimile machines), as well as telecommunications products such as local area networks (LANs) and modems. Figure 2 shows Dataquest's preliminary forecasts for system logic, low-end graphics, and disk drive chip sets for the DOS-compatible PC market. Tables 1, 2, 3, 4, and 5 list some of the suppliers for those three categories, as well as some suppliers of several interface and telecommunications chip sets.

Figure 1

Major Chip Set Applications



Source: Dataquest
March 1988

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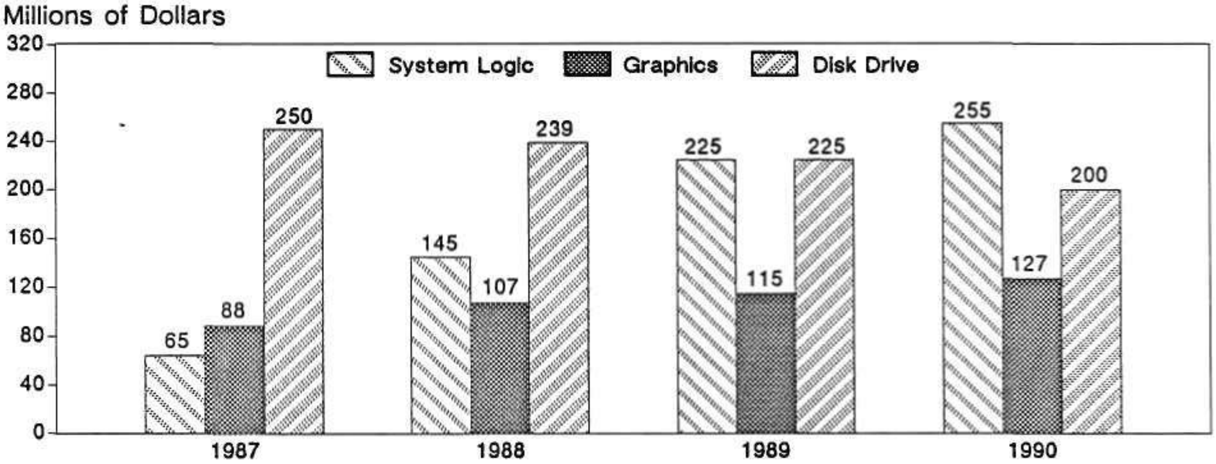
Figure 2

Chip Set Market Forecast
PC System Logic, Graphics, and Disk Drive



Note: A drop in controller board chip revenue is due to a migration to motherboards. Actual chip usage will increase, but it is not reflected here.

Source: Dataquest
March 1988

Table 1

PC System Logic Chip Suppliers

	PC Bus	AT Bus	Micro Channel
Chips & Technologies	X	X	X
Faraday (Western Digital)		X	X
G2 (LSI Logic)		X	
Intel (Uses Zymos' Chips)		X	
Logic Star		X	
Texas Instruments		X	
UMC		X	
VLSI Technology, Inc.		X	
Zymos	X	X	

Source: Dataquest
March 1988

Table 2

Graphics Chip Set Suppliers

Chips & Technologies	NSI Logic
Cirrus Logic	Paradise
Everex	Tseng Labs
Gemini	Video 7
Genoa	

Source: Dataquest
March 1988

Table 3

Disk Drive Chip Set Suppliers

	ST412 /506	SCSI	Other
Adaptec	X	X	
Advanced Micro Devices		X	
Cirrus Logic	X	X	X
Data Technology	X	X	
Emulex	X	X	
Logic Devices		X	
NCR	X	X	X
SMS	X	X	
Western Digital	X	X	X

Source: Dataquest
March 1988

Table 4

Interface Chip Set Suppliers

	MCA	VME	ISDN	FDDI
Advanced Micro Devices			X	X
Altera	X			
AT&T			X	
Chips & Technologies	X			
DY-4		X		
Force		X		
Intel			X	
Mitel			X	
Motorola		X		
Performance Technologies		X		
Plessey				X
Rockwell			X	
SBE		X		
Siemens			X	
Technology Consortium		X		

Source: Dataquest
March 1988

Table 5

Telecom Chip Set Maket Overview

	LAN/Ethernet	Modem/Fax
Advanced Micro Devices	X	X
Chips & Technologies	X	
Exar		X
Fairchild		X
Fujitsu	X	
GE		X
Gould/AMI		X
Intel	X	X
Mitel		X
Mostek	X	
Motorola	X	X
MPS		X
National Semiconductor	X	X
NEC	X	
Oki		X
Rockwell	X	X
Seeq	X	
SGS/Thomson		X
Sierra Semiconductor		X
Silicon Systems, Inc.		X
Standard Microsystems	X	
Texas Instruments	X	X
VLSI Technology		X
Western Digital	X	X
Xecom, Inc.		X

Source: Dataquest
March 1988

As is evident, many options currently are available, each with unique features and capabilities. But the decision of which products to use, if any, requires careful examination.

REWARDS AND RISKS OF CHIP SETS

The User's Perspective

Chip sets can provide an overall optimum solution for many new system designs. In terms of integration, for example, well-engineered chip sets offer a significant reduction in the number of components needed for a given system. Table 6 illustrates the reduction in ICs required to build an IBM PS/2 Model 80 clone, using the chip set offering from Chips & Technologies, Inc.

Table 6

PS/2 Model 80: IBM ICs versus Chip Sets

	IBM PS/2 Model 80	Chips/280 Implementation
Standard Logic	144	43
Microdevices	8	4
ASICs	19	0
Memory Devices	13	12
Chip Set Devices	0	7
Total*	184	66

*Does not include system RAM

Source: Dataquest
March 1988

Along with integration come benefits of optimized performance and system reliability. Higher functionality and lower power consumption, of course, are typical by-products of chip count reduction, due to the lessening of on- and off-chip and package delays. In addition, chip set designs usually integrate as many related functions as possible onto each device. Fewer devices on a board and, hence, fewer solder joints and package connections can offer greatly enhanced reliability.

Another benefit of using chip sets is that they are available immediately, almost as off-the-shelf commodity parts and, thus, can speed time to market. This is particularly important to OEMs building products with short product life cycles. (Personal computer manufacturers, for example, must cycle new designs every 6 to 18 months to remain competitive.)

For many OEMs lacking their own IC design and manufacturing capabilities, chip sets may provide the only viable path to entry into a given market. Most systems can be built around standard logic devices. However, with the cost of most chip sets near that of the components that they are replacing and with their inherent advantages, chip sets may be the commodity of choice.

Using chip sets, however, is not for everyone. Product differential is often more difficult, because every OEM using the same off-the-shelf parts ends up with basically the same system. And while most chip sets are designed using ASIC methodologies and CAD tools enabling modification of parts for a given buyer, adding proprietary features to a chip set has an impact on time to market as well as component cost.

In general, most chip sets are sole-supplied. That is, only one vendor actually offers the part, although each supplier usually has several manufacturing foundries available for its own use.

A final concern in the use of chip sets is that of legality, especially with parts that enable the unauthorized cloning of another company's system. For example, OEMs that are currently examining the building of IBM PS/2-compatible systems are being directed by chip set suppliers to obtain licensing through IBM before using the seller's chips. Certainly, much uncertainty still clouds this area. Thus, it behooves potential users to do their homework on these types of systems first.

The Supplier's Perspective

A silicon supplier's ability to provide the systems solutions available through chip sets truly adds value to the product. Thus, vendors are generally able to realize much higher margins on chip sets than on other parts. Interestingly, many chip set suppliers do not own their own fabs and are able to shop around for the best technologies at the lowest prices while avoiding the internal cost of constantly developing leading-edge processes themselves. Of course, such practices are not without obvious supply risks.

For silicon vendors that sell into markets already seeing penetration by chip sets, the absence of similar offerings in their product portfolios may result in substantial loss of business. Take, for example, Intel, which, without its own chip set, essentially lost $40 million worth of microperipherals business to Chips & Technologies last year. In a case such as this, a vendor cannot afford to stay out of the chip set business. (Intel has, in fact, signed an agreement with chip set supplier Zymos for AT-compatible parts and reportedly is developing its own PS/2-compatible devices.)

Many additional chip set applications remain to be uncovered in the data processing, communications, industrial/instrumentation, consumer, automotive, as well as military markets. Silicon manufacturers with system expertise can serve as market drivers and reap the rewards by introducing innovative products.

But developing and supporting chip sets are not trivial tasks. They require a comprehensive understanding of an OEM's system as well as the needs of the intended final users. And just as the end products experience short product life cycles, so (and even more so) do the ICs going into those systems.

Heavy support, including technical assistance and extensive documentation, is demanded from users, and herein lies a major differentiating feature among various chip set suppliers. As a result, many companies are not well equipped to become significant players in the chip set business.

STRATEGIES FOR SELECTING (OR BECOMING) A VENDOR

Price and performance are obvious key considerations in deciding whether or not to use chip sets, but in selecting a supplier, the following issues are equally, if not more, critical:

- System expertise
  - It is important to know whether a potential supplier is merely copying parts from another company's data book or truly understands your system requirements. This can make the difference between fully compatible parts and almost compatible parts.

- Track record

  - Has the potential vendor been delivering parts in a consistent, timely manner?

  - Have the parts always performed to specifications?

  - Has the supplier locked in some other solid, loyal customers, or have they switched vendors after one or two transactions?

- Foundry/second sourcing

  - More often these days, rumors are spreading about upcoming foundry capacity shortages, particularly in sub-2-micron CMOS technologies. The recent earthquake in Japan that debilitated the Hitachi fab and the current big shortage of memory chips throughout the world have the potential to shrink capacity further for nonmemory products, including chip sets. Now, more than ever, multiple-sourcing and long-term contracts for capacity from a vendor's foundry are essential.

- Growth path

  - How committed and capable is a supplier to fulfill product migration needs?

  - How well resourced is a supplier in terms of cash, capital, and personnel?

  - Having access to a product line that can be upgraded and expanded easily may provide the edge needed in remaining competitive.

- Flexibility

  - Many OEMs will need proprietary or specialized features incorporated within their parts. While many of the suppliers can accommodate these needs, not all can provide turnkey services or deliver CAD tools to the OEM to perform its own modifications. Timing, pricing, and level of customization are all important factors here.

- Service, service, and more service

  - Although this term is almost trite these days, the use of chip sets necessitates a rekindling and revamping of the concept. A user of chip sets has a lot at stake: with them, the entire heart of an OEM's system essentially has been turned over to a third party. For this reason, it is imperative that the supplier truly act as part of the team. A chip supplier must be willing and able to go to any lengths to ensure that the OEM's system gets to market on time and according to specifications.

Without a doubt, chip sets show promise of many benefits to users and suppliers alike. New architectures and applications are emerging for a variety of electronic equipment, including digital televisions, VCRs, and flight and automotive control systems, to name a few. The challenges put forth, then, are these:

- How will each OEM optimize the use of chip sets?

- How will each IC supplier be a player in the chip set market?

Nanci Magoun

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Research Newsletter

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NAPM ELECTRONICS GROUP SPONSORS FIRST PURCHASING CONFERENCE

INTRODUCTION

The National Association of Purchasing Management's (NAPM's) Electronics Group held its first purchasing conference from March 2 to 4, 1988, in Dallas, Texas. Approximately 125 people from the electronics purchasing community came together to discuss the theme "Purchasing Excellence through Professional Development." Dataquest both participated in and attended the conference; this newsletter presents highlights of the event, which contained an impressive roster of speakers.

SPEAKER HIGHLIGHTS

The first evening's reception and dinner was hosted by Wyle Laboratories, after which Charles M. Clough, Wyle's president and COO, spoke about the driving forces that are changing distribution. He believes that distributors often have the best insight into changing market dynamics because they are affected first and lead the market. He cited the following market forces that will shape distribution in the future:

- Increasingly complex products are being marketed to a large audience. Broad commodity orientations are becoming focused into specially defined segments. He showed the forecast for ASIC technology, which will make up 60 percent of the industry by 1990, to substantiate this change in product mix.

- Regionalization is accelerating, with emphasis on market share growth in individual regions.

- The customer base is expanding, with emphasis on market expansion based on target end markets and meeting specific needs within those markets. He mentioned Wyle's kitting program and support of just-in-time (JIT) programs as examples.

- Partnering and concentration of resources are increasing.

- The massive move toward electronic data interchange will lower transaction costs and inventories.

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Chuck Thompson, senior vice president and director of World Marketing for Motorola's Semiconductor Products Sector, presented an industry update following Mr. Clough's speech. He presented the information from an end, or application, market focus showing the driving forces in the world's semiconductor industry. The military market was the industry's first real market, followed by business and data processing. He also cited newer markets in residential, personal, and transportation electronics, showing the increased pervasiveness of semiconductors and the room for penetration that still exists, because increasing pervasiveness in a greater number of units equals growth. In support of this, he mentioned the growth in the number of customers who now buy "reasonable" quantities of semiconductors. He believes that personal electronics has much room for growth. In all, he forecast a worldwide semiconductor market of $43 billion in 1990, growing to $160 billion in the year 2000.

Following opening remarks by Lisa Martin, Chairman of NAPM's Electronics Group, Robert J. Nahabit, C.P.M. and president of Nahabit & Associates, kicked off the next morning's events. In a motivating speech to the audience of purchasing agents and managers, he discussed the topic, "Does a Buyer Need to Be Technically Trained?" He stated that, while buyers do not necessarily need to be designers or engineers, they should understand the commodity that they are purchasing and the vocabulary of the trade. They should be able to read and understand specs and be involved in design concept meetings and forecast sessions. He stated that buyers should continue to remain active in training, including staying up-to-date on purchasing literature and regular visits to vendors. Buyers should also stay informed and participate in value-added analysis. He said that there were too many part- and order-number placers who viewed their role as picking up the phone, placing orders, and pushing paper.

The premise behind his speech was that the purchasing community members are not merely spenders of company money, but investors of corporate assets whose goal is to obtain the best return on investment. To that end, members of the purchasing community must forge ahead in education and emphasize their key role in their own organizations, Mr. Nahabit emphasized. Companies must be equipped to do the job right the first time and develop the best purchasing department possible, because if they fail to invest up front, they will pay, one way or another.

To reiterate, Mr. Nahabit said that buyers must be poised to change with the industry, although they need not be technically trained. He used ASIC technology as an example, given Mr. Clough's projection that ASICs will constitute more than 50 percent of the industry. He asked the audience if they knew how to pick ASIC vendors and how to second-source, and if they knew the definition of PG tapes and issues surrounding ASICs in surface-mount or SOI packages. Knowledge of these subjects is what differentiates the informed and trained purchasing specialist from the run of the mill, according to Mr. Nahabit.

Wes Sagawa, senior vice president of Product Marketing and Management of Arrow Electronics, spoke next on distribution in 1988. The topic of distribution was important to this audience because, when asked, most of them raised their hands to the question, "How many of you buy more than 75 percent through distribution?" This was a diverse group, coming mostly from small companies.

Mr. Sagawa stated that competition and quality are key issues and that companies must be able to adapt to change. He cited the difference between Penn Central and Chrysler Corporation in their ability to weather their company crises. Companies cannot boast and rest on historical successes, he stated, using the analogy that a person cannot continue to look in a mirror but must be looking out windows.

He also mentioned that the industry will continue to shrink. In 1928, there were 348 auto manufacturers; today there are 3. In 1928, there were 2,547 airlines; today there are 8. Mr. Sagawa thinks the same thing is happening in electronics and distribution. In 1972, the top 5 percent of distributors held 32 percent of distributor resales. Today, the top 5 percent have 48 percent, and he believes that they will have 60 percent by 1992. On that note, he mentioned the major forces challenging distributors:

- Customers want better service, especially quality and reliability.

- Suppliers are pressing for distributors to find new customers.

- Distributors and suppliers no longer receive "warm fuzzies" from Wall Street—the high-tech honeymoon is over.

Mr. Sagawa believes that distributors must take the following steps:

- Carry fewer suppliers

- Expand their markets and emerge into new customer segments

- Form stronger partnerships with customers

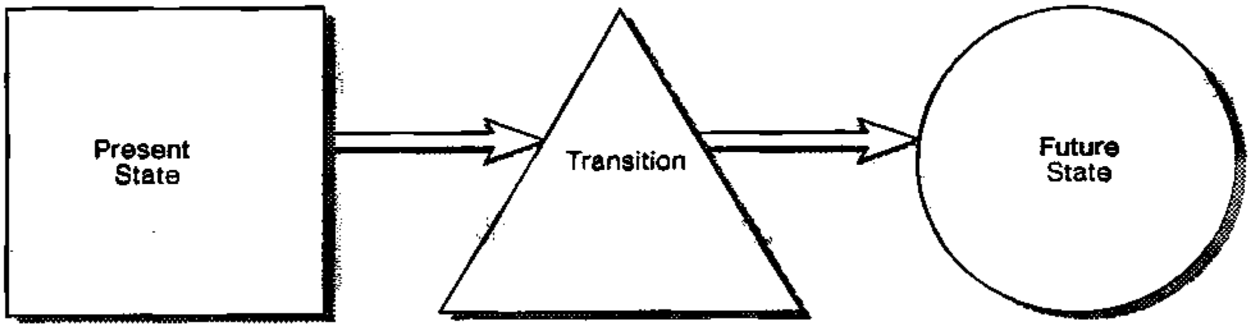
- Continue to make on-time delivery a quality issue

Robert P. Ebers, president of Impletec, a consulting and training firm, gave a presentation on adapting to change. He said that the United States has the cultural handicap of not having enough flexibility to allow for change. Old management patterns are no longer working, and the United States is not holding up well under competition. He said that people change before organizations do and discussed the key factors behind change.

People's actions, said Mr. Ebers, are a response to external environments over which they have little control. These environments provide opportunities and problems and also provoke anxiety. If people can take advantage of the opportunities, reduce or solve the problems, and eliminate anxiety, they are successful. But they frequently find themselves repeating the same action, often as a habit, because this is what has been successful for them in the past. When trying to change, however, what needs to change are the very things that have proven successful in the past.

According to Mr. Ebers, Americans think in linear or sequential "left brain" format. This, he said, has created atrophy in the work force because we have created a work force that cannot change, does not take responsibility, and cannot make decisions, especially at the accelerating pace that current markets are dictating.

Mr. Ebers illustrated the three distinct phases of change:



These three distinct stages of change must occur before complete change will happen, he said. They must occur in the above order, and pain or anticipated pain absolutely must exist before any major changes can be made. Pain, he said, is part of the process. Too often, in the United States, we try to reverse the order of the process by deciding what the change should be and then applying it immediately to the current environment—thereby forcing a transition.

Mr. Ebers also stated that during the transitional period preceding a major change, the following phenomena will occur:

- Heightened energy
- Increased struggle to gain control
- Stress
- Increased conflict

These transitions must take place and be managed, however. One way Mr. Ebers suggested increasing flexibility and willingness to change is to introduce trivial (but creative) changes in people's day-to-day life styles. These little variations of routine increase the ability to adapt.

Stan Bruederle, vice president of research for Dataquest's Components Division, provided the audience with an industry update. He said that political and economic uncertainty would prevail in 1988, although growth will occur in electronics. Dataquest's semiconductor market growth projection for 1988 is as follows:

- 21.1 percent in North America
- 20.7 percent in Japan
- 14.0 percent in Western Europe
- 31.5 percent in Rest of World

Mr. Bruederle also predicted that the second half of 1988 will be weaker than the first half, beginning a slowdown that will be present throughout 1989. He discussed the fact that a shortage of capacity exists for state-of-the-art technologies, such as 1Mb DRAMs, 32-bit MPUs, ASICs, and Fast SRAMs.

Gordon Marshall, president, CEO, and chairman of the board of Marshall Industries, discussed the effects of government intervention. He expects the current DRAM shortage to be around for a while and to get worse before it gets better, which will probably affect the overall health of the electronics industry.

Mr. Marshall's view of the progression toward government intervention is as follows:

- The cut in DRAM prices was started by a U.S. company.
- The Japanese semiconductor manufacturers followed suit.
- The United States then cried to the U.S. government.
- FMVs and the trade agreement resulted.
- Japan slowed production because the industry was in a recession.
- Japan slowed capital investments.
- The gray market dried up temporarily.
- 256K capacity was being shifted to 1Mb (no new capacity was being added).
- 1Mb yields have been extremely low.
- Concurrently, American business picked up and demand soared.

The result, he said, has been a "double whammy." He mentioned that 1Mb DRAM demand may outstrip supply by as much as 100 million parts, worldwide, but that it takes an investment of $100 million to build a front end that can make 20 million parts. Therefore, the name of the game is a huge commitment. U.S. companies, however, are small in comparison with the huge size of Japanese conglomerates. A company has to progress through the DRAM manufacturing learning curve—it cannot just back into 1Mb production without going through 64K and 256K. This makes it difficult for U.S. companies to reenter the market.

Mr. Marshall believes that the U.S. government has discouraged Japan from getting too involved, one way or another, and that the result is a vicious cycle. The Japanese, he said, are fiercely competing against one another, and the United States is getting caught in the middle.

John V. Roach, president, CEO, and chairman of the board of Tandy Corporation, spoke about keeping the United States out in front. He said that companies must be low-cost producers and mentioned three key strategies to accomplish this:

- International sourcing—buying wherever it makes the most sense. Tandy has 400 people in the Far East, half of whom are in some form of quality control. They issue all their purchase orders in dollars, and they would rather pay a bit higher price in their contracts and know their costs than take the hit for exchange rate fluctuations.

- Vertical integration—make the make-or-buy decision based on what makes the most sense. Tandy is highly integrated except, for example, with semiconductors. To that effect, Mr. Roach remarked that usually there were more times when he was glad he was not a producer of semiconductors than times when he wished he was—the current situation included.

- Manufacturing facilities location—put manufacturing facilities where it makes the most sense. Manufacturing automation has displaced much of labor cost. This, combined with exchange rates, favors U.S. production in many circumstances. He said that manufacturers should take advantage of the latest technology for quality control and efficient manufacturing.

Mr. Roach thinks that the United States has a unique window of opportunity—a rare time to create a turnaround in U.S. competitiveness. Automation is available, the yen is in our favor, and sentiment has rallied around U.S. support. He said that manufacturers should play on all fronts by being both importers and exporters, and both domestic and international manufacturers.

Jerry Wasserman, vice president of Arthur D. Little, Inc., gave a presentation on Japanese pricing policies. He said that there are several key factors that explain pricing policies:

- Cost of money
- Subsidies
- Profit expectation
- Market scope
- Domestic markets
- Capital intensiveness

The cost of money is much lower in Japan, where the prime rate is about 4 percent compared to 9 percent in the United States. The savings rate is 20 percent of disposable income, compared with the U.S. rate of 5 percent.

Subsidies come in the form of MITI-sponsored programs and trading companies that assume marketing costs, extended payment terms, and accelerated invoice settlement. Profit expectations are low in Japan. Mr. Wasserman used NEC's earnings of $100 million on $17 billion of sales last year as an example. The emphasis in Japan is on revenue growth, which is more important in Japan than profit—market share is paramount. Stockholders have little power.

Japanese companies look to world markets. Here again, market share is key. He said that Japanese companies are worldwide companies that sell domestically; most U.S. companies sell domestically and "just happen to be" international. The emphasis is quite different. Japan's domestic markets are highly protected. Performance expectations are high and government regulation is stringent. Requirements for selling in Japan are complicated.

With respect to capital intensiveness, he said that automation is rampant in Japan and that the focus has been on high-quanlity production and products. Labor-intensive manufacturing has moved offshore.

All combined, pricing in Japan is used as a tool for capturing market share. Japanese companies operate in an environment that permits and encourages aggressive pricing strategies. This focus is quite different than that of U.S. companies.

Tom Temin, editor of Electronics Purchasing magazine gave a speech on proactive purchasing strategies. He said that there were 14 pressures on buyers and sellers of semiconductors in 1988. He explained them accordingly:

- Dealing with mergers and acquisitions
- More danger of government intervention
- Tighter conditions for VLSI—stretching lead times
- Demand exceeding supply of surface-mount components
- Fewer distribution channels carrying fewer lines
- Political instability in Korea
- Uncertain capital equipment markets (shaping trends in available technology)
- Explosion in noncatalog solutions
- Greater demand for zero-defect and reduced incoming inspection
- Shorter product life cycles
- Greater diffusion of purchasing to worldwide markets
- Lead time management by suppliers
- Pressure on military suppliers as resources go to support shortages in the commercial market
- Greater worldwide technological prowess, competition between regions

DATAQUEST CONCLUSIONS

The day ended with a panel of purchasing managers discussing how they would handle tough issues. This created a good forum for audience participation. The last day's event focused on plant tours at Texas Instruments and Boeing Electronics.

The users in the audience had a good opportunity to discuss key issues throughout the conference. Speakers addressed a variety of topics that were interesting and insightful, and we were particularly pleased to gain the perspective of such a unique and qualified list of speakers.

Anthea C. Stratigos

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Research *Bulletin*

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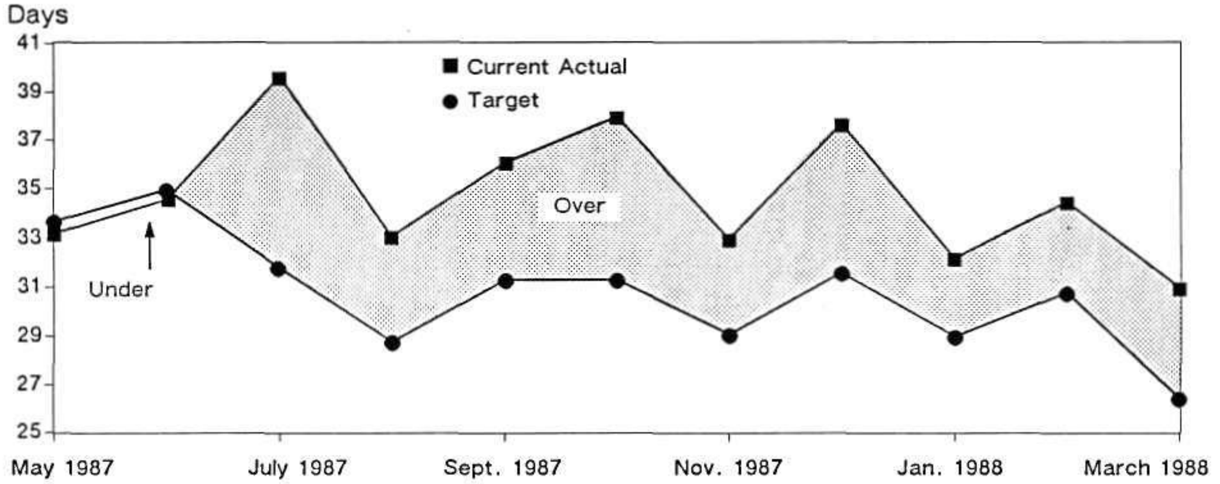
MARCH PROCUREMENT SURVEY: AVAILABILITY TURNS INTO ALLOCATION

The availability crunch of high-density DRAMs and 32-bit microprocessors that we highlighted in February has continued unabated, and in many cases, DRAMs are on allocation. Overall targeted and actual inventory levels declined this month, as shown in Figure 1, while 60 percent of the respondents reported that their sales have risen. This outcome reinforces how end-use demand affects procurement practices—end-use demand decreases inventories while key raw material supplies remain tight. As shown in Figure 2, the computer segment of the survey showed actual inventory levels rising slightly (up 3 percent over target), but anything within this range reflects good inventory control. Except for DRAMs, lead times have remained stable at around 12 weeks, reflecting adherence to contractual delivery schedules.

Figure 1

Current Actual versus Target Inventory Levels (All OEMs)



Source: Dataquest
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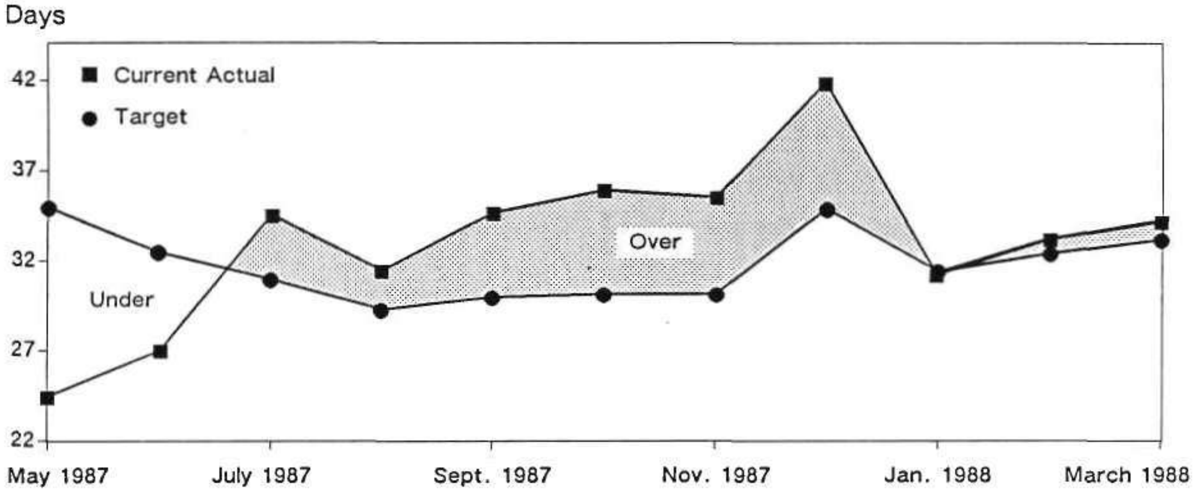
Figure 2

Current Actual versus Target Inventory Levels
(Computer OEMs)



Source: Dataquest
March 1988

Overall pricing (except for DRAMs) has remained relatively unchanged since last month, while orders to distributors have continued at the same elevated levels of last month.

DATAQUEST OBSERVATIONS

The current availability problems affecting DRAMs and high-end microprocessors are not as severe for users who have in place long-term procurement arrangements. Granted, most users want more of these parts and improved lead times, but it appears that those who have good relationships with vendors are faring better than those who do not. As mentioned in last month's report, the balance of supply with demand for DRAMs and 32-bit MPUs will begin to be seen by mid- to late summer (third quarter 1988) as production volumes come into the market. The rest of the market appears fairly well balanced as supplies continue to meet demand forecasts.

Mark Giudici

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THIRD ANNUAL PROCUREMENT SURVEY—MAJOR ISSUES SHIFT IN 1988

SUMMARY

Results of our third annual procurement survey were announced at Dataquest's Semiconductor User and Applications Conference held in San Francisco, California, in late February. This year, the most important issue raised by major electronic equipment manufacturers was that of component availability, stretching lead times, and shortages.

Semiconductor users also stated that their plans to shift electronic equipment production offshore were slowing—a trend that for now reverses a major move seen in the last two years. Although the issue of cost and cost reduction is still paramount, the overall frenzy has calmed somewhat during the last twelve months.

The manufacturers that make up the Electronic Business 200 participated in our annual data and trends-gathering project, which takes a look at what semiconductor buyers are saying. This year, the 44 percent overall survey response rate indicates that users expect to increase their 1988 purchases by more than 13 percent. In our 1987 survey, users projected growth for the year at just over 13 percent, while the actual industry growth was 21.4 percent. We believe that users continue to be cautious in their projections despite the general consensus that demand is robust. Dataquest believes that North American semiconductor consumption will grow 21.1 percent this year.

Survey Structure

Each year, Dataquest's Semiconductor Application Markets service gathers information for semiconductor manufacturers about their customers and markets in the United States. Users who receive this information use it as a sounding board to compare their business perspective with that of their peers. In all, both sides get a better understanding of the business issues facing semiconductor buyers and sellers in the coming year.

For our surveys, the original list of 200 companies was pared to eliminate component, semiconductor, and software companies that do not buy semiconductors for use in their electronic systems and subassemblies. We also eliminated distributors from the survey audience. About 150 companies remain. Using this list, we then identify and

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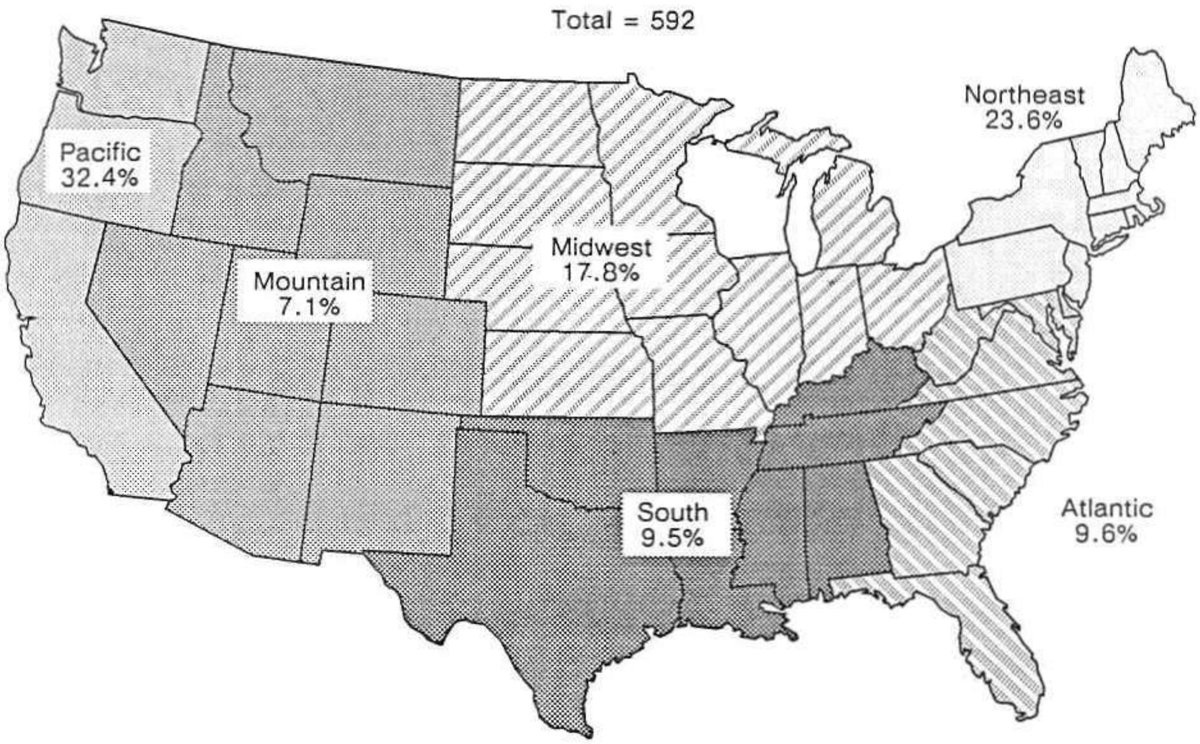
survey by telephone each procurement location within the 150 companies. Our interviews are held with buyers, purchasing managers, or individuals who are in material or corporate contract management. Nearly 600 individual locations make up the total audience. Figure 1 shows the geographical locations of these major customers.

We estimate that these users account for $260 billion in electronics revenue and 60 to 65 percent of North American semiconductor consumption. Obviously, when it comes to purchasing, many of them carry clout.

Figure 2 reflects the audience in terms of their major line of business. There are fewer data processing and communications participants than their purchases would indicate, since these are the two largest markets for semiconductors in the United States. The industrial base, much larger in number, is actually more diverse and fragmented, thus it accounts for a much smaller percentage of total purchases.

Figure 1

Procurement Survey Audience



Source: Dataquest
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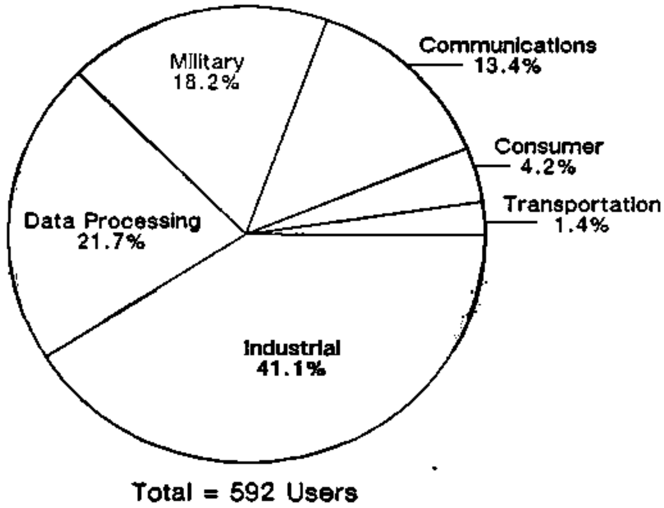
Figure 2

Survey Audience by Major Line of Business



Source: Dataquest
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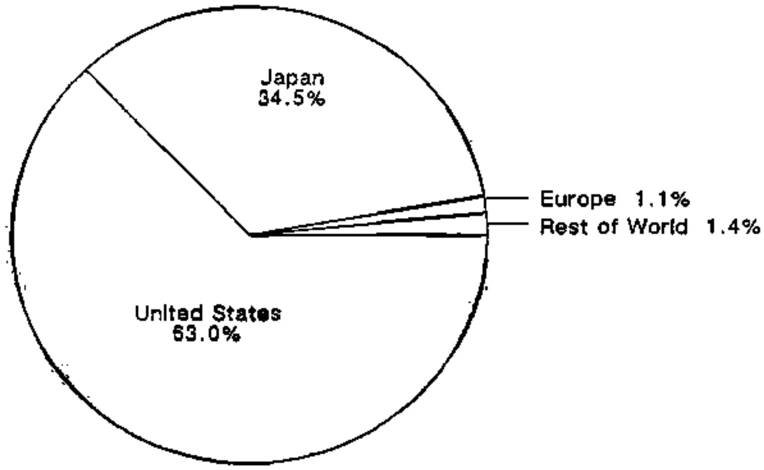
ASSESSING GLOBAL IMPACT

Once again, statistics were gathered about the regional base of semiconductor suppliers. We defined the regional base as the semiconductor company's country of origin and found that not too much has changed since last year. In this year's survey, 80.5 percent of purchases were made from U.S.-based semiconductor manufacturers, down slightly from 83.0 percent the previous year. Japan and Europe came in at 17.1 and 1.0 percent respectively; the Japanese portion was up from last year's 14.0 percent, while the European portion remained flat. This coincides with the 1987 market rebound that was driven by data processing—particularly PCs and related peripherals, which are memory intensive. ROW suppliers dropped slightly from 1.8 percent last year to 1.4 percent this year.

It's interesting to note that the value of components bought from non-U.S. suppliers was directly related to the type of equipment the electronic equipment manufacturer produced. As mentioned earlier, data processing manufacturers rely on MOS memory. This tendency can be seen in Figure 3, which shows the regional supplier base of users in the data processing arena.

Figure 3

Regional Supplies Base of Data Processing User



Source: Dataquest
March 1988

Shifts Offshore

Table 1 shows the response to our question about anticipated shifts to offshore production. The good news is that far fewer companies will shift a great deal of production. However, about the same number of users as last year still expected some shift. More users said that no movement was likely. Even more noteworthy was that for some, the word "shift" meant going to Western Europe or coming back to the United States. The respondents cited currency exchange rates and advances in automated manufacturing for their no longer having the need to move. The users said that labor costs are becoming a less significant portion of total cost and that many hidden costs associated with offshore production have become apparent over the last two years—including shipment costs, language barriers, and overall communication difficulties.

Users who believed that some move would occur stated the following as the reasons for their decision:

- Lower assembly costs
- Falling dollar, high price of yen, and other exchange-related reasons
- Buying and producing in local markets (where products are sold)
- Better quality

Table 1

Anticipated Shift to Offshore Production

Response	1986	1987	1988
A Great Deal	84.0%	10.1%	3.3%
Some	35.9%	33.2%	34.0%
Not at All	55.7%	56.7%	62.7%

Source: Dataquest
March 1988

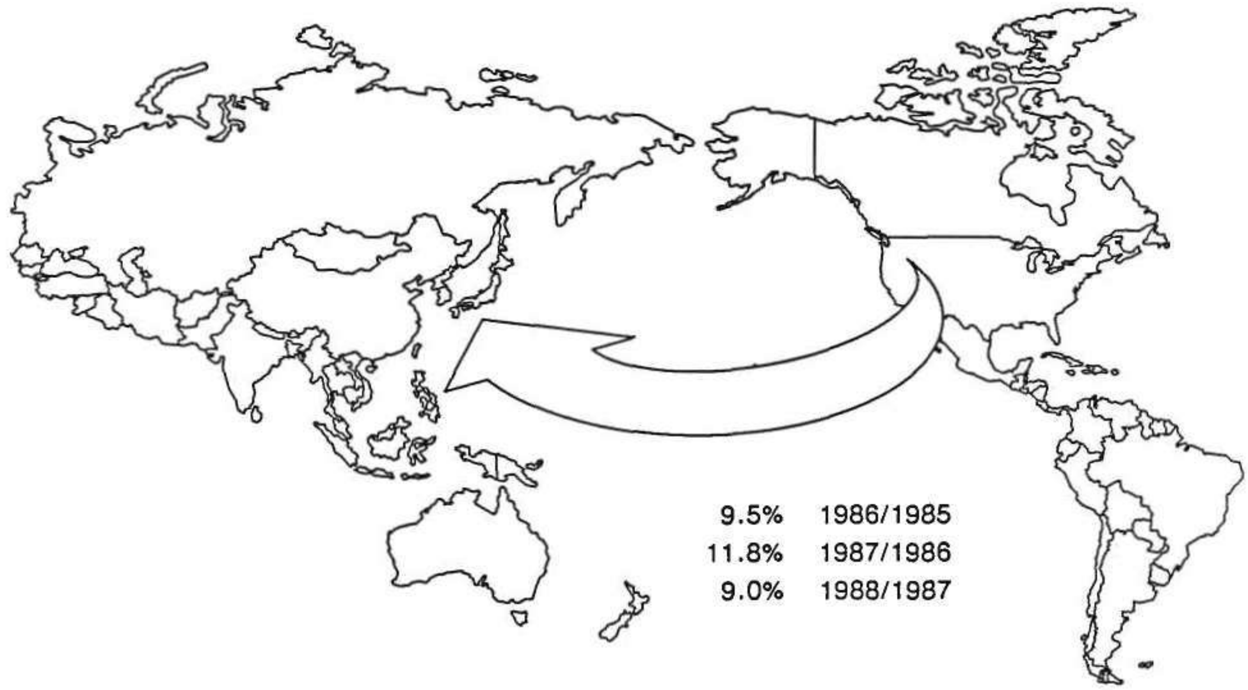
We believe that for the most part, the companies that had plans to move their facilities have already done so. Two years ago, we were the first to see this trend and said that it was primarily the data processing manufacturers who planned to move. This was a serious indicator for the U.S. market because of its reliance on data processing for a healthy semiconductor market. As a result, we saw dramatic increases in ROW semiconductor consumption. Today, ROW semiconductor consumption is 41 percent data processing and 45 percent consumer (a reflection of Japan's shift of low-end consumer goods). The third largest semiconductor market in the ROW is communications at 9 percent.

For the most part, users said that any further shifts would not significantly impact their domestic semiconductor consumption. While Dataquest's Asian Semiconductor and Electronics Technology Service still forecasts high growth in ROW consumption, projections are for a more moderate 32 percent growth in 1988 compared with the 62 percent and 54 percent seen in 1987 and 1986, respectively. Figure 4 shows the estimated U.S. consumption that, according to our audience, may still move abroad. This pattern coincides with historical growth rates in ROW and again indicates a slowing.

Once again, the message to semiconductor manufacturers is clear: Be a worldwide participant or lose position in the global market.

Figure 4

Estimated U.S. Semiconductor Consumption Moving Offshore
(Percent of Total Dollars)



Source: Dataquest
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ASSESSING INVENTORY LEVELS

Dataquest believes that fundamental industry transitions are still occurring that are significantly changing manufacturing operations. Offshore production is one, but streamlined operations, automation, and an overall concern about competitiveness are affecting the way that manufacturers are doing business with their suppliers. Many users mentioned "becoming world class" as a major goal and concern.

To this end, inventory strategies put in place over the last two years appear to be holding, despite the severity of the current DRAM crisis. This may be because many larger, more "sophisticated" companies implemented these programs, and they are the companies that established the partnerships that were required to make these programs successful. The partnerships, coupled with purchasing power, may mean that supply, though lean, is available, thus keeping inventory programs from crashing. Many companies that we have spoken with since the survey have indicated complete commitment to their inventory programs.

Over the past nine months, in our monthly surveys of a smaller audience, Dataquest has been is seeing an absolute resolution on the part of users to keep their inventories in line. Any month-to-month shifts are remedied in subsequent months. Right now, users are carrying about five to six weeks of inventory. Our annual survey statistics indicate the same thing. More users said that they were planning small increases in their inventories, but about the same number said they are planning decreases. Still, 40 percent said that target levels were in sync with current levels. Overall, we are not seeing any major changes or hiccups in inventory levels or management. We believe that this is quite promising, given the current industry environment.

WHAT ARE THE USERS SAYING ABOUT ASICs?

The adoption of ASIC technology continues to be of great interest. Although the procurement community is often unprepared to comment on a company's ASIC plans, we believe that their answers are revealing nonetheless. Users who do not know about ASIC use are an indication that ASIC adoption is still not far enough down a company's learning curve. Buyers who are aware and provide us with insight are an indication that more and more companies are integrating the knowledge of purchasing, design, and marketing, up front in system development—a trend we continue to see.

Answers to our survey continue to show that companies are relying on internal versus external design teams at a rate of three to one. This finding has been consistent over the past three years. Last year, 60 percent of our audience were nonusers of ASIC technology and 45 percent of them planned to adopt the technology. This year, only 50 percent did not use the technology, and of those, 59 percent believed that their companies were on the move to adopt the technology. This shows that the move to ASICs is continuing at a rapid pace.

Table 2 shows the nonusers and their major line of business for the past three years. Clearly, the data processing community has led the way and has been largely behind the ASIC industry's phenomenal growth. The last bastion is the industrial market. Reaching this multifaceted, highly fragmented, and somewhat conservative audience has been a real challenge. Geographically, they are widely distributed and their systems usually have stringent requirements and are produced in smaller volume, making the design costs associated with ASIC technology not as cost effective as a traditional solution. Price pressure on the ASIC market and supplier awareness of unique needs in this diverse but remaining marketplace should promote ASIC awareness and adoption in these companies.

Table 2

Who Are the ASIC Nonusers?

	Percent of Total Responses		
	1985	1986	1987
Data Processing	22%	18%	13%
Communications	16	11	15
Industrial	45	49	55
Consumer	2	6	2
Military	15	14	15
Transportation	0	2	0
Total	100%	100%	100%

Source: Dataquest
March 1988

We asked the nonusers what ASIC design methodology would be their technology of choice. Once again, we found that preferences varied by the major line of business of the respondents. They answered accordingly, with the technologies ranked by level of interest, as follows:

- Data Processing
  - Cell-based ICs
  - Gate arrays
- Communications
  - Cell-based ICs
  - Programmable logic devices
- Industrial
  - Programmable logic devices
  - Cell-based ICs
  - Gate arrays
- Military
  - Cell-based ICs

THE MAJOR ISSUES

In each of our surveys, we have asked the users an open-ended question about the major issues that they are facing in the coming year. Table 3 shows a comparative look at the main issues over the last three years.

In 1987, the top concerns involved the traditional pricing, availability, and quality. Yet, all of the issues also involved cost and cost reduction, including concerns about offshore manufacturing and procurement, which first appeared last year. User concerns about surface mount, ASICs, and product obsolescence also related to cost. Our analysts read each survey individually and the tone of last year's survey was much more frenetic than ever, with heated comments about competitiveness, international markets, and "buying American." Clearly, concern about the U.S. market position was rampant, and cries about government intervention and FMVs rang out loud and clear.

This year, the tone is much calmer, even though many of the issues are similar. At present, the major concern is availability. A myriad of concerns about memory components have replaced last year's concern about FMVs. Cost control is still a major concern, but offshore procurement and manufacturing have moved off the list. Even more startling is the lessening concern over quality. We believe that for many customers, Japanese and U.S. component quality has finally reached parity. The importance of quality has not dropped, but concern because of lack of quality has. Users are still working on inventory management, which is evidenced by the continuing concern about vendor reduction and just-in-time delivery (JIT). Concern over currency exchange rates has increased dramatically.

Table 3

The Major Issues

1986	1987	1988
Pricing	Pricing	Availability/lead times/ shortages
Quality/reliability	Availability/lead times	Pricing
On-time delivery	Quality/reliability	On-time delivery
Supply/availability/ shortages	On-time delivery	Cost control
JIT/inventory control	FMVs/trade agreement	Memories
Reducing vendor base	Cost control	Quality/reliability
Product obsolescence	JIT/inventory control	Reducing vendor base
Second-sourcing	Surface mount	New products/obsolescence
Forecasting	New products/obsolescence	JIT/inventory control
	ASICs	Fluctuating yen/currency exchange
	Offshore manufacturing and procurement	

Source: Dataquest
March 1988

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DATAQUEST CONCLUSIONS

We believe that high technology companies that want to become substantial competitors must be equally expert in design, manufacturing, and marketing. Carefully listening to the customer and keeping attention focused on the customer's customer is the key to remaining innovative. Companies must be able to seek and identify major trends and then react quickly, precisely, and with ease. Constant change is imminent.

To that end, we believe that companies that can effectively integrate marketing, design, purchasing, and manufacturing will be one step ahead of shorter product life cycles and product and market development. Integrated user and supplier relationships are paramount to competitiveness because in this manner, excellence is exchanged and enhanced. The word "partnership" may be overused and trite, but semiconductor buyers and sellers who can effectively tackle and solve the issues discussed in this year's survey will be on the leading edge. The users that are getting their parts today are those that established relationships when the call for "partnerships" was first sounded in 1986.

Overall, we believe that users are somewhat conservative in their estimates of future in purchases. Availability, lead times, and shortages will remain critical issues, but for those with close buyer/vendor ties, supply may be somewhat more secure. These connections may also temper the historical exaggeration seen in industry cycles. The shift to offshore manufacturing appears to be slowing, while cost control and manufacturing strategies continue to play a critical role in determining buyer action.

Anthea C. Stratigos

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1988 SEMICONDUCTOR USER AND APPLICATIONS CONFERENCE: SUCCESS BREEDS SHORTAGES

SUMMARY

Dataquest's most successful and widely attended Semiconductor User and Applications Conference ever was held February 22 and 23 in San Francisco. For the 213 people attending, the conference agenda provided an excellent backdrop for users and manufacturers of semiconductors to formally and informally discuss industry issues and how they are coping with the changing marketplace. The theme of the conference, "Buying and Selling Semiconductors in 1988," addressed four main areas: the outlook for 1988, buying strategies, the Dataquest product and technology update, and a panel discussion on government intervention and international trade. This newsletter will summarize the information presented at the conference and discuss how current situations are being addressed. The attendees of this year's conference are listed in Table 1.

Table 1

1988 Semiconductor User and Applications Conference Attendees

Electronic Equipment Manufacturers

3M Company	Ericcson Telecom	Megatest
AMP Inc.	Ford Motor Co.	NCR
AT&T	Fujitsu Espana	Nissei Sanyo
Acuson	GTE Government Systems	Northern Telecom
Apple Computer	General Electric	Poqet Computer Corp.
Bendix Electronics Corp.	Hayes Microcomputer	Research Machines
Boeing Corp.	Hewlett-Packard	Seimens AG
CMI	Honeywell	Storage Technology
Cerberus Ltd.	Hoya Electronics Co.	Tandem Computers
Datapoint	IBM	Tektronix Inc.
Dataproducts	Ing. C. Olivetti	Teradyne
Delco Electronics	Italtel	Timex Corp.
Digital Equipment Corp.	Itausa Export Co.	Unisys
Eastman Kodak	Lex Electronics	Wang Laboratories
Emerson Electronics Corp.	Mars Electronics	Xerox Corp.

(Continued)

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Table 1 (Continued)

1988 Semiconductor User and Applications Conference Attendees

Semiconductor Manufacturers

AMD/MMI
Cirrus Logic
Commodore Semiconductor
Compulab
Fujitsu Microelectronics
General Instrument
Gould Semiconductor
Harris Corp.
Hitachi America
Hyundai
Integrated CMOS Systems
Intel Corp.
LSI Logic
Lattice Semiconductor
Microchip Technology
Micron Technology
Mitsubishi Electronics
Mitsubishi Semiconductor
Motorola
NEC
National Semiconductor
Oki Semiconductors
Plessey Semiconductor
Precision Monolithics
Raytheon
SGS/Thomson Microelectronics
Samsung
Seattle Silicon Corp.
Seimens Components
Shinki Electronics America
Signetics
Singapore Technology Corp.
Standard Microsystems Inc.
Texas Instruments
Toshiba America
VLSI Technology
Vitelic
Wyle Labs

Other Conference Attendees

ABN Bank
American Electronics Assn.
Babson College
Bacher GmbH
Bank of America
CP Ventures
CRD
CS LIU
Citicorp
Coopers & Lybrand
Electric Buyers News
Electronic Purchasing
Financial Times
Government of Canada
INSEC
J.H. Whitney
Manufacturers Hannover Trust
Montana Science/Tech. Alliance
Plantek
Regis McKenna
San Jose Mercury News
Security Pacific Bank
Semiconductor Industry Assn.
U.K. Dept. of Trade & Industry
U.S. Venture Partners

Source: Dataquest
March 1988

1988 OUTLOOK

The two presentations given by Vladi Catto, vice president, corporate staff, and chief economist of Texas Instruments and by Gene Norrett, vice president and director of the Dataquest Components Division, covered how the overall economy will affect the semiconductor and electronic industries in 1988. Both TI and Dataquest forecast gradual growth in the electronics industry, although the semiconductor sector will continue to grow at an 18 to 21 percent clip. Two underlying economic trends that are impacting the economy are the 2.4 percent compound growth rate in the M1 money supply over the past two years and the devalued dollar in the international markets. Mr. Catto explained that the Korean and Taiwanese currencies have not yet realized their full value against the dollar. Although the rest of the world's currencies have come close to balance with the

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dollar, the Korean won and New Taiwanese dollar are still overvalued by 50 percent. Steady demand for electronic equipment in the computer and telecommunications industries are expected to sustain growth in these areas, as well as the semiconductor industry, in 1988.

In one of the many speeches that formally focused on customer/vendor partnering, Michael Graff, vice president of marketing—Semiconductor Sector at Harris Corp., reinforced the benefits as well as challenges facing companies considering alliance overtures. According to Mr. Graff, the following key factors must be understood and ingrained by these companies:

- Quality must be a given.
- Some form of statistical process control (SPC) must be agreed to by both parties.
- Process control must be used to optimize a customer's total product requirements.
- Ongoing quality communication results in locating where improvements are needed.

The vice president and group executive of Bendix Electronics Corp., Jerome Rivard, spoke on how semiconductor vendors can improve long-term relationships with their customers, using the automotive industry as an example. By combining high quality, SPC, and product uniformity, a buyer/vendor partnership can develop that benefits both parties. As technology continues to hasten the life cycle of products and capital expenditures continue to increase, the global marketplace will keep this tempo going, thus enabling better business relationships for those with foresight.

The third annual procurement survey results, which were presented by Anthea Stratigos, associate director of the Semiconductor User and Applications Group at Dataquest, noted many differences over last year's review. The key areas of change were in offshore production trends, inventory levels, and the ranking of major issues. Offshore production is expected to be de-emphasized after two years of continued increases, as currency exchange rates and prior moves offshore appear to have caused a reevaluation of the need to move offshore. Inventory levels are expected to increase by close to 10 percent over last year's levels, as availability of key semiconductor products has begun to impact inventory plans. In line with inventory trends is a new ranking of key issues that has raised availability/lead times/shortages above pricing for the first time since the survey was conducted. Quality has fallen from the number three issue last year to number six this year because quality levels have significantly risen worldwide.

Thomas Temin, editor of Electronics Purchasing magazine, presented the key pressures facing both semiconductor buyers and suppliers today. Of the many issues discussed, those pertaining to both users and sellers are government intervention, capital spending trends, user familiarity with ASICs, and the trend of purchasing involvement in the design stage of new products.

Jim Bilodeau, director of worldwide materials at Apple Computer, discussed how procurement strategies have enabled Apple to grow to a $2.7 billion company in 11 years. A proactive corporate structure combined with short- and long-term procurement strategies allowed a company that is "highly dependent on the Pacific Rim for product" to increase 1987 revenue 40 percent over 1986 levels. Mr. Bilodeau described the need to provide open communication to vendors, in "up" demand periods as well as "down" periods in order to maintain forecast credibility—one of the areas often overlooked in long-term arrangements.

AT&T's director of market management, Daniel Lankford, spoke from the semiconductor vendor perspective about the ingredients needed to cement a successful buyer/vendor partnership. He stated that the following elements combine to form the basis of a long-term working relationship:

- Coincident technologies
- Top management commitment
- Complementary strategic objectives
- Consistent revenue targets
- Explicitly defined areas of cooperation
- Realistic expectations

Mr. Lankford's presentation focused on the often-overlooked captive semiconductor manufacturer/outside buyer relationship and what one can expect in this type of long-term partnership.

Dan Hamel, semiconductor business operations group manager at Digital Equipment Corporation, described what users require of semiconductor manufacturers to remain competitive. Mr. Hamel discussed needed improvements that will be required by the majority of semiconductor users by the end of this decade, particularly in the following areas:

- Customer service
- Time to market
- Vendor predictability
- Quality improvement programs
- Lead-time reduction
- Just-in-time and ship-to-stock programs
- Electronic data interchange systems

Another perspective on the changing electronics marketplace was presented by Tim Propeck, vice president of marketing at AMD/MMI. Mr. Propeck discussed the areas that need to be addressed when a company's supplier merges with another supplier or company. Complementary product lines and technologies, economies of scale, and service levels are among the most important topics that must be scrutinized whenever a merger of suppliers occurs, in order to minimize any disruption to quality and shipment levels.

Tom Wang, associate director of the Asian Semiconductor and Electronic Technology Service at Dataquest, described the major electronic companies in the Far East and the areas on which each of them is and will be focusing in the semiconductor market. Mr. Wang then discussed the advantages and disadvantages of doing business in this geographic area and what one should be aware of when doing business with or considering Pacific Rim vendors.

DATAQUEST PRODUCT AND TECHNOLOGY UPDATE

The following Dataquest industry analysts presented updates on the major semiconductor product families and provided outlooks for the upcoming year. The topics covered were memories, microdevices, ASIC devices, chip-set trends, and overall prices and lead times.

Victor de Dios, a Semiconductor Industry Service (SIS) senior industry analyst, discussed memory market trends, stating at the outset that he had no good news regarding near-term increases in DRAM supplies. He showed the effect that the strengthening yen has had on the import and export price of Japanese memory products at various exchange rates and how current exchange levels favor internal Japanese sales. Mr. de Dios also discussed the impact that emerging memory technologies and applications will have on the future market.

The microcontroller and processor trends that were discussed by Alice Leeper, an SIS industry analyst, pointed out that the microcontroller market, although not as well publicized, enjoys almost a two-to-one dollar consumption edge over microprocessors ($2.1 billion compared with $1.3 billion). Forecasting that 8-bit microcontroller and 16-bit microprocessor products will show the strongest growth through 1993, Ms. Leeper also reviewed the 32-bit and RISC microprocessor marketplace. Noting that both markets are very young with many competitors and that standards are still being formulated as vendors vie for market share, the watchword given for this area is "caution."

Andy Prophet, an SIS senior industry analyst, showed that the ASIC market is now beyond the start-up stage but that it is not yet fully established compared with more mature standard product semiconductor markets. Mr. Prophet covered gate arrays, cell-based ICs, and programmable logic devices (PLDs), and discussed where these products are going. He showed that the life cycle of gate arrays averages 8 years and that cell-based designs average 10 years, whereas PLDs average 6 years. These life cycles reflect the design time of the devices and the corresponding applications into which these products go. In his speech, Mr. Prophet also highlighted a by-product of the ASIC revolution: the emergence of added-value design centers that create system solutions using ASIC design technology.

An example of this added-value design center approach was shown by Semiconductor User and Applications Group industry analyst Nanci Magoun, who discussed how chip sets are affecting the electronics marketplace. Ms. Magoun listed the advantages and disadvantages of chip sets for both users and manufacturers, and also identified many applications for which chip sets can and have been used with great effectiveness. By identifying the major vendors of chip sets and offering user and supplier strategies, this presentation clarified many of the issues surrounding this emerging market.

Mark Giudici, a Semiconductor User and Applications Group industry analyst, presented the prices and lead times for the major semiconductor families and described the forces that will impact this industry in the future. The product families covered in his presentation were standard logic, microprocessors, memories, and ASIC devices. In general, the mature product lines for each family (i.e., 74-S, LS, HC, C, 4-bit MCUs, slow SRAMs, low-density EPROMs, and 3-micron gate arrays) will slowly rise in price as demand shifts over to newer technologies, thereby reducing the supply of these mature parts. The effect of the economy and the U.S.-Japan Semiconductor Trade Arrangement will keep prices modulated once memory supplies come into line with demand by the end of the third quarter of 1988. It was noted that the advantages of long-term buyer/vendor arrangements described earlier in the conference have offset some of the perturbations of the current market.

GOVERNMENT INTERVENTION AND INTERNATIONAL TRADE

The second afternoon of the conference gathered together all of the parties affected by the U.S.-Japan Semiconductor Trade Arrangement. The following viewpoints were heard: AEA's senior vice president of public affairs, Ralph Thompson; SIA president, Andrew Procassini; Stack GmbH (Europe) managing director, Bernard Hadley; Dataquest senior industry analyst of the Japanese Semiconductor Service (Japan), Sheridan Tatsuno; U.S. DOC senior industry specialist for microdevices, Joan Rolf; Unisys director of procurement and contracts-Component Engineering and Procurement Organization (U.S. user), W.N. Sanabria; and National Semiconductor Corporation vice president and general manager, Microcomponents Systems Division (U.S. vendor), Randy Parker.

After the speakers gave their opening remarks describing the impact that the arrangement has had on them, a lively question-and-answer period ensued that raised many issues regarding freedom of trade and the role of government in a market dominated by one country. The issues raised at the session will continue to affect procurement practices at least through 1991, when the arrangement expires. One item was made very clear: For better or worse, government intervention has become a standardized influence in the memory procurement decision-making process for the near future.

OVERALL CONFERENCE REVIEW

This year's Semiconductor User and Applications Conference provided what most conferences strive for—a forum to discuss topical and strategic issues, both in formal and informal settings. The attendees' exchange of experiences since the last conference, as well as the information presented from the podium, was very enlightening. The theme of buying and selling semiconductors will always have a current undertone; this year, it was the availability of scarce DRAM chips. Possibly next year, the underlying theme will be that supply has come into balance with demand.

Mark Giudici

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A COMPARATIVE LOOK INSIDE AMERICA'S LEADING 32-BIT PCs

SUMMARY

As 32-bit personal computers appear on (and under) the desktops of America, new opportunities are emerging for the suppliers of ICs for these systems.

Dataquest expects 32-bit PC shipments, including those based on Intel's 80386 and Motorola's 68020 microprocessors, to exceed 1.5 million units in 1988. Shipments in 1990 will top 4 million, and perhaps reflect a much higher tally, should today's leading workstation vendors introduce PC-based systems.

While no less than 25 companies introduced 32-bit PCs last year, three manufacturers (Compaq, IBM and Apple—the "CIA" of the PC world??) captured the spotlight as the market drivers. Because these OEMs set the standard on which most clones are built, the following IC analysis of their respective products can lend some insight into the semiconductor demands for these systems. Figure 1 summarizes the IC content for system logic of 32-bit PCs offered by Apple, Compaq, and IBM. (All systems include 1MB of RAM, and only the IBM PC has graphics built into the motherboard.)

Each of these systems—Apple's Macintosh II, Compaq's Portable 386 and Desktop 386/20 with cache memory, and IBM's PS/2 Model 80—boasts proprietary features and benefits. Each has carved out its own segment: Compaq shipped an estimated 90,000 386-based PCs last year, IBM shipped more than 100,000 units, and Apple reportedly sold more than 100,000 Mac IIs too. Despite their differences, however, the following common elements with respect to IC usage and functionality have become evident:

- CMOS continues to replace TTL standard logic.
- System logic and other proprietary functions are being integrated into application-specific ICs.
- Functions such as graphics and disk drive control, once offered through add-on boards, are now being incorporated more often into the motherboard, or, at least, graphics boards are shipped with the system.

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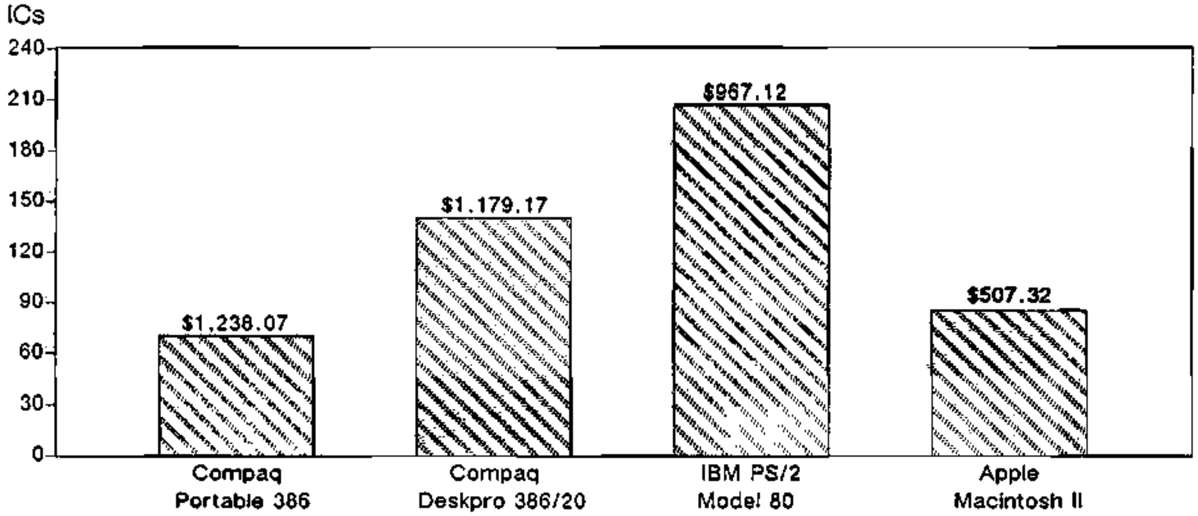
- The standard for graphics resolution is increasing.
- Smart, higher-performance disk drive interface chips are being used.
- Large standard RAM offerings (1MB) and easy memory expandability through OEM-supplied SIP modules are the norm.
- The reduced quantity of chips and use of surface-mount packaging continue to shrink the system footprint.

Figure 1

PC System Logic IC Comparison



Source: Dataquest
March 1988

MACINSIGHT INTO THE FUTURE OF PCs AND SEMICONDUCTORS

The Mac II brings a new and somewhat more serious character to Apple. Unlike the old Mac, this one has color, a large monitor, expansion slots, more on-board and addressable memory (256 times more, in fact), and is much, much faster. In other words, Apple is finally ready to compete head to head for the business and technical environments currently dominated by Big Blue (the Mac's new IBM-look-alike cabinet seems symbolic of this goal).

Most importantly, the Mac II has an open architecture. So critical was the open architecture to Apple, in fact, that Jean-Louis Gassee, vice president of product development, ordered a license plate reading "OPEN MAC," according to an article in the New York Times. The Mac's architecture combines NuBus, a well-documented multiprocessor environment developed at Massachusetts Institute of Technology, with the popular interface standard Small Computer Systems Interface (SCSI). These two elements have brought Apple a plethora of support products and peripherals from third-party vendors. This combination, in turn, affords customers a wide choice of applications and options early in the new Mac's life and is critical to its acceptance in business and technical environments.

Mac II Semiconductor and Packaging Analysis

The Mac II, built around Motorola's 68020 32-bit microprocessor and 68881 floating-point coprocessor running at 15.7 MHz, is designed to be a computational workhorse. It is shipped with 1MB of RAM—expandable to 8MB on-board and up to 2GB with NuBus expansion boards.

A look at the Mac II motherboard (Figure 2) provides evidence that Apple intends to keep pushing board and IC technologies in its quest for price/performance leadership. The Mac II motherboard contains a mere 50 ICs, excluding system RAM. It is interesting to note that the quantity of ASICs (custom and programmable chips) is approaching that of SSI/MSI standard logic devices (with counts of 16 and 21, respectively).

All of the four custom parts used on the Mac II motherboard reportedly were supplied by VLSI Technology, Inc., and include the 44-pin Apple Sound Chip (ASC), which contains two 1K sound buffers, as well as the system's 168-pin socketed Memory Management Unit (MMU). With the upcoming release of the Mac UNIX operating system (A/UX), however, VLSI's MMU will be replaced with Motorola's 68451 PMMU. The remaining eight motherboard ASICs, 15ns HAL devices in plastic dual-in-line packages (DIPs), were supplied by MMI and reportedly provide control logic functions.

Apple made use of numerous special-purpose peripheral controllers and included two Sony power amplifier/sound chips, an Integrated Woz Machine (IWM) floppy disk controller, two Apple Desktop Bus (ADB) chips, a serial port controller, as well as NCR's 53C80 CMOS SCSI controller.

Table 1 provides a breakout and estimated cost of the components used on the Mac II motherboard.

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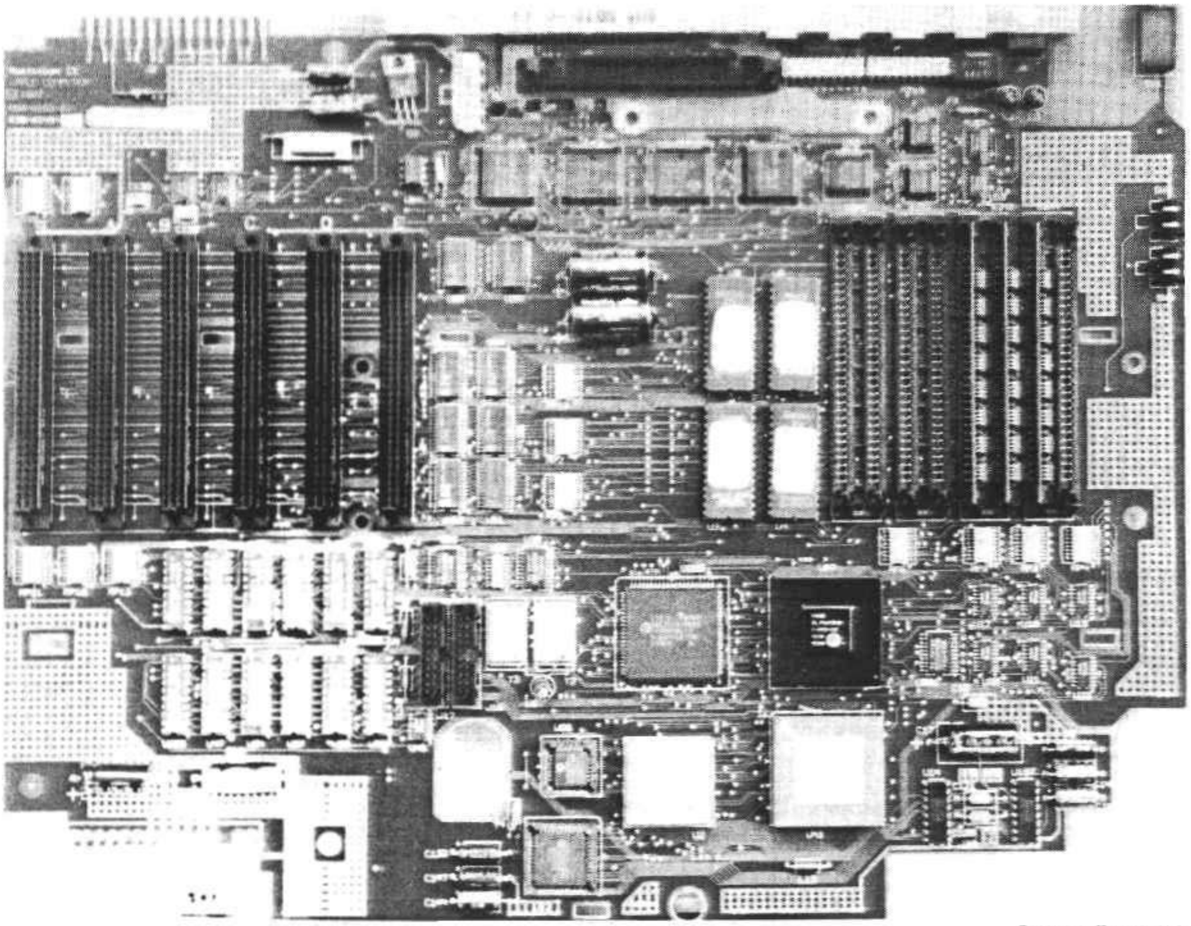
Figure 2

Mac II Motherboard



Source: Dataquest
March 1988

Table I

Mac II Motherboard IC Analysis

Component	ICs per Component	Supplier	Estimated Cost
Standard Logic			
FAST	2	Motorola	
LS	12	Motorola, MMI	
ALS	1	Texas Instruments	
AS	2	Texas Instruments	
HCL	2	Motorola	
Other	2	VLSI Technology, Motorola	
Subtotal	21		$ 7.84
ASICs			
Custom/Gate Arrays	4	VLSI Technology	
Programmable Logic	12	MMI	
Subtotal	16		118.58
Micros/Peripherals			
68020, 17.7-MHz MPU	1	Motorola	
68881, FPU Coprocessor	1	Motorola	
Peripherals/Controllers	7	Motorola, AMD, NCR, GI, Rockwell, Sony	
Subtotal	9		257.30
Memory			
DRAM (256K, 120ns)	32	NEC	
EPROM	4	GI	
Subtotal	36		123.60
Total	82		$507.32

Source: Dataquest
March 1988

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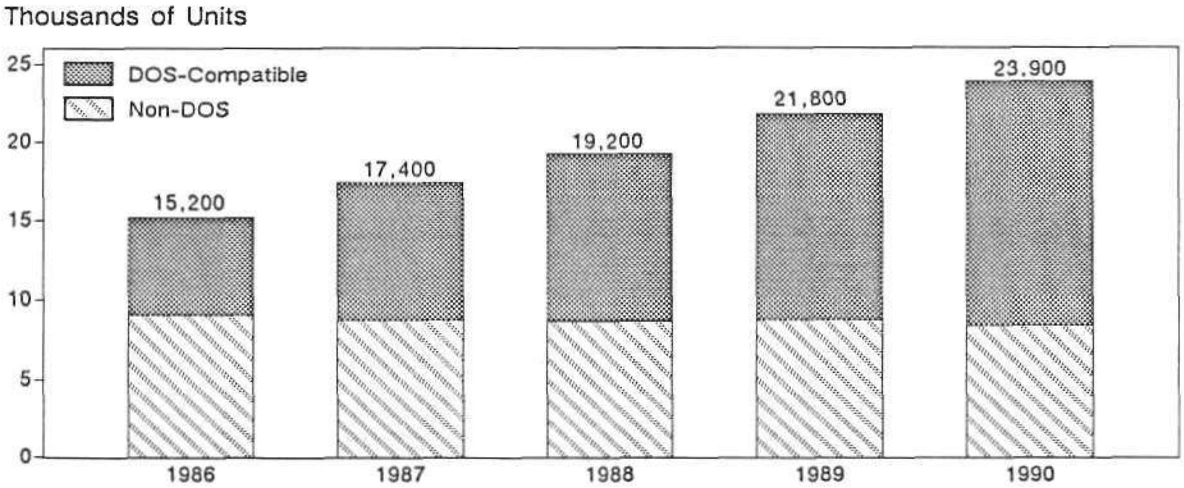
Macinferences

Whether or not the Mac II will be a success in the marketplace is another issue. After all, for most single-user PC applications, DOS machines already lead the market and, as shown in Figure 3, are expected to gain even more momentum throughout 1990. And even though the Mac II can be fitted with a $1,500 DOS board (with its own Intel 80286 processor), those wanting DOS are likely to buy a true DOS machine. (The minimum price of a DOS-fitted Mac II is $5,500 versus about $2,000 for one of many available IBM PC AT clones.)

Figure 3

PC Operating System Trends



Source: Dataquest March 1988

As a UNIX-based technical workstation, the Mac II shows more promise by offering users its friendly Apple environment for other tasks such as word processing, graphics, and desktop publishing. But in the UNIX world too, the Mac is seeing competition from more mature 32-bit workstations from makers such as Sun Microsystems. These workstations are now offered for less than $5,000.

Because it offers its own operating system, Apple has built a loyal following of patrons, and, for them, the Mac II provides their long-awaited faster and expandable machine. Its new capabilities for high-resolution color graphics, on-board memory expandability (to 8MB today, and up to 2GB later), as well as connectivity to a wide variety of input and output devices will appeal to Apple's audience of scientists, engineers, graphics artists, educators, and business users.

Undoubtedly, Apple continues to be a technical innovator, and, regardless of its long-term marketability, the Mac II can provide some good insight into the future of the PC and the related semiconductor market.

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OVERVIEW

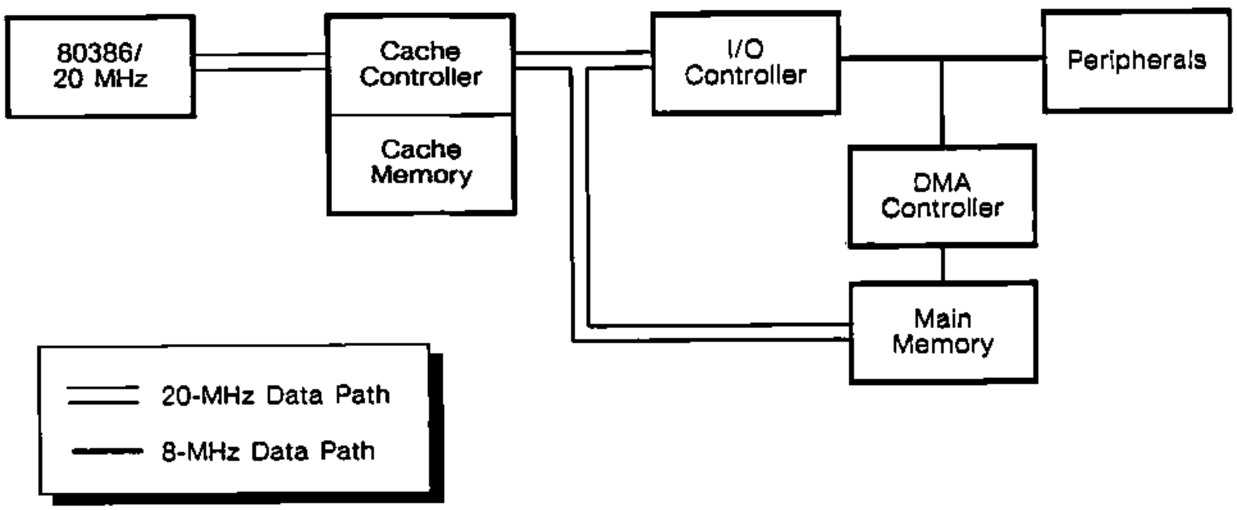
Compaq's Deskpro 386/20: Caching In

As the first manufacturer of an 80386-based PC (see SAM newsletter number 1987-08, "Impact of the Compaq 386: How the 32-bit PC Market is Shaping Up"), Compaq continued in its pioneering spirit by introducing, several months ago, one of the industry's earliest PCs with a cache memory system.

In order to implement its cache system, Compaq designed its own new architecture (Flex Architecture), which provides separate buses for concurrent memory and I/O operations. Compaq claims that such a scheme (see Figure 4) allows the system's 20-MHz 80386 processor to run at its peak performance level, while the peripheral I/O bus runs at the industry-standard 8-MHz speed.

Figure 4

Compaq Flex Architecture



Source: Compaq

The Deskpro 386/20 also incorporates a 121-pin coprocessor slot that accommodates either the Intel 80387 or pin-compatible, floating-point coprocessor board built by Weitek. The latter option reportedly provides improvement over the 80387 option in that the processing speed is more than doubled.

Compaq is the leading PC IBM clone manufacturer, capturing nearly 5 percent of the total worldwide PC market in 1986. Key to Compaq's success is its uncompromised, total compatibility with IBM's PCs. (Compaq has claimed, in fact, that its line of PCs is more compatible across the complete line of IBM PCs than are members of IBM's own line among themselves.)

As with other Compaq models, the Model 386/20 adheres to IBM's AT architecture, with Compaq not yet committing itself to Big Blue's new Micro Channel Architecture. From operating system and software points of view, at this point, there are no significant differences. From a hardware point of view, however, none of the new Micro Channel adapter boards will fit in Compaq's PCs, due to a different connector scheme. But since the PS/2 and Micro Channel are still in their infancy, Compaq has adopted the theory (shared by Dataquest) that much life is left in the AT-type architecture. When it becomes clear that the world is moving to Micro Channel, Compaq will likely move too.

Compaq Model 386/20 IC Analysis

Compaq's use of a cache memory scheme introduced some new ICs and capabilities into the personal computer arena. With Intel's new 82385 cache controller chip and 32KB of high-speed static RAM (35ns), for instance, system performance has been improved greatly over that of Compaq's earlier 80386-based models.

From an integration standpoint, Compaq has never been on the leading edge—perhaps in keeping with its compatibility with IBM. Not only did Compaq use a number of standard logic and peripheral devices that could have been integrated easily into ASICs (and, in fact were integrated into the new portable version), but also relied almost totally on space-consuming, through-hole packages. Likewise, with the standard 1MB of system RAM, Compaq uses a full add-on board (housed in a dedicated slot) with 36 256K DRAMs (80ns), 20 standard logic devices, and 2 programmable logic devices—all in through-hole packages. Tables 2 and 3 provide the IC content of the Deskpro 386/20 motherboard and memory card.

Table 2

Compaq Deskpro 386/20 Motherboard ICs

Component	ICs per Component	Supplier	Estimated Cost
Standard Logic			
FAST	22		
LS	14		
ALS	12		
AS	3		
AC	1		
Other	2		
Subtotal	54		$ 19.83
ASICs			
Custom/Gate Arrays	2	Compaq	
Programmable Logic	2	MMI, Signetics	
Subtotal	4		82.80
Micros/Peripherals			
80386, 16-MHz MPU	1	Intel	
80387, FPU Coprocessor	1	Intel	
82385-20	1	Intel	
Peripherals/Controllers	8	Intel, Signetics	
Subtotal	11		872.95
Memory			
16K SRAM, 35ns	16	Sony	
Subtotal	16		52.00
Total	85		$1,027.58

Source: Dataquest
March 1988

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Table 3

Compaq Deskpro 386/20 Memory Card ICs

Component	ICs per Component	Supplier	Estimated Cost
Standard Logic			
FAST	11		
LS	4		
ALS	5		
Other	1		
Subtotal	21		$ 7.09
ASICs			
Programmable Logic	2	MMI, Signetics	
Subtotal	2		9.50
Memory			
256K S-Column DRAM	32	Fujitsu	
Subtotal	32		$ 135.00
Total Memory Board ICs and Cost	55		$ 151.59
Total Systems ICs and Cost	140		$1,179.17

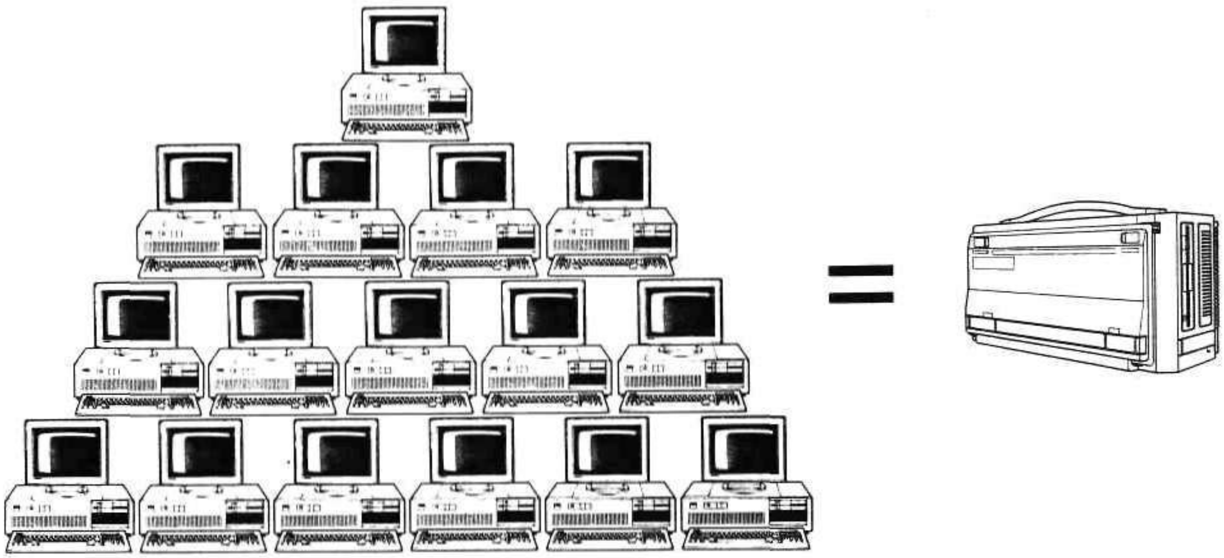
Source: Dataquest
March 1988

Compaq's 386 to Go

Squeezed into its 20-pound, 16 x 8 x 10-inch housing, Compaq's Portable 386 has the highest performance level (and the highest price, at $7,999) of all the currently available carry-along PCs. As illustrated by Compaq in Figure 5, much power has been squeezed into a small space over the years.

Figure 5

Evolution and Miniaturization of PCs



16 Original IBM PC's
Circa: *1981*
Cost: $48,000 @ $3,000 ea.
Weight: 800 lbs @ 50 lbs ea.
Performance: Total of 4.8 MIPS* @ .3 MIPS ea.

1 COMPAQ PORTABLE 386™
Circa: September 29, 1987
Cost: $7,999
Weight: 20 lbs
Performance: 5 MIPS

**Million Instructions Per Second*
COMPAQ PORTABLE 386™ is a trademark of Compaq Computer Corporation

Source: Compaq

In order to support the large installed base of old DOS-compatible software, the Compaq Portable has speed-selectable options allowing operation ranging from a full 20 MHz down to an XT-compatible 6 MHz. Because the Portable 386 is being marketed into compute-intensive technical, scientific, and business environments, the system comes equipped with 1MB of RAM, a 40MB fixed disk drive with 30ms of access time, and built-in software to support the Lotus/Intel/Microsoft (LIM) extended memory specification. (This lets software address RAM above 640KB.) For even greater performance, expansion options include an 80387 coprocessor, a 100MB fixed disk drive (25ms access time), RGB interface for hook-up of an external color monitor, as well as 32-bit memory expansion up to 10MB.

Compaq Portable 386 IC Analysis

Needless to say, squeezing so much power into such a small box necessitated the use of ASICs and surface-mount technology (SMT) packaging. Compaq used seven ASICs, all SMT, integrating a wide range of functions. Table 4 provides a summary of the functionality and number of pins for each of these parts.

Besides the ASICs and a Zilog floppy disk controller, none of the remaining 56 nonmemory ICs used SMT packaging. It is likely that future versions of this PC may require a change in packaging.

In terms of memory, as with the other PC models compared here, a standard 1MB of system RAM was included on the motherboard. The 1MB of RAM was supplied on two memory modules with six ICs each (four 256Kx4 and two 256Kx1 DRAMs), resulting in a final 512KB (with parity) in a 256Kx18 organization. Table 5 summarizes the ICs included on the Compaq Portable 386 motherboard.

Table 4

Compaq Portable 386 ASICs

Part Name (Supplier)	Package	Functions
SMAP ASIC (Fujitsu)	100-pin LCC	DMA memory page register CPU status port Memory-refresh timer
System ASIC 1	100-pin LCC	Timer/interrupt Word DMA
System ASIC 2	100-pin LCC	Timer/interrupt Byte DMA
Paged Memory Controller ASIC	80-pin LCC	CPU memory execution Cycle requests Address decoding
Expansion Bus Interface ASIC	80-pin LCC	Latch/buffer logic Data bus conversion logic Bus logic and control
Peripheral ASIC	80-pin LCC	Disk drive functions Data transfer rate control Serial/parallel interface Fixed disk drive interface Other disk drive control
FSPDS ASIC (IMP)	28-pin LCC	Floppy disk data separation Floppy disk interface circuitry

Source: Dataquest
March 1988

Table 5

Compaq Portable 386 Motherboard ICs

Component	ICs per Component	Supplier	Estimated Cost
Standard Logic			
FAST	7		
LS	17		
ALS	11		
AC	1		
Other	9		
Subtotal	45		$ 16.42
ASICs			
Custom/Gate Array	7	Fujitsu, IMP, Compaq	
Subtotal	7		227.40
Micros/Peripherals			
80386-20, 20-MHz MPU	1	Intel	
80387-20, 20-MHz FPU	1	Intel	
Peripherals	3	Zilog, Signetics, Fujitsu/Intel	
Subtotal	5		748.75
Memory			
256K EPROM	2	TI	
1Mb DRAM (80ns)	8	Toshiba	
1Mb DRAM (85ns)	4	NMBS	
Subtotal	14		245.50
Total	71		$1,238.07

Source: Dataquest
March 1988

IBM'S "MICRO CHANNEL" TO SUCCESS IN THE 32-BIT ARENA

In April of 1987, just one month after Apple's introduction of the Mac II, IBM introduced its next generation of personal computers, the PS/2. In many respects, however, IBM's announcement represented a flip-flop with Apple in corporate philosophies: As the Mac II NuBus opened up Apple's architecture, the PS/2 Micro Channel bus closed IBM's.

Consistently losing market share to a host of clone makers since its first PC introduction in 1981, IBM has an opportunity to start anew with the Micro Channel. Like NuBus, Micro Channel is an intelligent bus. When it is combined with the upcoming new operating system (OS/2), the combination enables the PS/2 to offer quantum leaps in performance and features over the previous line of IBM PCs.

Model 80 Semiconductor Analysis

IBM continues to base its PCs (migratory products in the DOS world) on the Intel 80xxx line of microprocessors. In the case of the Model 80, then, the costly ($250) 16 MHz 80386 is the heart of the system. Unlike its 80286-based counterparts, Models 50/60, the Model 80 uses an inordinate amount of standard logic components (144 versus 56). But because IBM currently offers only a bulky, free-standing 386 system, board space was not necessarily a big concern. (Perhaps the tower model was introduced prematurely as an answer to Compaq's 386, which was introduced nearly seven months earlier, before IBM had a chance to integrate much of the design into custom chips.) If, and when, the desktop version arrives, a new board design that uses more ASICs will be needed.

IBM did use several proprietary CMOS ASICs for the Model 80, including a 121-pin direct memory access (DMA) controller, a 212-pin video graphics array (VGA) chip, and an 84-pin floppy disk controller that supports two 3.5-inch drives (one 720KB drive and one 1.44MB drive). The drives can read and write into both low- and high-density disks. Interestingly, despite IBM's agreement with Intel for the latter's peripherals library, the interrupt controllers were not integrated into ASICs. Clone chip makers suggest that perhaps the function was not available as an ASIC cell. It is just as likely, however, that IBM is waiting to include additional functionality into future proprietary chips and was in no rush to integrate everything. Integration is surely in the plans, however, as evidenced by IBM's near-total use of surface-mount components. Figure 6 is an illustration of the Model 80 motherboard with its key integrated functions. This is followed by a summary of the ICs used in the Model 80 (Table 6).

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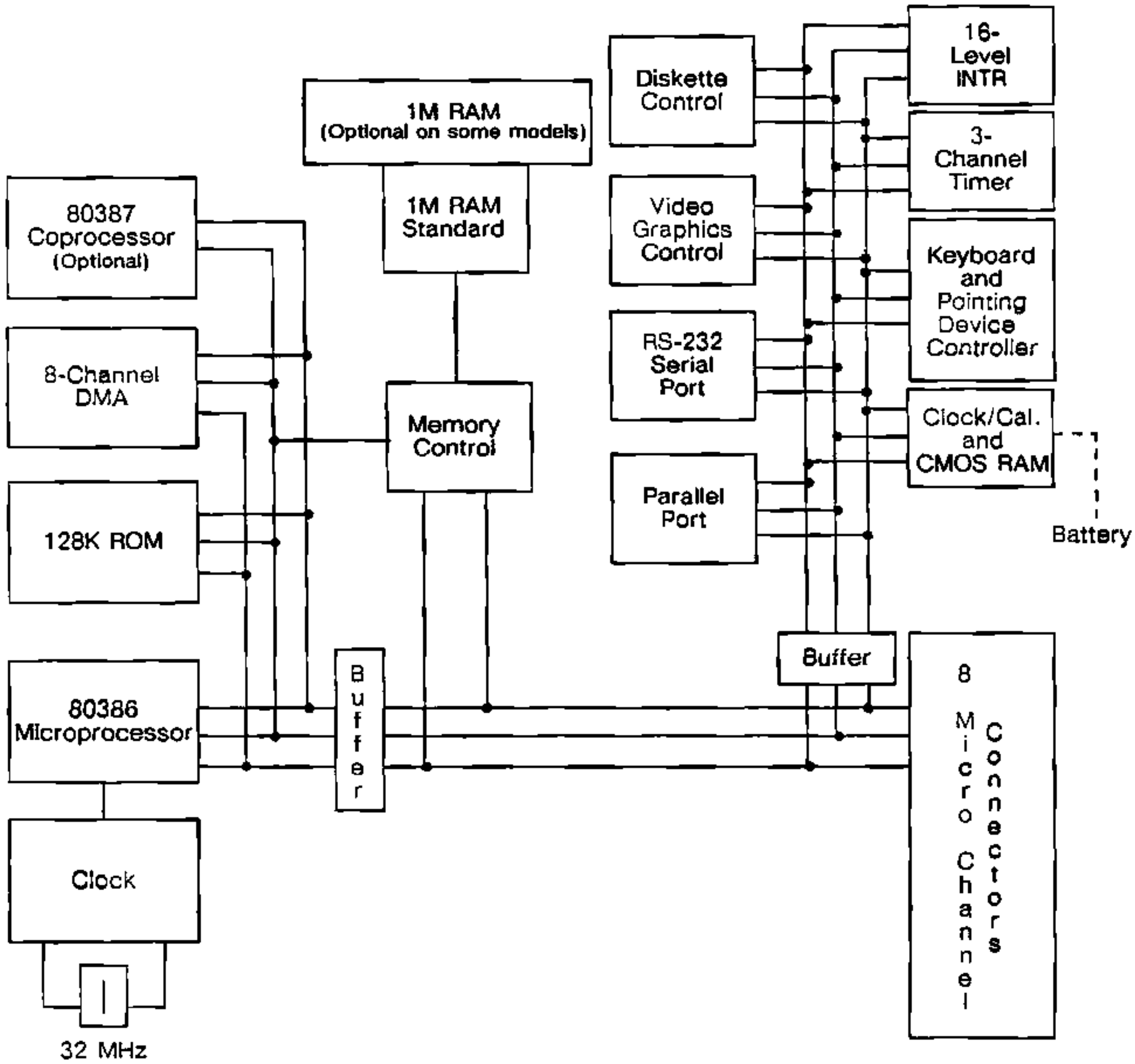
Figure 6

IBM PS/2 Model 80
System Logic Block Design



Source: IBM

Table 6

Model 80 Motherboard IC Analysis

Component	ICs per Component	Supplier	Estimated Cost
Standard Logic			
FAST	80		
LS	12		
ALS	34		
AS	2		
HCT	1		
S	9		
Other	6		
Subtotal	144		$ 49.12
ASICs			
Custom/Gate Arrays	4	IBM	
Programmable Logic	15	AMD, MMI	
Subtotal	19		$138.55
Micros/Peripherals			
80386, 16-MHz MPU	1	Intel	
80387, FPU Coprocessor	1	Motorola	
Peripherals/Controllers	6	Intel, National, NEC	
Subtotal	8		$593.00
Memory			
64K DRAM	8	NEC	
27256-12 256K EPROM	4	Intel	
IMSG171S VLUT	1	Inmos	
1MB DRAM, 80ns	10	IBM	
Subtotal	36		$186.45
Total	207		$967.12

Source: Dataquest
March 1988

DATAQUEST COMPARISONS AND CONCLUSIONS

In addition to the trends cited within the "Summary" section, our look inside these PCs reveals that the IC content of a PC—particularly in the higher-performance spectrum—represents an increasing portion of the total system cost.

Dataquest estimates that, on the average, the semiconductor I/O ratio (the cost of components compared with the final system price) for PCs priced above $1,000 was about 6.4 percent in 1987. Growth to 7.2 percent (equaling a 9 percent jump) is expected in 1988, caused largely by the migration of functionality and by the increased performance and memory requirements on the PC motherboards. As summarized in Table 7, in the cases of the four high-end PCs analyzed here, the I/O ratios were higher, averaging 12.8 percent with a coprocessor and 8.3 percent without a coprocessor.

Table 7

Integrated Circuit I/O Ratio Summary

System	PC Price	IC Cost	I/O Ratio (with Coprocessor)	I/O Ratio (no Coprocessor)
Compaq 386/20	$9,499	$1,179	12.6%	7.6%
Compaq Portable 386	$7,999	$1,238	15.5%	9.9%
IBM Model 80 (16 MHz)	$6,995	$ 967	13.8%	8.4%
Apple Mac II	$5,499	$ 507	9.2%	7.4%
Average Ratios			12.8%	8.3%

Source: Dataquest
March 1988

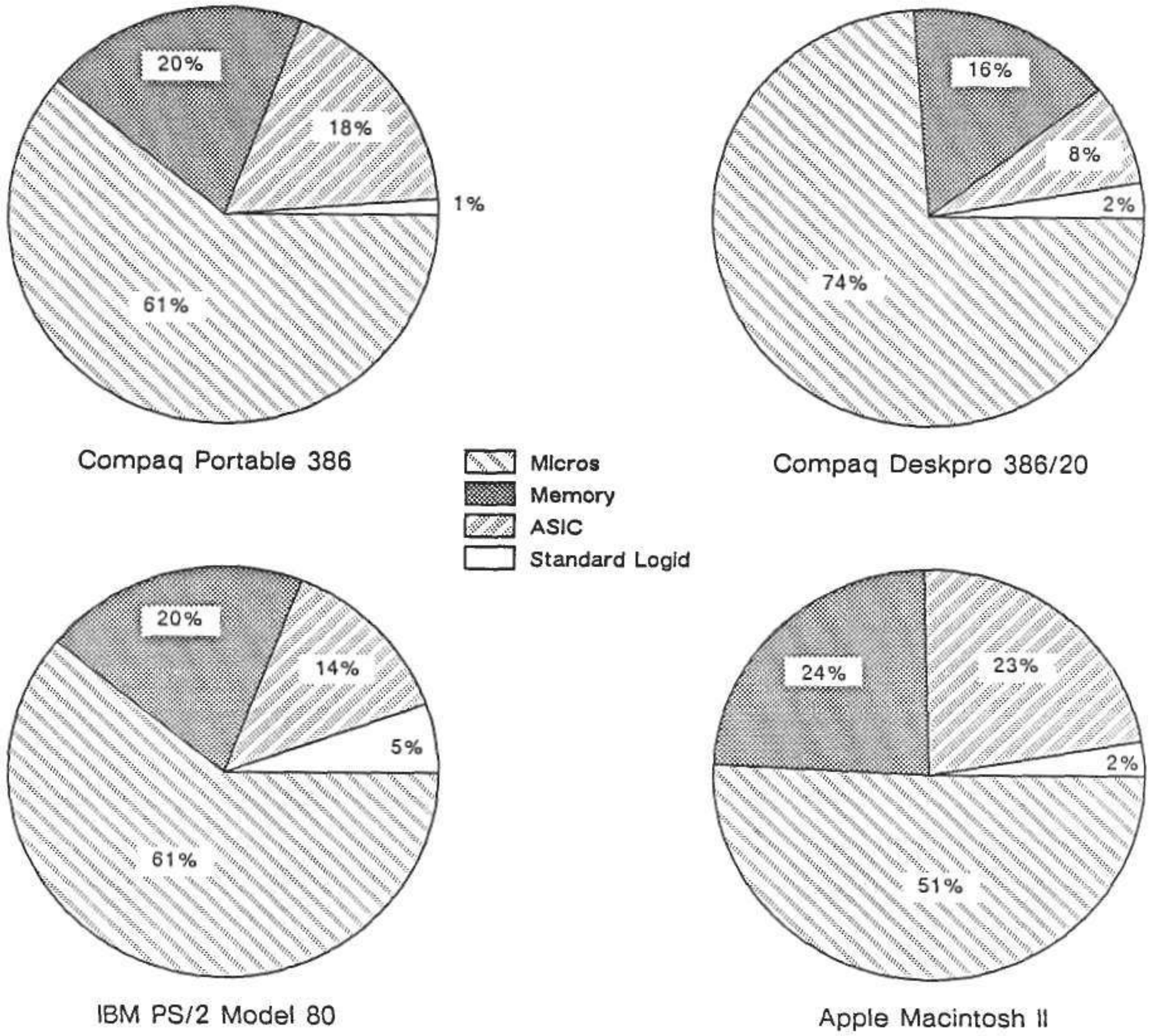
From Table 7, it appears that Apple optimized its IC usage. But this comparison is not so simple. The Mac II, after all, with its own proprietary operating system, is based on the much lower-priced Motorola microprocessor, in contrast to the other DOS-based PCs requiring Intel-designed parts. In fact, if one factored in the incremental cost ($510) of Intel parts—a 20-MHz 80386 and 80387—over the IC cost of Motorola parts in a Mac II, Apple's semiconductor I/O ratio would jump to 18.5 percent.

With respect to these microdevices, it is also interesting to note the much greater drop in the I/O ratios for the DOS-based machines when the coprocessor cost is omitted. This relates to Intel's practice of charging a heavy premium for a coprocessor ($450 in volume for a 20-MHz 80387, which is 65 percent more expensive than the 80386 microprocessor to which it attaches) versus Motorola's strategy to attract the incremental business ($100 for the 20-MHz 68881 coprocessor and $130 for the 68020 in volume).

A look at the overall consumption of the various types of ICs used in each of the PCs is presented in the pie charts in Figure 7. As illustrated, next to the microdevices, memory chips account for the largest IC expense in building PCs. Given today's volatile memory market and skyrocketing prices due to the worldwide memory chip shortage, memory chips now represent a higher portion of the total system cost. (The IC costs for each PC in this report are based upon estimated prices in the quarter of product introduction.)

Figure 7

Comparison of ICs in the 32-Bit PCs (Percentage of Total System IC Cost)



Source: Dataquest
March 1988

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Finally, though not surprisingly, the two PCs with the smallest system logic footprints made the heaviest use of ASICs, in terms of both percentage of the total IC cost as well as functionality per IC. In all cases, it is evident that the use of ASICs has displaced most of the small- and medium-scale integration (SSI/MSI) standard logic components in these PCs. (SSI/MSI parts average just 2.5 percent of the total IC dollars spent per system.) This does not imply that standard logic has met its end in the PC world: New opportunities are arising for more highly integrated (LSI) parts as well as for the hybrid (application-specific standard logic) devices known as chip sets.

With the demand for high-end PCs to handle desktop publishing, office automation and networking, and technical applications, system architectures and operating systems will continue to evolve rapidly in the years to come. As predicted for some time, OEMs will utilize more and more ASIC technology (and surface-mount packaging) in order to push performance and integration. (Apple Computer has recently established an ASIC task force to research its own market demands and industry trends for the next 5 to 10 years.)

As IBM and Microsoft begin to deliver their next-generation PC operating system, OS/2, memory chip suppliers will see their greatest challenges, and rewards, in recent times. For instance, users of IBM's enhanced version of OS/2, known as the extended edition (OS/2EE), will require a minimum of 4MB of system RAM. In addition, the need for ever faster, higher-density, and safer permanent data storage will drive continued development of removable storage devices requiring fast, dense, and nonvolatile memory ICs.

Another area of growing interest and applicability to IC suppliers and OEMs alike is that of software emulation products that can allow DOS applications to run on previously non-DOS compatible platforms. A company named Insignia Solutions, for instance, introduced a software package that allows a Sun workstation (and reportedly soon, a Mac II) to operate totally as a fully functional DOS-compatible PC. Disk drives can be attached and DOS floppy disks can be used—all running as one window or multiple windows under the host operating system, UNIX. Several other companies are working on similar products. The implications of such products, if they are fully developed as promised, are great. PC buyers will be able to select any platform that best suits their primary needs and, at the same time, satisfy their company's requirements for fully DOS-compatible systems. This, of course, could open the doors to an even greater array of system and IC suppliers.

In any case, PCs continue to be major consumers of ICs, and a mutual dependency is growing stronger between OEMs and silicon suppliers. Those who are able to establish strong relationships in the near term will be best suited to face the design, supply, and pricing challenges for PCs in the next decade.

Nanci J. Magoun

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RISC ARCHITECTURE: A PROCESSING PANACEA OR A COMPETITIVE MARKET MEASURE

INTRODUCTION

Much has been written regarding microprocessors using reduced-instruction-set computing (RISC) architecture. Currently, there is ongoing debate between complex-instruction-set computing (CISC) and RISC architecture companies, with each camp vying for the title of the fastest processing machine.

Depending on the application, each type of processor has merits. Since the merits of CISC are already well known, this newsletter defines RISC, outlines the market participants and products, submits a user perspective, and provides a market forecast.

WHAT IS RISC?

The definition of RISC lends itself to the tenet that simpler is better. By design, not only is the instruction set reduced, but so is the complexity of the control logic and of other internal facilities. In accordance with that belief, RISC machines have architectures that are typically hardwire controlled rather than microcoded. They perform simple loading and storing operations via a very fast set of on-chip registers, using a sophisticated memory hierarchy to maintain efficiency.

The current objective of RISC is to execute one instruction per clock cycle in a sustained manner. As technology progresses, this rate could be reduced to one instruction per partial cycle or even multiple instructions per cycle.

Also, it has been determined that about 80 percent of an average computational task is performed by 20 percent of the instruction set. This statistic formed the foundation of a simplified instruction set with the goal of reducing the number of clock cycles per instruction executed.

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The Technical Aspects

Performance is clearly the key in virtually all semiconductor devices. Moreover, in RISC designs, this has never been more true. Effective processing speed, as measured in millions of instructions per second (mips), is the yardstick by which true performance is measured. However, the cost of those desired mips is becoming the next largest parameter for a selection decision.

WHAT PRODUCTS ARE AVAILABLE AND FROM WHOM?

Currently, several companies produce a RISC or RISC-like microprocessor engine. The implementations vary, but the general theme remains the same. Table 1 lists the current market participants and their announced products.

Many of the suppliers listed in Table 1 are alternative sources of original designs from a few select companies. Dataquest believes that more original designs will be released to the merchant market over the next couple of years. However, partnerships are now being formed to build needed support.

Table 1

RISC Microprocessor Suppliers and Products

Company	Product
Acorn Ltd.	ARM
AMD	Am29000
BIT	SPARC* version (ECL)
Cypress	SPARC version (CMOS)
Fujitsu	MB86900 (SPARC)
IDT	R2000 second source
INMOS	T414, T800
Integraph	C300 (Clipper)
LSI Logic	R2000 second source
MIPS Computer Systems	R2000
Motorola	Name not announced
Performance	R2000 second source
VLSI Technology Inc.	VL86C010 (ARM)

*SPARC is a design originated by Sun Microsystems.

Source: Dataquest
March 1988

SYSTEM DESIGN/APPLICATIONS

Simply stated, the movement toward RISC designs has been prompted by the basic need for the accelerated processing of data. Companies involved in designing systems or peripherals have recognized the benefit of using RISC as the computing engine, but they have implemented this in various ways. Table 2 shows several system manufacturers and their design approaches.

As noted in Table 2, many systems manufacturers have their own approaches, either via in-house microprocessor designs or perhaps by implementing ASIC versions (discrete). What this may imply is that not all of the traditional computing applications are ready for merchant RISC microprocessor solutions.

It is highly probable that even as more merchant RISC devices are introduced to the market, some, if not many, systems suppliers will still choose to implement their own designs to fit very specific requirements.

This might suggest that other applications are better suited to the merchant RISC devices. These applications, such as high-speed disk drives, graphics, communication, and even signal processing, could be in the peripherals area.

Table 2

System Designs Using RISC Architectures

Company	RISC Method
AT&T	Merchant MPU (SPARC)
Celerity Computing	Discrete design
Edge Computers	Discrete design
Hewlett-Packard	Proprietary MPU
IBM	Proprietary MPU
MIPS Computer Systems	R2000
Prime Computer	Merchant MPU (R2000)
Pyramid Systems	Discrete design
Ridge Computers	Discrete design
Silicon Graphics	Merchant MPU (R2000)
Sun Microsystems	SPARC
Xerox	Merchant MPU (SPARC)

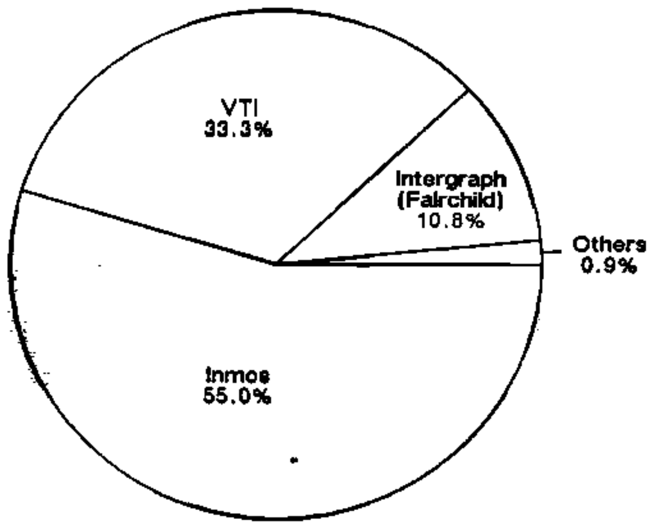
Source: Dataquest
March 1988

RISC FORECAST

Dataquest estimates that RISC processors accounted for approximately 60,000 units shipped in 1987, or almost 4 percent of the total 32-bit microprocessor market. Figure 1 shows Dataquest's estimates of the market shares of the three primary suppliers of commercial RISC microprocessors in 1987.

Figure 1

Estimated 1987 RISC Unit Market Share



Source: Dataquest
March 1988

With the number of RISC designs being introduced, Dataquest expects shipments of RISC processors to increase rapidly from 1987 through 1992, growing at a compound annual growth rate (CAGR) of 151.4 percent, which is faster than that of CISC processors. Dataquest forecasts that by 1992, RISC processors will account for 29.0 percent of all 32-bit processor revenue (see Figure 2). However, this rapid growth should begin to slow as the market matures.

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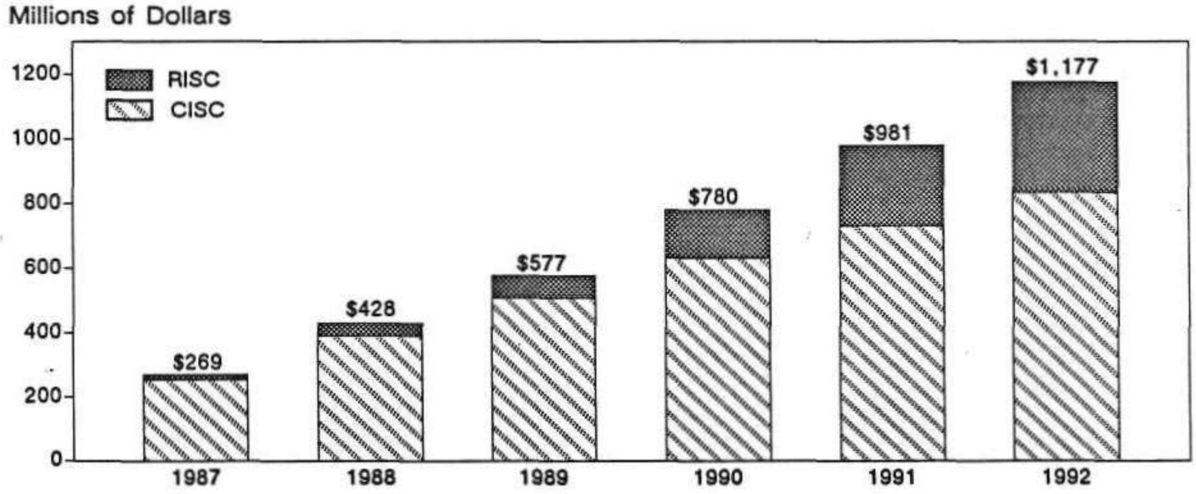
Figure 2

32-Bit Microprocessor Revenue Forecast



Source: Dataquest
March 1988

DATAQUEST ANALYSIS

All evidence points to the fact that RISC, as a discipline, clearly has a place in the computing market, but it may not be an end-all for architectural evolution. CISC is far from a fading breed. There are many ways to enhance performance, and specific aspects of RISC are clearly applicable to CISC speed enhancement. Hence, Dataquest believes that the two approaches can coexist and perhaps contribute to the evolution of monolithic microprocessors from the TTL logic replacements that they once were to the more sophisticated computers-on-a-chip that they might eventually become.

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Mark A. Giudici
Brand A. Parks
Alice K. Leeper

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Research *Newsletter*

SUIS Code: 1988–1989 Newsletters: January–March
1988–05

IBM: SEMICONDUCTOR SUPPLIER AND BUYER

OVERVIEW

IBM is facing a future where its position in computer markets is being challenged. Between plug-compatible mainframe makers and PC clone houses, IBM's is under attack in almost every market that it serves. The road to survival will test, among other skills, IBM's ability to utilize new technology effectively. Its case could prove to be a model for OEMs and a useful guidepost for merchant semiconductor suppliers.

Crucial elements of IBM's forward strategies are the management of semiconductor technology and its application to system solutions. Having the right technology at the right time is vitally important to this quest. Although IBM secures a large part of its semiconductor needs on the outside, it also has recognized the need to develop its own technology and production facilities. Toward this end, IBM has embarked on a plan to invest heavily in semiconductor technology development and manufacturing capability.

Dataquest estimates that in 1986, IBM had $36.0 billion in worldwide hardware revenue and consumed an estimated $2.9 billion in semiconductors. We believe that IBM purchased $1.1 billion of its total semiconductor consumption. This made IBM, for that year, the largest buyer of semiconductors in the world, accounting for 4 percent of the total open semiconductor market. The remainder of IBM's consumption, $1.8 billion, was satisfied internally, making the company also one of the top three producers in the world.

The balance between making and buying semiconductors is affected directly by IBM's competitive strategies. The strategic sensitivity of the target system will determine, to a great degree, the source of the technology. If the system is commodity-like, then, typically, it will utilize a high percentage of merchant components. IBM's first personal computers typified commodity-like systems, as they consisted of 95 percent merchant semiconductors. If a system is deemed strategic, then IBM typically will use captive semiconductor technology. With captive capability, it can create computer systems that not only hit new price/performance goals but also create defensible competitive boundaries with proprietary silicon architectures. The PS/2 and the implementation of the Micro Channel Architecture are good cases in point.

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MAKE OR BUY DECISIONS

Although the strategic nature of a system most heavily affects the source of technology, several secondary factors also affect the process. An ever-present factor in any of these decisions is the very real event of not-invented-here (NIH), especially in a situation in which there is some overlap with internal programs. In this situation, objectivity is paramount. Often, the best technology-sourcing decisions are made by placing a project in a semiautonomous environment, as IBM did with its highly successful PC program. The following are many of the factors that IBM or any OEM considers when assessing the semiconductor make-or-buy crossroad:

- These factors favor captive sourcing:
  - Proprietary or advanced technology required for system differentiation
  - Custom needs (e.g., military, consumer, packaging)
  - Controllable supply, delivery, costs, and quality
- These factors favor merchant sourcing or alliances:
  - Up-front investment not possible
  - Proprietary hardware technology not needed
  - Technology incubation in an entrepreneurial environment
  - Surge demand coverage
  - Supplementary or complementary extension of internal resources

ELECTRONIC EQUIPMENT MANUFACTURING

Dataquest compiled the following list of various electronic equipment manufacturing and technology locations for IBM's worldwide operations. With the exception of the personal computer (Entry Systems Division) and military/aerospace (Federal Systems Division) groups, these locations are involved in very little volume procurement. However, the engineering and manufacturing input to the procurement decision can come from any of these locations.

- Personal computers and workstations:
  - Boca Raton, Florida
  - Raleigh, North Carolina
  - Austin, Texas
- Mainframes
  - Poughkeepsie, New York

- Midrange and special computers
    - Endicott, New York
    - Rochester, Minnesota
    - Boeblingen, West Germany
    - Kingston, New York
    - Yasu, Japan
- Storage systems
    - San Jose, California
    - Rochester, Minnesota
    - Tucson, Arizona
    - Fujisawa, Japan
    - Hursley, United Kingdom
- Printers
    - Charlotte, North Carolina
    - Endicott, New York
    - Boeblingen, West Germany
    - Lexington, Kentucky (phasing out)
- Display terminals
    - Raleigh, North Carolina
    - Hursley, United Kingdom
    - Kingston, New York (graphics also)
    - Fujisawa, Japan
- Typewriters/keyboards
    - Lexington, Kentucky
- Copiers
    - Charlotte, North Carolina

- Military/aerospace
  - Manassas, Virginia
  - Owego, New York
  - Houston, Texas
  - Gaithersburg, Maryland
  - Huntsville, Alabama
- Communication
  - Raleigh, North Carolina
  - Gaithersburg, Maryland
  - Santa Clara, California
  - La Gaude, France
- Research
  - Yorktown Heights, New York
  - Zurich, Switzerland
  - San Jose, California

Table 1 presents a detailed breakdown of the PS/2 manufacturing organization.

Table 1

PS/2 Manufacturing Organization

Location	Internal Role
Austin, Texas	Main board production
Boca Raton, Florida	Final assembly and test
Fujisawa, Japan	Production of 3.5-inch disk drives
Lexington, Kentucky	Keyboard and 5.25-inch Winchester drive controller production
Raleigh, North Carolina	Display production and Model 30 assembly
Rochester, Minnesota	Production of 5.25-inch Winchester disk drives
Toronto, Canada	Austin subsidiary and power supply assembly
Greenock, Scotland	Board and final assembly
Guadalajara, Mexico	Board and final assembly
Wangaratta, Australia	Board and final assembly

Company	External Role
Alps Electronics, Ltd.	Source of 3.5-inch disk drive
Avco Electronics	Assembler of memory and graphics boards
SCI Systems, Inc.	Prime off-load of main processor board production
Solectron Corporations	Secondary off-load of main processor board
Tatung, Co.	Display source
Texas Instruments, Inc.	Secondary off-load of main processor board

Source: Electronics Busines
March 1988

SEMICONDUCTOR TECHNOLOGY AND MANUFACTURING

IBM has extensive capabilities in fundamental semiconductor research and applied research and development, as well as manufacturing technology. Although often associated with avant-garde developments in solid-state physics, such as the recent breakthroughs in superconducting, IBM also has a proven track record in bringing semiconductor technology into volume application. IBM is, in fact, one the world's leading 1 Mbit DRAM suppliers—its market being itself.

IBM is in a position to cover a full spectrum of system architectures and performance requirements by possessing both submicron MOS as well as high-performance bipolar processes. It is also strong in the area of packaging, in which it has developed a high-density, high-heat-dissipation technology called Thermal Conduction Module (TCM). This packaging technique has helped IBM flagship 3090 computer family achieve vast performance improvements over prior offerings. They also have extensive presence in ASIC technology. Given the level of gate array usage, especially in its mainframes and personal computers, IBM is believed to be the world's largest producer of gate arrays.

The company has also taken a leading position in the Sematech program. Along with AT&T, IBM has offered some of its leading-edge products (1 and 4 Mbit DRAMs) to the project as test vehicles to perfect new manufacturing techniques.

IBM is estimated to have invested $2 billion in semiconductor manufacturing capability over the past three years. Research and development expenditure, as related to semiconductor technology, is also estimated to be $2 billion for the same time period. Manufacturing investments have been global. Both the Vermont and New York facilities were expanded, as were international facilities in France, West Germany, and Japan. It is believed that the bulk of the resources is going toward development of CMOS processes and products and toward the continued refinement of bipolar capability. CMOS technology is needed for IBM's program of supplying the needs of both the Entry Systems Division as well as the small and midrange computer groups. IBM is also believed to be the only United States-based company to have invested in 8-inch wafer processing capability. Moreover, IBM also participated in the VHSIC program and is using that technology through the Federal Systems Division.

Table 2 is a listing of IBM's principal semiconductor-related facilities located worldwide.

As an integral part of its technological strategy, IBM acquires technology from outside entities, as necessary. Through a series of strategic alliances ranging from direct investments to joint developments and exchanges, IBM has complemented its internal resources. Table 3 lists a sampling of some of those relationships.

Table 2

IBM Semiconductor Facilities

Location	Activity
Essex Junction/Burlington, Vermont	R&D, MOS and bipolar production
Hopewell Junction/East Fishkill, New York	R&D, MOS and bipolar production
Manassas, Virginia	R&D, VHSIC production
Corbeil-Essones, France	R&D, MOS and bipolar production
Sindelfingen, West Germany	MOS memory production
Hannover, West Germany	MOS memory production
Yasu, Japan	MOS production
Boeblingen, West Germany	R&D
Zurich, Switzerland	R&D
San Jose, California	R&D

Source: Dataquest
March 1988

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Table 3

Technological Alliances

Company	Purpose
GE	ASIC and BICMOS smart power, joint development and production
Intel	Access to microprocessor designs, ASIC joint development
Oxford Instruments	Development of synchnrotron for X-ray lithography (0.1 micron)
Rockwell	Digital GaAs joint development
Texas Instruments	Local area network ICs

Source: Dataquest
March 1988

PROCUREMENT PRACTICES

It has been said that the effort of getting a product qualified for sale to IBM is not unlike the approval process for military markets. The scrutiny under which IBM places the product design, the manufacturing methods, the management, and general service issues is unsurpassed. But more often than not, when the qualification process is completed, the vendor has a better product and better overall system to serve the needs of its customer base.

Corporate Component Procurement (CCP) in Poughkeepsie, New York, and Component Procurement European Center (COMPEC) in Canejan, France, coordinate the majority of IBM's semiconductor procurement worldwide. In the past, varying degrees of procurement control have been delegated to the Entry Systems and Federal Systems Divisions to serve their unique needs.

The following is a list of vendor qualification criteria applied by IBM's procurement personnel to potential suppliers:

- Latest technology available
- Business/technical interfaces
- Local manufacturing
- Internal data to support qualification
- Competitive pricing
- Just-in-time (JIT) delivery
- Serviceability
- Flexibility of supply
- Zero-defect quality

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Qualification can take from from 6 to 18 months. Both product performance and reliability are assessed through electrical testing and defect analysis (life test and physical analysis). Initially, quality is assessed by IBM, but, in time, as vendor relationships mature, responsibility for quality assurance can be delegated to the vendor. As a preventative measure, IBM may ask that key process control data be submitted on a regular basis. Upon qualification of a product, IBM will place the vendor on an annual program of quality improvement, complete with monthly monitoring, quarterly reviews, and regular meetings.

Semiconductor Procurement

IBM worldwide hardware revenue was approximately $36 billion in 1986. Table 4 is a breakdown of IBM's revenue, based, in part, on its annual report and on market share estimates from other technology services within Dataquest. The largest revenue segment was in mainframe or corporate resource computing systems, accounting for an estimated 36.5 percent of the total. Personal computers reflected the second largest segment, accounting for 19.1 percent, and storage systems for 18.7 percent.

By using a combination of input/output (I/O) modeling and industry surveys, Dataquest estimates IBM's total 1986 semiconductor consumption is in Table 5. The total of $2.86 billion represents an I/O factor of 7.9 percent.

Figure 1 presents the estimated 1986 semiconductor purchases for IBM. These numbers are based on both primary and secondary research sources. We estimate that semiconductor purchases represented 39 percent of IBM's total needs. Its also estimated that the Entry Systems Division, in sourcing for the personal computer line, accounted for 60 percent of those purchases. The Federal Systems Division is also a heavy user of merchant components. Prior content analyses done at Dataquest indicate that the low-end printers and display terminals also use a high percentage of outsourced devices.

Table 4

Estimated IBM 1986 Worldwide Revenue by Major Product Line (Millions of Dollars)

Product	Revenue
Mainframe Systems	$13,133
Personal Computers	6,880
Storage	6,736
Midrange Systems	3,666
Military/Aerospace	2,121
Display Terminals	1,040
Communication	900
Printers	800
Typewriters	393
Copiers	326
Total	$35,995

Source: Dataquest
March 1988

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Table 5

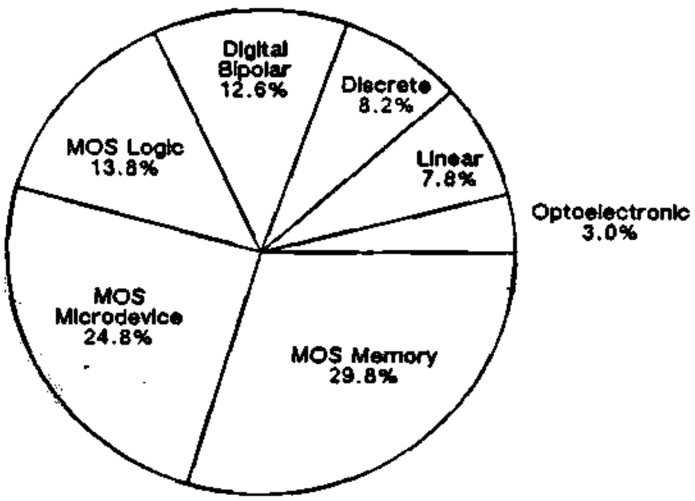
Estimated IBM 1986 Semiconductor Consumption by Major Product Line (Millions of Dollars)

Product	Semiconductor Consumption
Mainframe Systems	$1,160
Personal Computers	790
Midrange Systems	384
Storage	235
Military/Aerospace	105
Communication	65
Display Terminals	60
Printers	42
Typewriters	12
Copiers	7
Total	$2,860

Source: Dataquest
March 1988

Figure 1

Estimated IBM 1986 Semiconductor Purchases



Total = $1,125 Million

Source: Dataquest
March 1988

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DATAQUEST CONCLUSIONS

In the battle for the global computer system markets, IBM has chosen to rely heavily on internal semiconductor technology as part of its overall strategy. Although IBM's complete 1987 financial results were not released before publication of this newsletter, we estimate that outside semiconductor purchases were down 5 to 10 percent from 1986. The prime component driving the declining purchases is the ramp-up of the PS/2 line, which uses predominantly captively produced components.

Given the desire to incorporate proprietary technology to differentiate its strategic systems as well as the intensity of semiconductor capital investment and R & D, we believe that IBM will continue to reduce its dependency on merchant supply. However, the "leftovers" could well continue to be a billion dollar opportunity for fortunate suppliers.

Gregory L. Sheppard

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Research Newsletter

SUIS Code: 1988–1989 Newsletters: January–March
1988–4

THE QUICKENING PACE OF DRAM SHORTAGES AND RISING PRICES

In September 1987, Dataquest predicted higher 1988 DRAM prices in a research bulletin entitled "Higher DRAM Prices Forecast: The Politics of Pricing." The 256K DRAM prices were projected to hit $3.00 by the end of 1988, and 1Mb DRAM prices were expected to decline at a very slow rate.

The price forecasts drew justifiable skepticism. By the end of 1987, the foreign market values (FMVs) of both 256K and 1Mb DRAMs dropped substantially below market prices. MITI effectively lifted the production constraints and allowed higher levels than manufacturers could reasonably match. There were no reports of rampant production line stoppages due to the DRAM storage. DRAM vendors announced aggressive 1Mb DRAM production plans.

Fears of 256K DRAM shortage were also relieved. Texas Instruments announced a foundry agreement with Hyundai. Micron Technology boosted its capacity with a successful die shrink program.

However, in January DRAM users were greeted with sudden changes in the DRAM market.

- The 256K DRAM shortage became a greater problem than the 1Mb DRAM deficit. Unauthorized distribution channels currently sell at $4.00 to $6.00. Certain manufacturers raised their prices to about $3.50 for standard speeds and packages. Others now carry $4.00 prices in their backlogs.

- Once a growing pipeline, the 1Mb DRAM supply via unauthorized channels tightened, raising prices in these channels to about $30.00 to $40.00. Dataquest believes that many DRAM users depend on these channels for upsides and variations in their purchasing requirements.

- The European and Asian markets are desperate in their 256K DRAM needs. Dataquest heard that U.K. Prime Minister Margaret Thatcher recently sent a letter to Japanese Prime Minister Noboru Takeshita concerning the damage that DRAM shortages are wreaking on her country's electronics industry.

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POTENTIAL CAUSES

From our investigation and observations, Dataquest believes that the following are the probable causes of recent events.

- Japanese manufacturers recently finalized their fiscal 1988 budgets. Dataquest believes that DRAM users have discovered that the production plans remain conservative and will not meet their projected demand requirements. Many manufacturers have indicated that they are booked through the third quarter of 1988.

- There are reports that in January, MITI further tightened DRAM exports by unauthorized distribution channels such as some Japanese sales representatives and trading companies. There are very limited noncaptive 1Mb DRAM applications in Japan at present. Dataquest believes that this situation is causing the Japanese distribution channels to seek business abroad. These distribution channels are reputable companies and are not to be mistaken for the suitcase brigades.

- The 1Mb DRAM yields still are not performing to plan for many companies, especially those employing trench calls. While there are legitimate technical difficulties, Dataquest believes that the political umbrella—the trade agreement and MITI initiatives—has lessened competitive intensity and the drive to improve costs and yields.

- Tragedy also contributed to the January demand shortage. In late December, a severe earthquake reportedly damaged Hitachi's Mobara plant, a major 1Mb DRAM producer. Although the extent of the damage cannot be ascertained, Dataquest believes that at least January availability was affected. The Taiwan market suffered a major blow, with the theft of NT$ 50 million worth of 256K DRAMs from the Taipei airport.

1988 OUTLOOK

Dataquest expects the high third-channel prices to have a short-lived effect. Eventually, the DRAMs will find the appropriate channel, which, in this case, should be the manufacturers' legitimate overseas operations.

However, DRAM users should brace themselves for gradually increasing 256K DRAM prices and only slight decreases in 1Mb DRAM prices in the United States. Levels of 256K DRAM production continue to decrease. With the conservative investment status in the industry, many manufacturers are transforming their 256K DRAM production areas into the 1Mb DRAM production sites. On the other hand, 1Mb DRAM availability is not likely to grow substantially, as manufacturers still struggle with their yields.

DATAQUEST ANALYSIS

Dataquest sees little relief this year in DRAM availability, as long as product demand remains robust. DRAM users must contend with four factors that will greatly limit availability.

- DRAM producers remain skeptical about the demand requirements and booking rates of their customers. Many still recall the 1985 "nightmare" and cringe at the thought of reliving it.

- Political intervention by MITI and the U.S. Department of Commerce has limited competition and, with it, the urge to improve yields and capacity rapidly.

- U.S. manufacturers can provide a semblance of 1Mb DRAM competition but hesitate to do so because of technical problems and the alluring profits of the 256K DRAM market.

- The SIA and MITI may lock horns again soon over the Japanese market access issue and the imposition of new trade sanctions. Hidden agendas and plans of action may once more disrupt the DRAM marketplace.

Manufacturers maintain control of their destinies only within a confined space. The boundaries of this space are clearly determined by governmental agencies. Within the confined space, these manufacturers face great uncertainty concerning future demand and a fluctuating exchange rate.

Mark A. Giudici
Victor de Dios

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Dataquest

Conference Schedule

1988

Semiconductor Users/Semiconductor Application Markets	February 22-23	Westin St. Francis Hotel San Francisco, California
Computer Products	March 1	Hotel Inter-Continental New York City, New York
	March 4	Back Bay Hilton Boston, Massachusetts
	March 7	Santa Clara Doubletree Inn Santa Clara, California
Copying and Duplicating	March 7-9	The Pointe at Squaw Peak Phoenix, Arizona
Imaging Supplies	March 9-10	The Pointe at Squaw Peak Phoenix, Arizona
Telecommunications	March 21-23	Hyatt Regency Monterey Monterey, California
Electronic Printer	April 5-7	Hyatt Regency Monterey Monterey, California
Imaging Supplies	April 7-8	Hyatt Regency Monterey Monterey, California
Japanese Semiconductor	April 11-12	Century Hyatt Hotel Tokyo, Japan
Computer Storage	April 18-20	Santa Clara Marriott Santa Clara, California
Color Conference	May 2-3	Hyatt Regency Cambridge Cambridge, Massachusetts
European Semiconductor	June 8-10	Gleneagles Hotel Auchterarder, Scotland
Display Terminals/Graphics and Imaging	June 13-15	Hyatt Regency Monterey Monterey, California
Electronic Publishing	June 16-17	Silverado Country Club Napa, California
European Copying and Duplicating	June 29-July 1	Bristol Hotel Kempinski Berlin, West Germany
Financial Services	August 28-30	Silverado Country Club Napa, California
Western European Printer	September 7-9	Hilton International Wien Vienna, Austria
Manufacturing Automation/CAD/CAM	September 12-15	Hyatt Regency Monterey Monterey, California
Personal Computer	September 21-23	Silverado Country Club Napa, California

(Continued)

Information Systems	September 30–October 7	Tokyo American Club Tokyo, Japan
Technical Computer	October 5–7	San Diego Princess San Diego, California
Semiconductor	October 17–19	San Diego Princess San Diego, California
European Telecommunications	October 19–21	Hilton International Brussels Brussels, Belgium
Office Equipment Dealer/ Electronic Typewriter	November 2–4	Hyatt Regency Cambridge Cambridge, Massachusetts
Asian Semiconductor and and Electronics Technology	November 7–8	Seoul, Korea
Industrial Automation	November 30–December 2	Palace Hotel Madrid, Spain

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Research *Bulletin*

SUIS Code: 1988–1989 Newsletters: January–March
1988–03

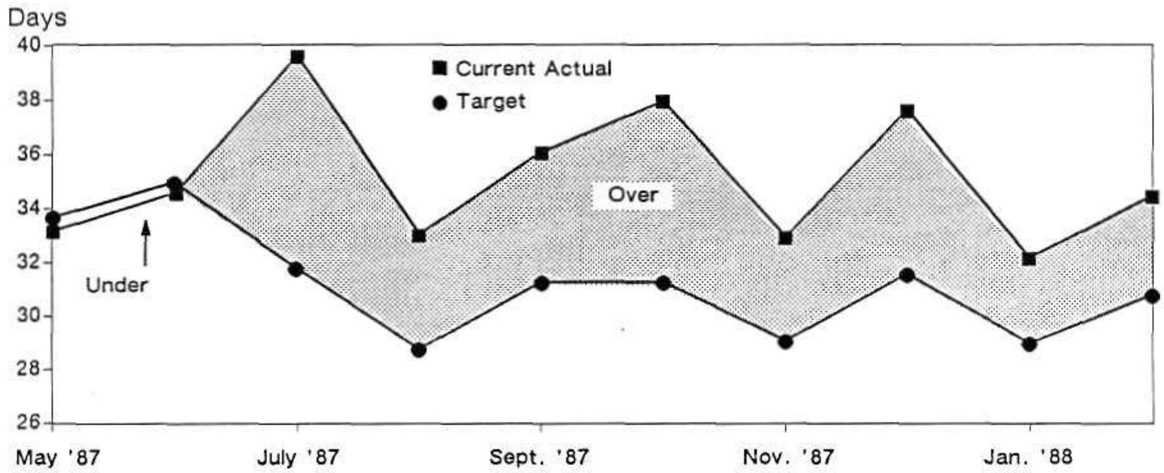
FEBRUARY PROCUREMENT SURVEY: THE WATCHWORD IS AVAILABILITY

INTRODUCTION

The supply–demand balance in the semiconductor marketplace noted in last month's survey still exists for the majority of commodity semiconductors, but was short-lived for key DRAM and 32-bit microprocessor parts. Allocation notices for the high-density and high-speed versions of these two device families are beginning to appear in the latest survey responses. Although lead times remain a relatively stable 12 weeks and overall pricing is steady, 1Mb DRAMs and 32-bit MPUs have registered price increases of 10 percent over our last review. The overall survey inventory levels shown in Figure 1 have risen slightly to approximately 12 percent above targeted levels, while the computer segment of the survey depicted in Figure 2 is actually 2 percent below its targeted inventory range.

Figure 1

Current Actual versus Target Inventory Levels
(All OEMs)



Source: Dataquest
February 1988

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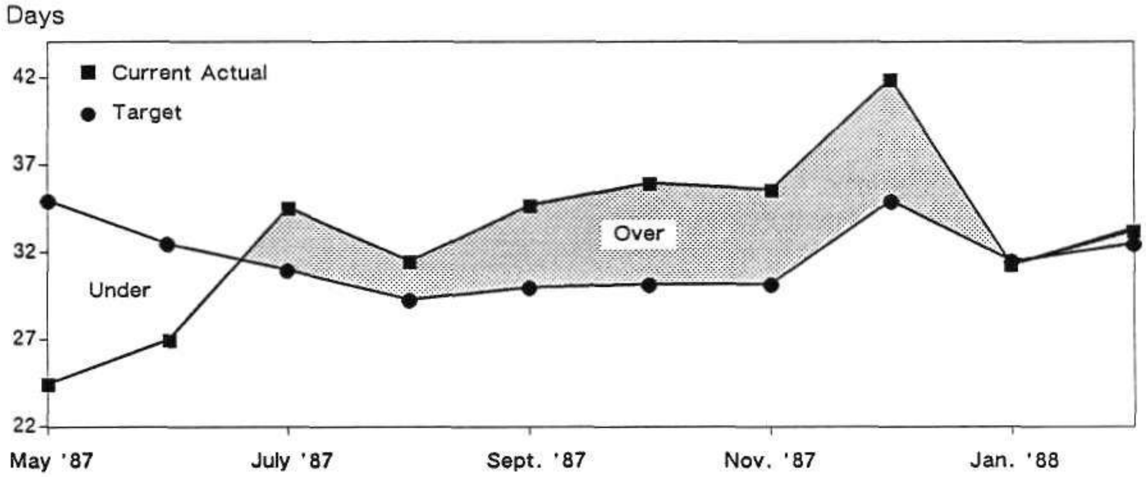
Figure 2

Current Actual versus Target Inventory Levels
(Computer OEMs)



Source: Dataquest
February 1988

The majority of the survey respondents cited the 1986 U.S.-Japan semiconductor agreement as being the root cause of the current DRAM supply shortfall. Orders to distributors have increased slightly, partially in response to the availability issues noted above. Sales of the surveyed companies remained steady but flat after adjusting for the beginning of the year slow period.

DATAQUEST OBSERVATIONS

It appears that the demand for key semiconductors, although never truly in balance with supply, continues to exaggerate delivery schedules and pricing. The transition in fabrication capacity from the 256K to the 1Mb DRAM is also constraining supply of both parts at a time when buyers are beginning to ramp up production for the new part. Dataquest expects this situation to be remedied by mid-1988 because a multitude of vendors will then have 1Mb DRAM product available. We will continue to watch the availability issue closely in upcoming surveys.

Mark Giudici

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Research Newsletter

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1988-02

1987 PRELIMINARY MARKET SHARE
BROAD BASED RECOVERY IN SEMICONDUCTORS

Preliminary estimates of the worldwide semiconductor market indicate a 24.3 percent expansion of the revenue base of the top 100 vendors, from $29.4 billion in 1986 to $36.6 billion in 1987. A comparison of the 1986 and 1987 revenue bases of semiconductor companies is shown by region in Table 1. The continued decline of the U.S. dollar against the Japanese yen and the European currencies has a significant first-order impact on the valuation of revenue. The second- and third-order effects of the devaluation of the dollar should cause changes in cost structure, prices, and the competitive dynamics in the worldwide market.

Table 1

**Worldwide Semiconductor Market
Revenue of Top 100 Companies
(Billions of U.S. Dollars)**

Regional Companies	1986	1987	Percent Change
Japanese Companies	$14.0	$17.8	27.2%
North American Companies	11.7	14.2	21.7%
European Companies	3.3	4.0	20.8%
Rest of World Companies	0.4	0.6	63.9%
Total	$29.4	$36.6	24.3%
Exchange Rates			
Japan: Yen/US$	167.0	144.0	(13.8%)
Europe: ECU/US$	145.9	125.3	(14.1%)

Source: Dataquest
January 1988

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Japanese companies continued to gain share of the worldwide semiconductor market, as shown in Table 2.

The revenue bases and growth rates of the top 100 companies are shown by product area in Table 3. Since the top 100 semiconductor companies account for more than 99 percent of world semiconductor revenue, we will use their combined revenue as an estimate of the total market. The top 50 major semiconductor suppliers worldwide are ranked by product area in Tables 4 through 19.

Table 2

Worldwide Semiconductor Market
(Percentage of Market Share)

Regional Companies	1984	1985	1986	1987
Japanese Companies	40%	42%	46%	48%
North American Companies	48	45	42	39
European Companies	11	12	11	11
Rest of World Companies	1	1	2	2
Total	100%	100%	100%	100%

Source: Dataquest
January 1988

Table 3

Worldwide Semiconductor Market
Revenue Base of Top 100 Companies
(Billions of U.S. Dollars)

Product	1986	1987	Percent Change
Total Semiconductor	$29.4	$36.6	24.3%
IC	$22.6	$28.7	26.8%
Bipolar Digital	$ 4.3	$ 4.7	9.7%
Bipolar Memory	$ 0.6	$ 0.7	5.6%
Bipolar Logic	$ 3.7	$ 4.0	10.4%
Standard Logic	$ 2.3	$ 2.4	3.9%
ASIC	$ 1.4	$ 1.6	21.7%
MOS Digital	$12.6	$17.1	36.3%
MOS Memory	$ 4.5	$ 5.8	29.6%
MOS Micro	$ 3.4	$ 5.1	49.6%
MOS Logic	$ 4.7	$ 6.2	32.9%
Standard Logic	$ 1.6	$ 1.8	12.5%
ASIC	$ 3.1	$ 4.4	43.2%
Linear	$ 5.7	$ 6.9	18.7%
Discrete	$ 5.3	$ 6.2	15.9%
Optoelectronic	$ 1.5	$ 1.7	16.6%

Source: Dataquest
January 1988

SEMICONDUCTOR MARKET SHARE

NEC continued to lead the semiconductor market with revenue exceeding $3 billion in 1987. Toshiba continued to grow faster than the market, displacing Hitachi from second to third place. Motorola and Texas Instruments remained in the top 5, with revenue exceeding $2 billion each. Intel advanced three notches, to eighth place in the top 10, growing twice as fast as the total semiconductor market (see Table 4 and Figures 1 and 2). The combined entity of National/Fairchild ranked 11th. The combined entity of AMD/MMI ranked 12th and was expected to break the billion-dollar barrier for the first time in 1987.

Table 4

Preliminary Worldwide Semiconductor Market Share Rankings (Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
1	1	NEC	$ 2,638	$ 3,193	21.0%
3	2	Toshiba	$ 2,276	$ 2,939	29.1%
2	3	Hitachi	$ 2,307	$ 2,781	20.5%
4	4	Motorola	$ 2,025	$ 2,450	21.0%
5	5	Texas Instruments	$ 1,781	$ 2,125	19.3%
6	6	Fujitsu	$ 1,365	$ 1,899	39.1%
8	7	Philips-Signetics	$ 1,258	$ 1,597	26.9%
11	8	Intel	$ 991	$ 1,500	51.4%
10	9	Mitsubishi	$ 1,136	$ 1,481	30.4%
9	10	Matsushita	$ 1,206	$ 1,479	22.6%
7	11	National/Fairchild	$ 1,365	$ 1,431	4.8%
12	12	AMD/MMI	$ 838	$ 1,015	21.1%
13	13	SGS Thomson	$ 806	$ 850	5.5%
14	14	Sanyo	$ 615	$ 786	27.8%
18	15	Oki	$ 438	$ 651	48.6%
17	16	Siemens	$ 442	$ 595	34.6%
19	17	Sharp	$ 433	$ 594	37.2%
16	18	Sony	$ 458	$ 555	21.2%
15	19	GE Solid State	$ 509	$ 554	8.8%
20	20	Rohm	$ 377	$ 480	27.3%
21	21	ITT	$ 312	$ 357	14.4%
30	22	Samsung	$ 170	$ 316	85.9%
25	23	Sanken	$ 224	$ 294	31.3%
22	24	Harris	$ 260	$ 277	6.5%
23	25	Analog Device	$ 243	$ 274	12.8%

(Continued)

Table 4 (Continued)

Preliminary Worldwide Semiconductor Market Share Rankings (Millions of Dollars)

24	26	General Instrument	$ 236	$ 274	16.1%
29	27	LSI Logic	$ 194	$ 260	34.0%
26	28	Telefunken Electronic	$ 219	$ 258	17.8%
28	29	Fuji Electric	$ 205	$ 248	21.0%
27	30	Hewlett-Packard	$ 217	$ 240	10.6%
31	31	Seiko Epson	$ 165	$ 211	27.9%
32	32	Honeywell	$ 157	$ 176	12.1%
34	33	International Rectifier	$ 145	$ 172	18.6%
38	34	VLSI Technology	$ 112	$ 170	51.8%
33	35	Gould AMI Semiconductors	$ 155	$ 155	0.0%
44	36	New JRC	$ 92	$ 141	53.3%
36	37	Plessey	$ 112	$ 128	14.3%
35	38	Sprague	$ 122	$ 124	1.6%
41	39	Burr-Brown	$ 98	$ 120	22.4%
39	40	TRW	$ 105	$ 116	10.5%
56	41	Micron Technology	$ 63	$ 115	82.5%
37	42	Siliconix	$ 112	$ 115	2.7%
43	43	NCR	$ 94	$ 114	21.3%
65	44	Chips & Technologies	$ 41	$ 112	173.2%
40	45	Powerex	$ 99	$ 106	7.1%
42	46	Ferranti	$ 96	$ 100	4.2%
51	47	Integrated Device Technology	$ 72	$ 98	36.1%
54	48	Rockwell	$ 65	$ 95	46.2%
47	49	Inmos	$ 80	$ 91	13.8%
53	50	United Microelectronics	$ 69	$ 90	30.4%
		Total Market Estimate	$29,380	$36,570	24.3%

Source: Dataquest
January 1988

Figure 1

Top 10 Worldwide Semiconductor Manufacturers for 1987

Company	1986 Rank	1987 Rank		1986 Sales	1987 Sales
				(Millions of Dollars)	
NEC	1	1		2,638	3,193
Toshiba	3	2		2,276	2,939
Hitachi	2	3		2,307	2,781
Motorola	4	4		2,025	2,450
Texas Instruments	5	5		1,781	2,125
Fujitsu	6	6		1,365	1,899
Philips-Signetics	8	7		1,258	1,597
Intel	11	8		991	1,500
Mitsubishi	10	9		1,136	1,481
Matsushita	9	10		1,206	1,479

Source: Dataquest
January 1988

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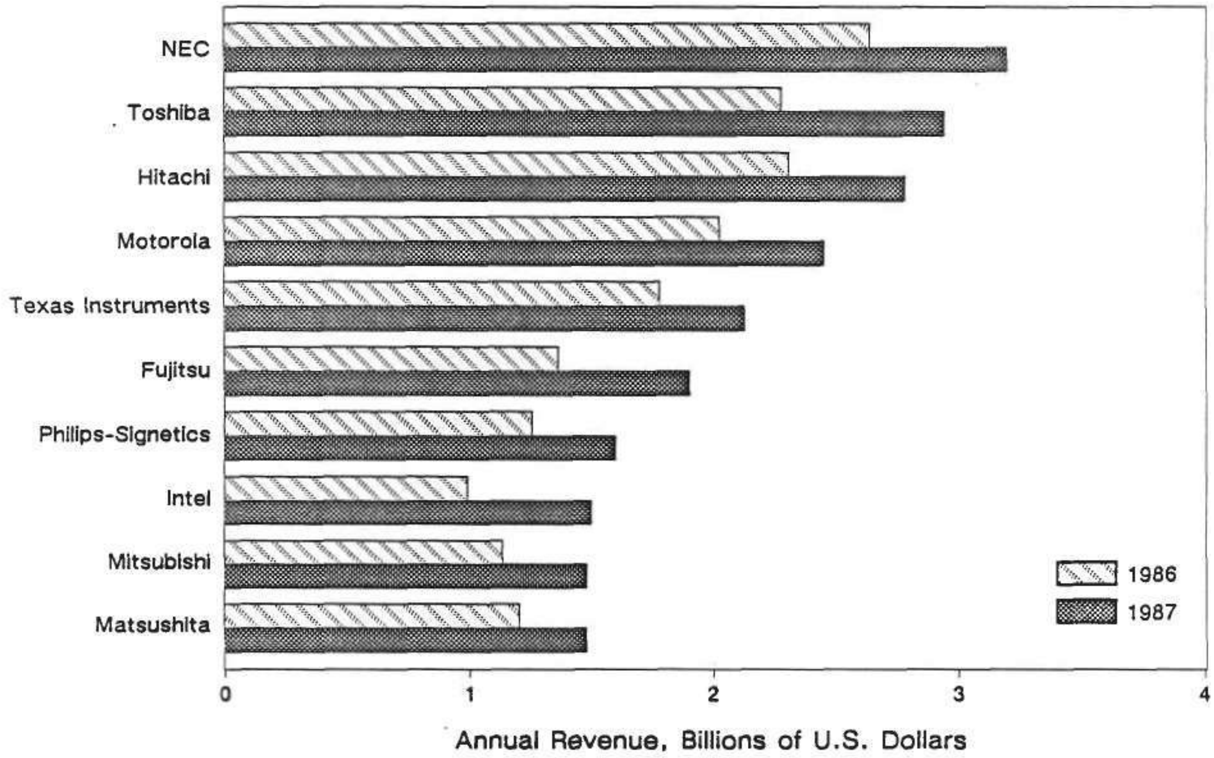
Figure 2

Worldwide Semiconductor Market Share
Top 10 Companies



Source: Dataquest
January 1988

The high-fliers among the top 50 include Fujitsu, ranked 6th and growing at 39.1 percent; Intel, ranked 8th and growing at 51.4 percent; Oki, ranked 15th and growing at 48.6 percent; Samsung of Korea, ranked 22nd and growing at 85.9 percent; Micron Technology, ranked 41st and growing at 82.5 percent; and Chips & Technologies, ranked 44th and growing at 173.2 percent. These companies focused on high-growth product areas such as MOS micros, ASICs, and memories. Chips & Technologies, Integrated Device Technology, Micron Technology, New Japan Radio Company (JRC), Rockwell, and United Microelectronics of Korea were new entrants to the top 50.

NORTH AMERICAN MARKET SUMMARY

The market share rankings in the North American semiconductor and IC markets are shown in Tables 5 and 6. Market share data in the regional markets by detailed product category is available from Dataquest Components Division Services. Japanese market data is available from the JSIS, European market data is available from the ESIS, North American market data is available from the SIS, and Rest of World market data is available from the ASETS.

Preliminary estimates of the North American market revenue indicate that the semiconductor market grew 20 percent, from $9.8 billion in 1986 to $11.8 billion in 1987. The North American IC market grew 21 percent, from $8.3 billion in 1986 to $10.1 billion in 1987.

The top five companies in the North American semiconductor market are all U.S. companies. Motorola remained the clear leader in the North American market. Texas Instruments retained second place, while Intel displaced National/Fairchild from third place. AMD/MMI retained fifth place. Toshiba advanced three notches to sixth place, growing at almost three times the industry growth rate. Hitachi dropped three notches to 9th place, with declining North American revenue. The concentration of the North American industry is comparable to the worldwide industry with the top 5 holding 43 percent share and the top 10 holding 59 percent share.

The top five contenders in the North American IC market are the same as the top five in the semiconductor market. Toshiba gained share and Hitachi lost share in the North American IC market.

Table 5

Preliminary North American Semiconductor Market Share Rankings
(Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
1	1	Motorola	$1,309	$ 1,584	21.0%
2	2	Texas Instruments	$ 845	$ 980	16.0%
4	3	Intel	$ 629	$ 910	44.7%
3	4	National/Fairchild	$ 832	$ 848	1.9%
5	5	AMD/MMI	$ 515	$ 613	19.0%
9	6	Toshiba	$ 294	$ 464	57.8%
7	7	Philips-Signetics	$ 341	$ 372	9.1%
8	8	GE Solid State	$ 339	$ 367	8.3%
6	9	Hitachi	$ 398	$ 365	(8.3%)
11	10	Fujitsu	$ 251	$ 347	38.2%

(Continued)

Table 5 (Continued)

Preliminary North American Semiconductor Market Share Rankings (Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
10	11	NEC	$ 260	$ 335	28.8%
13	12	Hewlett-Packard	$ 217	$ 240	10.6%
12	13	Harris	$ 222	$ 236	6.3%
14	14	SGS Thomson	$ 169	$ 208	23.1%
15	15	LSI Logic	$ 162	$ 206	27.2%
22	16	Oki	$ 101	$ 168	66.3%
20	17	Mitsubishi	$ 114	$ 160	40.4%
16	18	Honeywell	$ 139	$ 158	13.7%
17	19	Analog Devices	$ 136	$ 151	11.0%
24	20	VLSI Technology	$ 96	$ 143	49.0%
18	21	General Instrument	$ 126	$ 138	9.5%
21	22	International Rectifier	$ 103	$ 125	21.4%
19	23	Gould AMI Semiconductors	$ 117	$ 123	5.1%
26	24	NCR	$ 94	$ 109	16.0%
25	25	TRW	$ 95	$ 100	5.3%
23	26	Sprague	$ 99	$ 98	(1.0%)
33	27	Samsung	$ 59	$ 96	62.7%
37	28	Micron Technology	$ 51	$ 94	84.3%
27	29	Powerex	$ 81	$ 86	6.2%
31	30	Raytheon	$ 63	$ 76	20.6%
34	31	Integrated Device Technology	$ 57	$ 74	29.8%
30	32	ITT	$ 63	$ 70	11.1%
46	33	Chips & Technologies	$ 36	$ 69	91.7%
41	34	Cypress Semiconductor	$ 44	$ 67	52.3%
40	35	Rockwell	$ 47	$ 65	38.3%
32	36	Inmos	$ 61	$ 64	4.9%
29	37	Siliconix	$ 66	$ 64	(3.0%)
38	38	Siemens	$ 49	$ 59	20.4%
28	39	Unitrode	$ 67	$ 53	(20.9%)
36	40	Zilog	$ 52	$ 53	1.9%
39	41	Precision Monolithics	$ 48	$ 46	(4.2%)
42	42	Standard Microsystems	$ 43	$ 43	0.0
44	43	VTC	$ 37	$ 43	16.2%
51	44	Xicor	$ 30	$ 43	43.3%
45	45	Burr-Brown	$ 36	$ 42	16.7%

(Continued)

Table 5 (Continued)

Preliminary North American Semiconductor Market Share Rankings (Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
57	46	Seeq	$ 27	$ 41	51.9%
43	47	Solitron	$ 37	$ 41	10.8%
50	48	Seiko Epson	$ 31	$ 40	29.0%
35	49	Silicon Systems	$ 54	$ 40	(25.9%)
47	50	Hughes	$ 36	$ 39	8.3%
		Total Market Estimate	$9,800	$11,800	19.8%

Source: Dataquest
January 1988

Table 6

Preliminary North American IC Market Share Rankings (Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
1	1	Motorola	$ 910	$ 1,125	23.6%
2	2	Texas Instruments	$ 800	$ 931	16.4%
4	3	Intel	$ 629	$ 910	44.7%
3	4	National/Fairchild	$ 796	$ 807	1.4%
5	5	AMD/MMI	$ 515	$ 613	19.0%
9	6	Toshiba	$ 252	$ 395	56.7%
8	7	Philips-Signetics	$ 325	$ 371	14.2%
7	8	GE Solid State	$ 339	$ 367	8.3%
10	9	NEC	$ 251	$ 326	29.9%
6	10	Hitachi	$ 356	$ 320	(10.1%)
11	11	Fujitsu	$ 230	$ 312	35.7%
12	12	Harris	$ 222	$ 236	6.3%
13	13	LSI Logic	$ 162	$ 206	27.2%
19	14	Oki	$ 101	$ 168	66.3%
15	15	SGS Thomson	$ 128	$ 156	21.9%

(Continued)

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Table 6 (Continued)

Preliminary North American IC Market Share Rankings
(Millions of Dollars)

1986 Rank	1987 Rank		1986 Revenue	1987 Revenue	Percent Change
14	16	Analog Devices	$ 136	$ 151	11.0%
17	17	Mitsubishi	$ 105	$ 150	42.9%
20	18	VLSI Technology	$ 96	$ 143	49.0%
18	19	Honeywell	$ 104	$ 128	23.1%
16	20	Gould AMI Semiconductors	$ 117	$ 123	5.1%
21	21	NCR	$ 94	$ 109	16.0%
25	22	Samsung	$ 57	$ 95	66.7%
28	23	Micron Technology	$ 51	$ 94	84.3%
22	24	Sprague	$ 85	$ 80	(5.9%)
24	25	Integrated Device Technology	$ 57	$ 74	29.8%
38	26	Chips & Technologies	$ 36	$ 69	91.7%
32	27	Cypress Semiconductor	$ 44	$ 67	52.3%
31	28	Rockwell	$ 47	$ 65	38.3%
23	29	Inmos	$ 61	$ 64	4.9%
29	30	Raytheon	$ 49	$ 59	20.4%
27	31	Zilog	$ 52	$ 53	1.9%
33	32	General Instrument	$ 43	$ 47	9.3%
30	33	Precision Monolithics	$ 48	$ 46	(4.2%)
34	34	Standard Microsystems	$ 43	$ 43	0.0
36	35	VTC	$ 37	$ 43	16.2%
44	36	Xicor	$ 30	$ 43	43.3%
37	37	Burr-Brown	$ 36	$ 42	16.7%
48	38	Seeq	$ 27	$ 41	51.9%
43	39	Seiko Epson	$ 31	$ 40	29.0%
26	40	Silicon Systems	$ 54	$ 40	(25.9%)
35	41	Siliconix	$ 39	$ 40	2.6%
39	42	Hughes	$ 36	$ 39	8.3%
42	43	ITT	$ 32	$ 39	21.9%
40	44	Western Digital	$ 34	$ 39	14.7%
45	45	Gold Star	$ 29	$ 34	17.2%
47	46	IMP	$ 28	$ 34	21.4%
41	47	Exar/Exel	$ 32	$ 32	0.0
54	48	Linear Technology	$ 20	$ 30	50.0%
46	49	Interdesign	$ 29	$ 29	0.0
56	50	AMCC	$ 19	$ 28	47.4%
		Total Market Estimate	$8,300	$10,100	21.2%

Source: Dataquest
January 1988

DATAQUEST ANALYSIS

The combined revenue of the worldwide semiconductor suppliers grew 24 percent, to $36.6 billion in 1987. The Asia-Pacific companies fared the best, growing at 64 percent. The Japanese companies grew 27 percent, while the North American and European companies grew about 21 percent each.

While interpreting the revenue growth, the reader should bear in mind that we are measuring the worldwide market in terms of the declining U.S. dollar. The dollar declined about 14 percent against the Japanese yen and the European currencies in 1987. Insomuch as the Japanese companies depend on their local market for about 75 percent of their semiconductor revenue, and the European companies depend on their local market for about 67 percent of their revenue, the real market positions for the Japanese and European companies are overstated by using the declining dollar as the unit of measure.

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Mark A. Guidici
Joseph Borgia

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Research Newsletter

SUIS Code: 1987–1988 Newsletters: January–March
1988–01

JANUARY PROCUREMENT SURVEY AND 1987 REVIEW

As we march into 1988, there is a sense of balance in the air between semiconductor supply and demand. The equation is complex, however. For the time being, mixing the factors of moderately growing demand, sufficient but tightening supplier capacity, the trade agreement, just-in-time delivery, a stock market crash, and several other variables yields a balanced marketplace. In general, end-equipment growth is strong but has leveled somewhat in the last three months. Although moderately excessive inventories were built in the last half of 1987, semiconductor orders and shipments have eased, thus avoiding a pathological correction situation later on. Nonetheless, we will scrutinize our 1988 survey data to ensure that the balance continues.

STATE OF THE INVENTORIES

According to our January survey, the overall semiconductor inventory excess will narrow to 11 percent. As indicated in Figure 1, this represents the healthiest situation since June 1987, when inventories were at the desired levels relative to business activity (target). Actual January inventories of 32 days were at the lowest point since the survey began in May 1987.

Figure 2 breaks out the inventory data for computer OEMs. With actual and target inventories in January nearly equal at 31 days, a similar conclusion can be drawn regarding the sound health of that segment. This is an interesting result for a segment that saw an overdemand for components in early 1987 and, subsequently, an oversupply in the latter part of the year.

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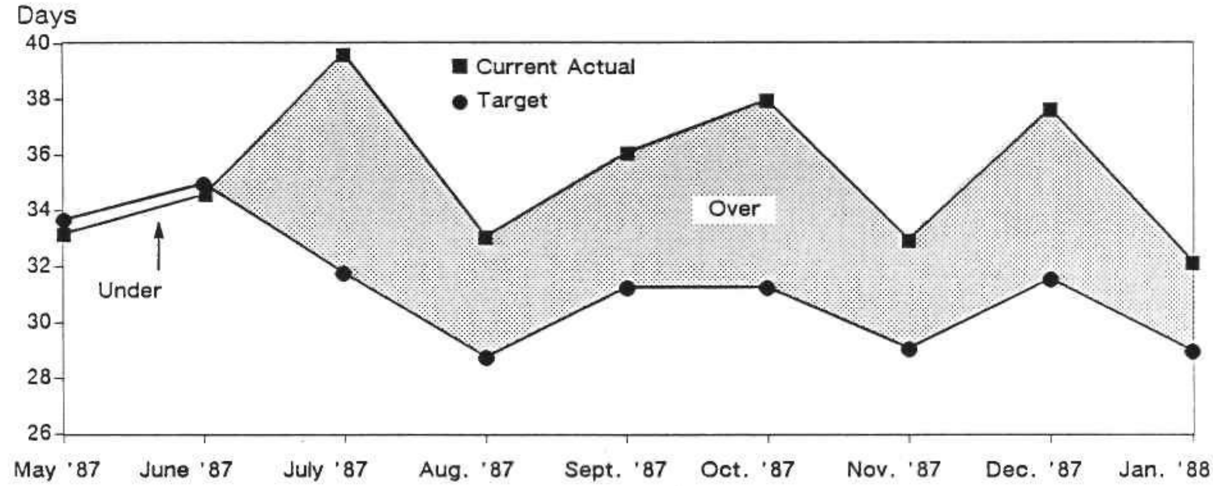
Figure 1

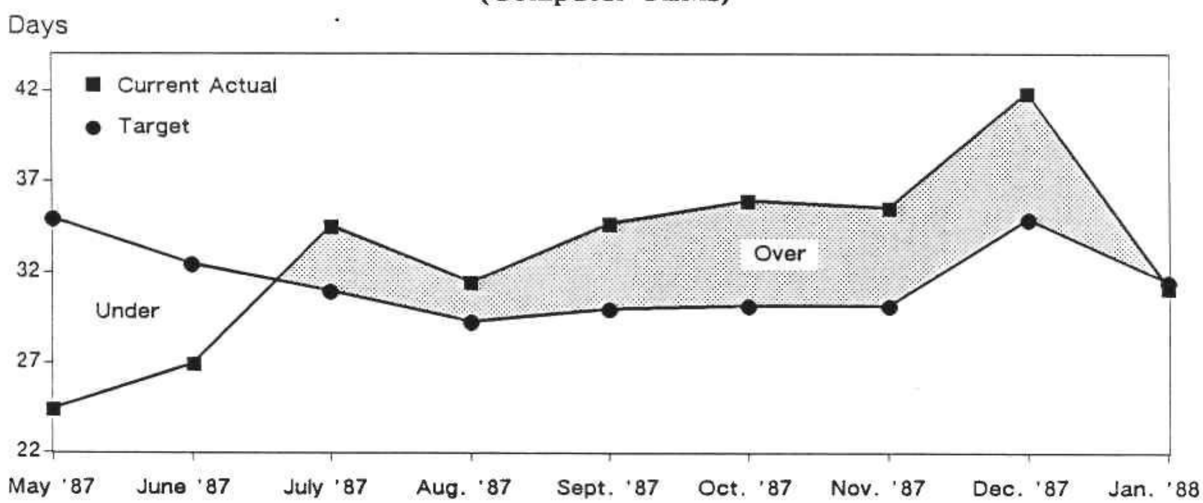
Current Actual versus Target Inventory Levels
(All OEMs)



Source: Dataquest
January 1988

Figure 2

Current Actual versus Target Inventory Levels
(Computer OEMs)



Source: Dataquest
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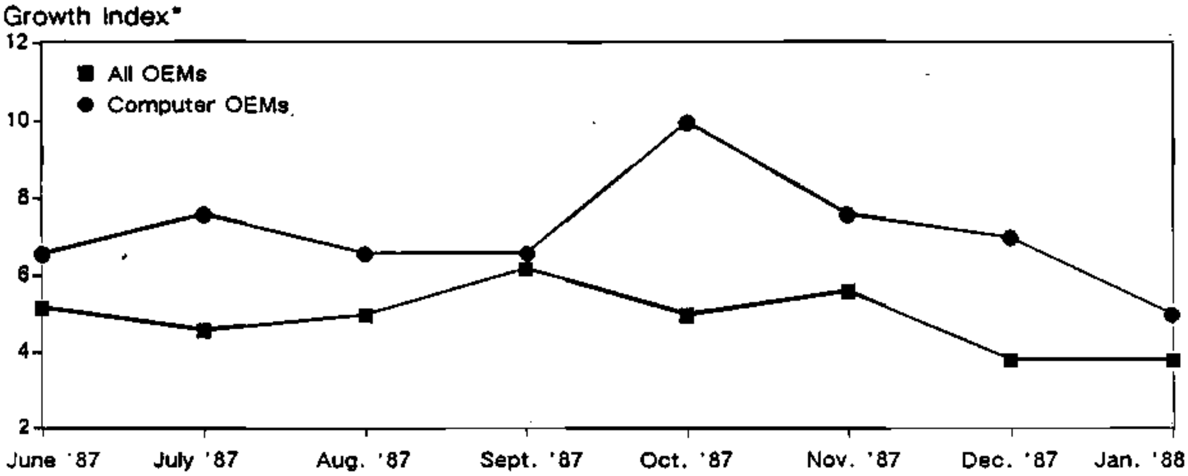
End-Equipment Sales Growth

On an index basis, the average OEM in our survey population has seen its end-equipment sales growth slowing since the third quarter of 1987. Sales are still growing, but the pace of growth has slowed. Detailed in Figure 3 are equipment sales growth index graphs for the total survey group and computer OEMs. Computer OEMs, on the average, have grown at a rate of 30 to 50 percent above the total group. While reflecting a higher degree of seasonality, January OEM sales growth has reached its lowest point since the index was started in June 1987.

Figure 3

Electronic Equipment Sales Growth



*Note: -10 through 0 = lower than last year
0 through 10 = higher than last year

Source: Dataquest
January 1988

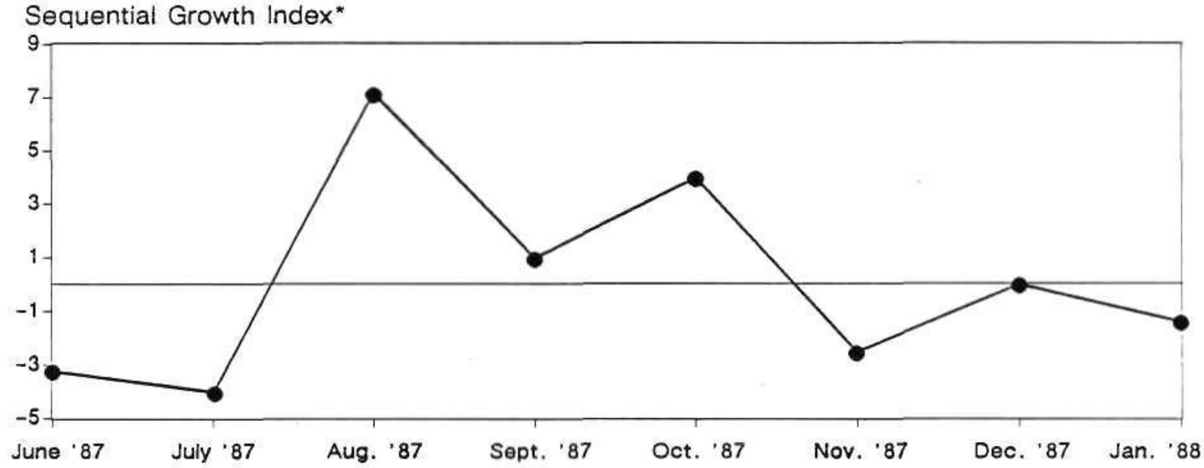
Slowdown in Semiconductor Orders and Shipments

Based on a similar index, semiconductor order placements will decline in January, compared with those in December (see Figure 4). This nonpositive order growth continues for the third straight month. As a lagged effect from slowing orders (see Figure 5), semiconductor shipments declined during January, for the second consecutive month. January shipments to all OEMs were noted to be down 9 percent, and down 7 percent to computer OEMs.

As in the past months, 256K and 1-megabit DRAMs continue to be hard to secure and are noted as still costing too much. Coupled with this is the observation of a raise in DRAM prices in the last month. Surface-mount logic and memory, and sole-sourced 32-bit MPUs are still hard to source for many. Discretes, especially transistors and most surface-mount varieties, are also in short supply.

Figure 4

Semiconductor Order Growth
(All OEMs)

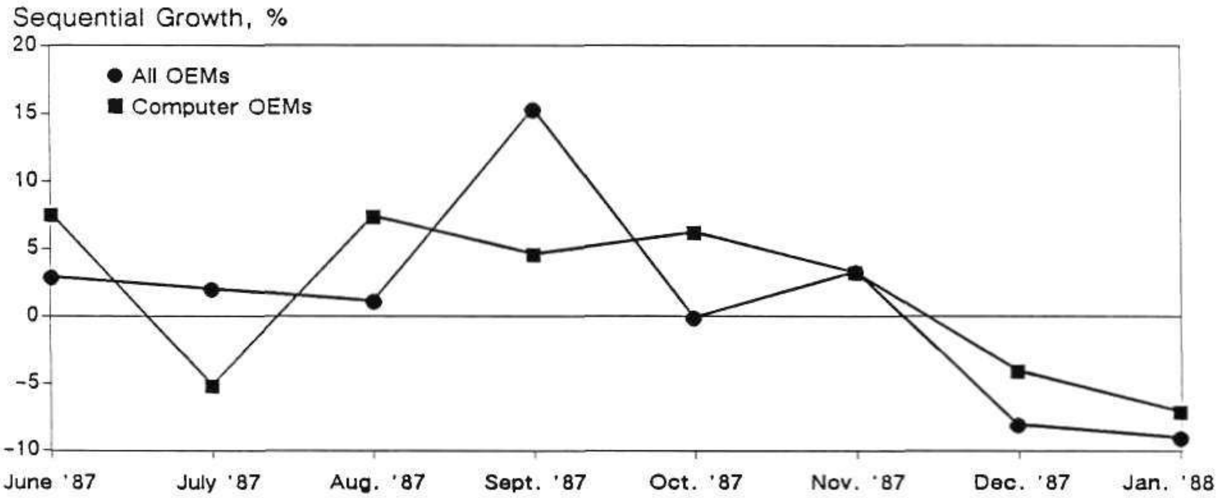


*Note: -10 through 0 = lower than previous month
0 through 10 = higher than previous month

Source: Dataquest
January 1988

Figure 5

Semiconductor Shipment Growth



Source: Dataquest
January 1988

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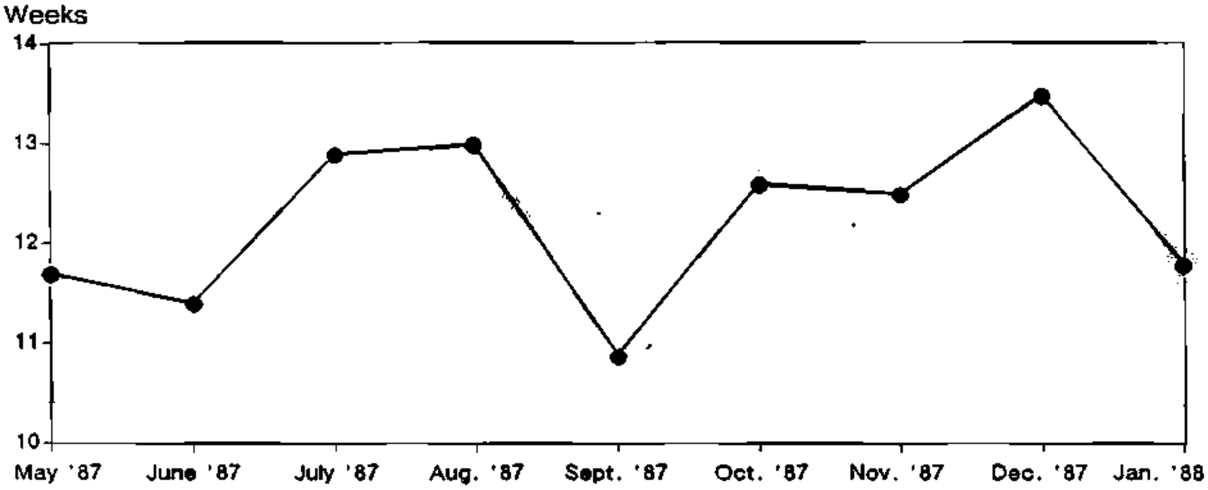
In general, there is a growing concern that sunset products are becoming unavailable. In order to preserve relationships with their customers, semiconductor vendors should approach obsolescence programs very carefully. It behooves semiconductor users to communicate their sensitivities early, so that surprises are avoided.

In spite of some hot spots, overall lead time dropped to 11.8 weeks in January, signifying an ongoing stable supply for the bulk of user needs (see Figure 6).

Figure 6

Lead Times—All Semiconductors



Source: Dataquest
January 1988

DATAQUEST CONCLUSIONS

The ultimate symbols of a healthy semiconductor industry are growing electronic equipment markets, coupled with proper levels of inventory to service that volume of business. Although not without a degree of underdemand in some product areas and overdemand in others, we are currently in a healthy situation.

The stability we are witnessing is best characterized by general price stability, as well as the continued relative shortness of lead times. So far, in this business cycle, semiconductor manufacturing capacity has more closely matched demand, and demand has not been driven by euphoric expectations of an equivalent PC boom. Probably just as important to creating this stability are the proactive efforts of suppliers and OEMs to form better relationships based on a degree of trust and improved inventory management. In this respect, maybe the electronics and semiconductor industries have grown up.

Mark A. Giudici
Gregory L. Sheppard

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April–June

The following is a list of the newsletters in this section:

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April–June

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April–June

- *JUNE PROCUREMENT SURVEY: SALES UP: INVENTORIES DOWN (1988-25)*
  - *Figure 1, Current Actual versus Target Inventory Levels (All OEMs), Page 1*
  - *Figure 2, Current Actual versus Target Inventory Levels (Computer OEMs), Page 2*

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Research *Bulletin*

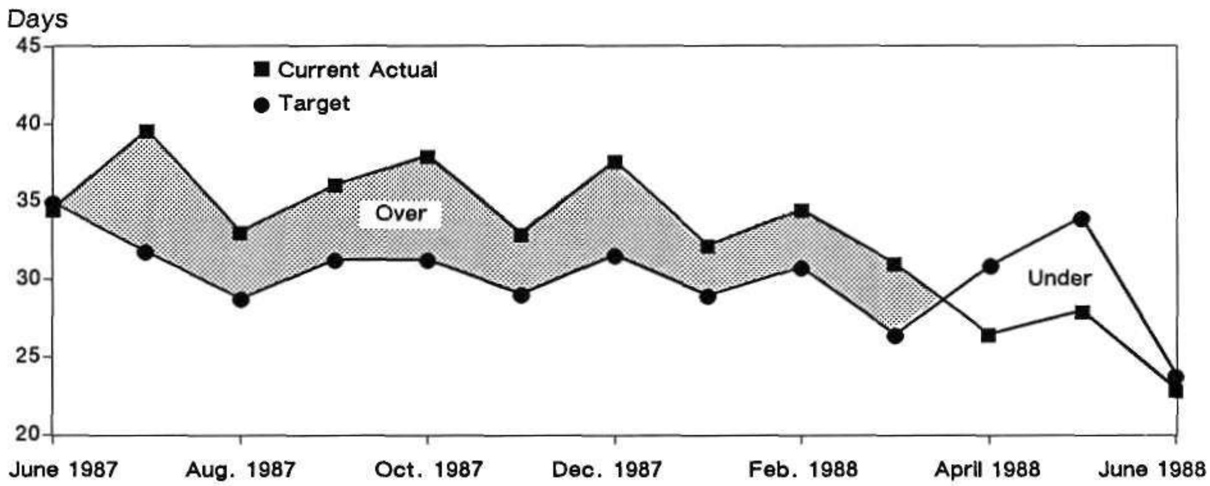
SUIS Code: 1988–1989 Newsletters: April–June
1988–25
0000310

JUNE PROCUREMENT SURVEY: SALES UP, INVENTORIES DOWN

The majority of respondents to our procurement survey expect June sales of their electronic systems to increase over the levels set in May. Semiconductor orders to feed this demand will remain flat over the next month, not due to a lack of demand, but due to the shortage of key memory devices. The correction of overall inventory level decreases (both targeted and actual) have more than offset the increases seen in May by falling to 24 and 23 days, respectively, as shown in Figure 1. Memory availability continues to plague medium–size to small companies, but only for DRAMs and some slow SRAM products. Adequate supplies of these parts are being delivered to larger companies and those with long–term vendor agreements in place.

Figure 1

Current Actual versus Target Inventory Levels (All OEMs)



Source: Dataquest
June 1988

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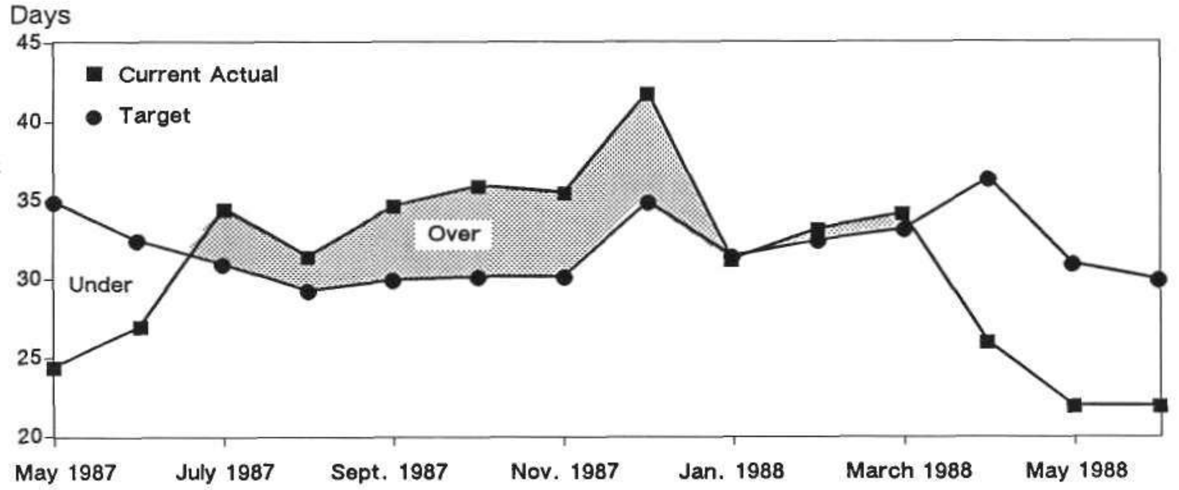
Computer OEMs continue to maintain stable inventory levels, with the target level coming down slightly from last month's 31 days. The flatness seen in Figure 2 is due in part to the shortage of DRAMs keeping supplemental semiconductor orders/inventories in check. Ancillary devices most affected have been slow microprocessors and some standard logic products.

Figure 2

Current Actual versus Target Inventory Levels
(Computer OEMs)



Source: Dataquest
June 1988

Pricing and lead times have remained relatively stable compared with last month's survey. Distribution orders have also remained flat at 3 to 15 percent, reflecting the overall market dilemma of obtaining scarce parts at reasonable prices.

Mark Giudici

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Research *Newsletter*

SUIS Code: 1988–1989 Newsletters: April–June
1988–24
0000426

SECOND-QUARTER UPDATE: DATAQUEST'S VIEW OF THE ELECTRONICS INDUSTRY

SUMMARY

Dataquest's coverage of more than 25 electronics industry segments puts it in a unique position to view the electronics industry as a whole and, more importantly, how the segments are interrelated. This newsletter gives Dataquest's view of the U.S. electronics industry, first by looking at the economy, then analyzing issues that cross industry boundaries or megatrends, then by looking at trends in each of the major electronics segments that Dataquest tracks.

THE ECONOMY

Our analysis of the economic outlook is the ground zero for all our forecasts. We rely heavily on the economic analysis of Dun & Bradstreet, our parent company, to help us develop our economic forecast.

As shown in Figure 1, we expect GNP growth in the United States to be approximately 2.8 percent in 1988 and 2.2 percent in 1989. However, 1989 will show some strength in the first half, with a slowdown in the second half of the year.

Two major uncertainties have been removed from the economic picture: What if there is a stock market crash, and what if the dollar declines in value? Both of these events already have happened and relieved at least some of the uncertainty.

The stock market crash had less effect than was anticipated. A Dun's 5000 survey at the end of 1987 showed that about 75 percent of the respondents said that their capital spending plans for 1988 were not affected by the crash. The quarterly Dun & Bradstreet Business Expectation Survey showed that the business sector expected only a slight decline in sales and profit and actually planned to increase employment in the same period.

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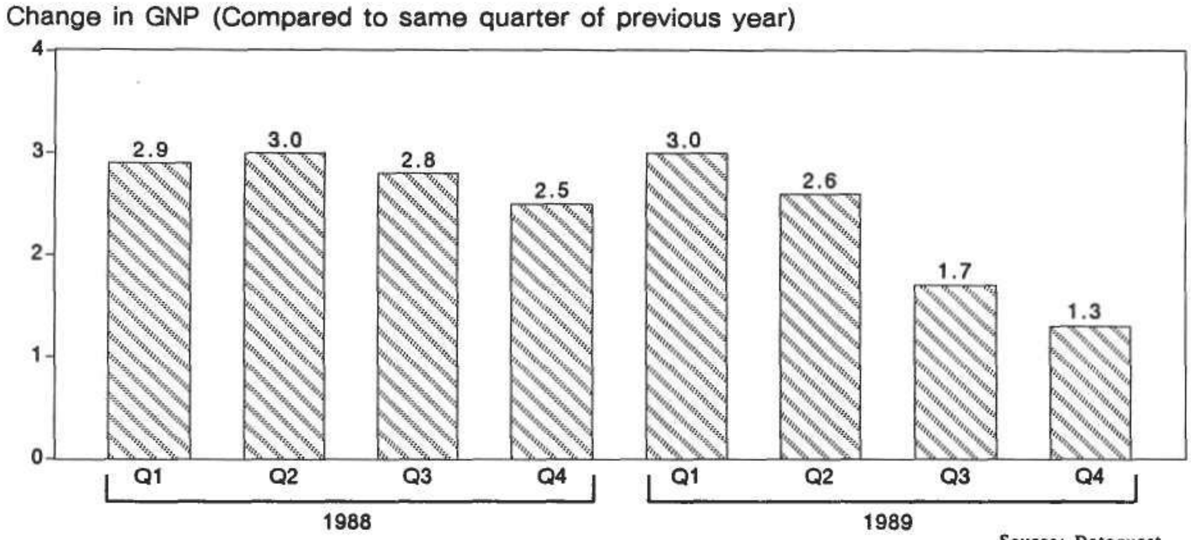
Figure 1

Estimated Change in GNP
Compared with Same Quarter of Previous Year



Source: Dataquest
June 1988

The United States is in its sixth year of economic expansion, and manufacturing capacity, at an average of 82 percent, is as high as it has been in the past two decades.

The current low value of the dollar has given a boost to manufacturing, and this, combined with the high-capacity usage typical of the later stages of economic expansion, is resulting in the addition of capacity and the resultant purchase of capital equipment. Such capacity expansion is good news for the electronics industry, which is enjoying the strongest market that it has seen since 1983.

Within this strong overall electronics market though, we see considerable fluctuations. These are caused by a number of factors including supply/demand relationships, product lifetime factors, and market saturation. Enhanced product capability also means that some products are encroaching upon others' territories. This is especially true in the computer market in which traditional definitions are rapidly becoming irrelevant.

Although economic growth is expected to slow in the second half of 1989, we still anticipate a relatively healthy electronics industry. The uncertainty factor is the value of the dollar. What effect will this have on world markets and the U.S. economy? The other major concern is the trade deficit. The lower-value dollar should do something to ease this problem, but the need exists for U.S. companies to recognize that they are operating in a global economy and expand further into overseas markets.

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MEGATRENDS

Dataquest sees the following trends emerging throughout the electronics industry:

- Standardization
- Alliances
- Intellectual property
- Competitiveness

Standardization

End users are finally flexing their combined muscles and demanding product compatibility. They no longer want to be tied to one vendor's development plans or product lines. The concept of selling solutions instead of systems has finally moved from the realm of platitudes to reality.

The result is an increased emphasis on standardization. In the computer world, standards that were once confined primarily to communications protocols are now spreading to operating systems, hardware components, data management systems, document exchange protocols, and peripherals interfaces.

The successful electronics manufacturer must identify those standards that are important to his industry and cooperate in their development. This demands increased levels of cooperation between companies.

Alliances

We have seen a number of mergers (the ultimate alliances) of major companies in the electronics industry in the recent past. Burroughs' and Sperry's forming Unisys in the computer area, and the mergers of National Semiconductor and Fairchild and of Advanced Micro Devices and Monolithic Memories in semiconductors are good examples. In all of these mergers, each company possessed a strength that its partner did not, and the combination has promised a more effective company. The jury is still out on how successful some of these mergers will be. The ability of the two companies to merge their separate cultures and grow from their complementary strengths will be the most important factors in determining the winners and losers.

Another form of alliance that has become important is the industrial consortium. Sematech is, of course, the publicized example. Government easing of antitrust restrictions to enable companies to share the benefits of joint R&D should help the United States to become more competitive in world markets.

"Virtual vertical integration" is a term that we have been using at Dataquest to describe alliances between users and vendors to their mutual advantage. These alliances often cross national boundaries and enable buyers to form strong relationships with their vendors to assure supply of critical components in times of shortage. Many of these virtual vertical integration agreements are facing a real test in the current shortage of 1 Megabit DRAMs.

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Intellectual Property

Paradoxically, this trend makes companies more aware of the importance of protecting their unique intellectual properties. The days of selling technology licenses to other companies just to make the quarter's numbers are over.

Protection of intellectual property is hampered by the lack of adequate relevant legislation. The short life cycle of today's electronic products means that a product can be obsolete by the time an intellectual property case reaches the courtroom. Defining intellectual property is also a problem, as cases such as the current Apple/Microsoft "look and feel" litigation show.

Increased concern with intellectual property rights is based on the following three major issues:

- Increased development costs. For example, the cost of developing a new generation of microprocessors can be as high as $80 million.

- Higher capital requirements. This is especially true in industries in which manufacturers are automating in order to compete effectively.

- Shorter product life cycles. The average lifespan of semiconductor logic families between 1965 and 1982 was 5.6 years. Microprocessor families, which were first introduced in 1972, have lasted an average of only 4 years, and application specific ICs can have lifespans that are measured in months.

Competitiveness

The falling value of the dollar has given U.S. manufacturers a brief respite in their efforts to conquer the global market. Enhanced productivity is one of the most important keys to competitiveness, and manufacturing automation may well give the U.S. electronics industry the opportunity to improve its position in world markets. Effectively implemented automation not only enhances productivity but can also improve the quality and consistency of the products manufactured.

THE MARKETS

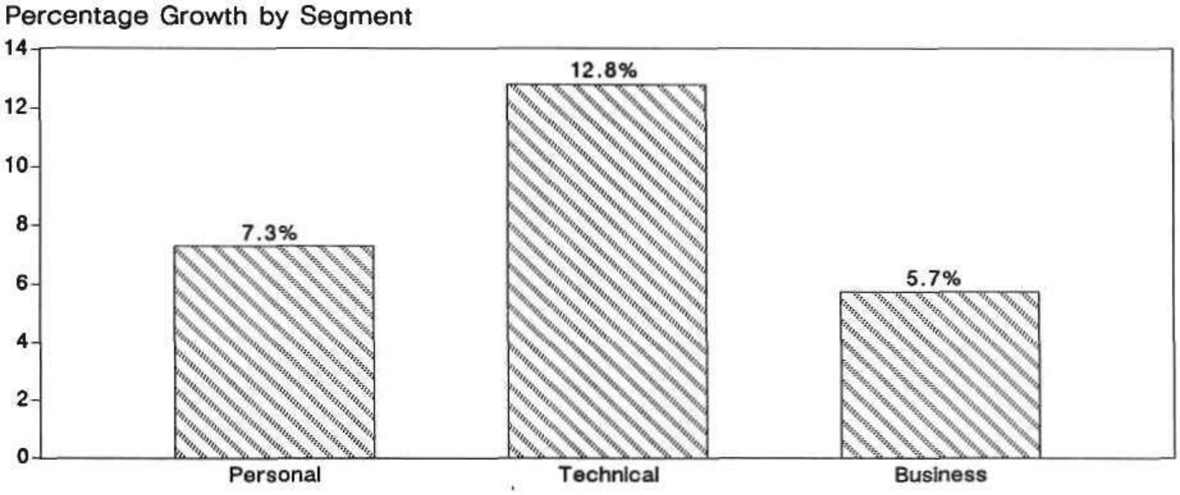
Computers

The DRAM shortage could have a significant impact on the growth of the computer industry in the coming year. We see continued growth in all segments of the computer industry. Figure 2 shows compound annual growth rates (CAGRs) for each segment over the period from 1988 to 1992.

The technical computer segment is the fastest-growing segment of the market, with a CAGR of 12.8 percent. Personal computers are forecast to grow at a relatively modest 7.3 percent and business computers at 5.7 percent. Forecasts for each of these markets are shown in Figures 3 through 5.

Figure 2

U.S. Computer Markets
Estimated Percentage Growth by Segment



Source: Dataquest
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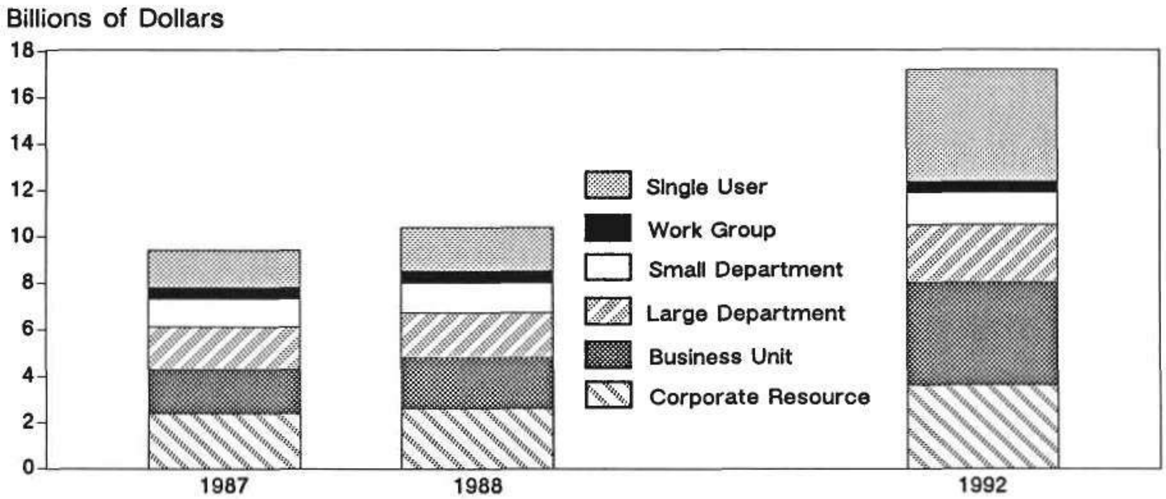
Figure 3

Technical Computer Market
Estimated U.S. Revenue



Source: Dataquest
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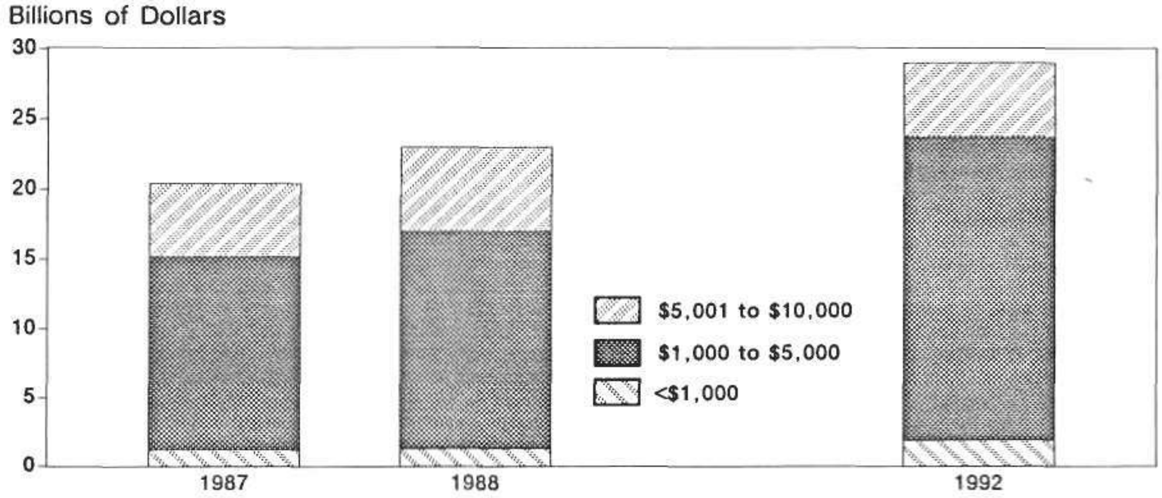
Figure 4

Personal Computer Market
Estimated U.S. Revenue
(Billions of Dollars)



Source: Dataquest
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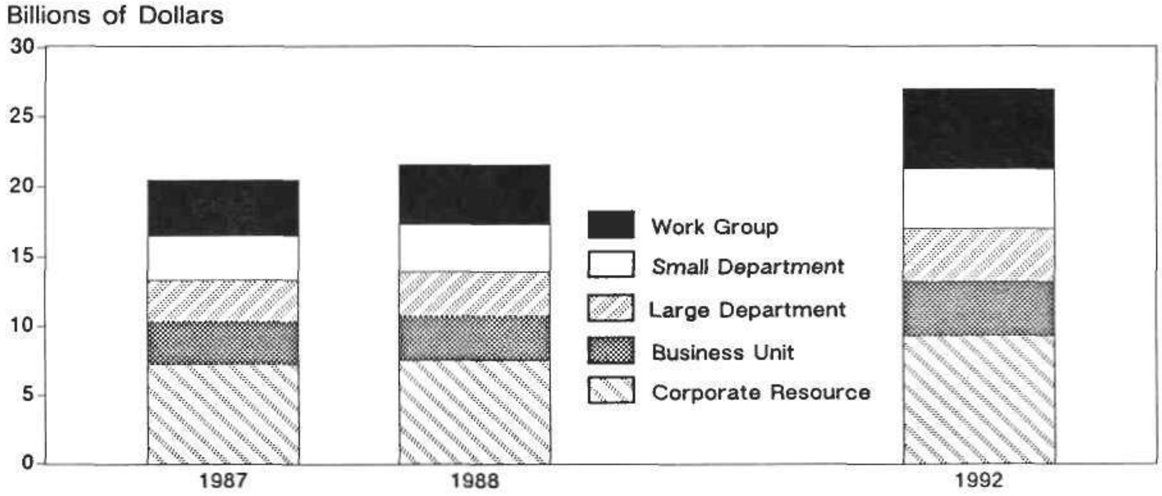
Figure 5

Business Computer Market
Estimated U.S. Revenue
(Billions of Dollars)



Source: Dataquest
June 1988

We believe that the following are the most significant trends in the computer industry:

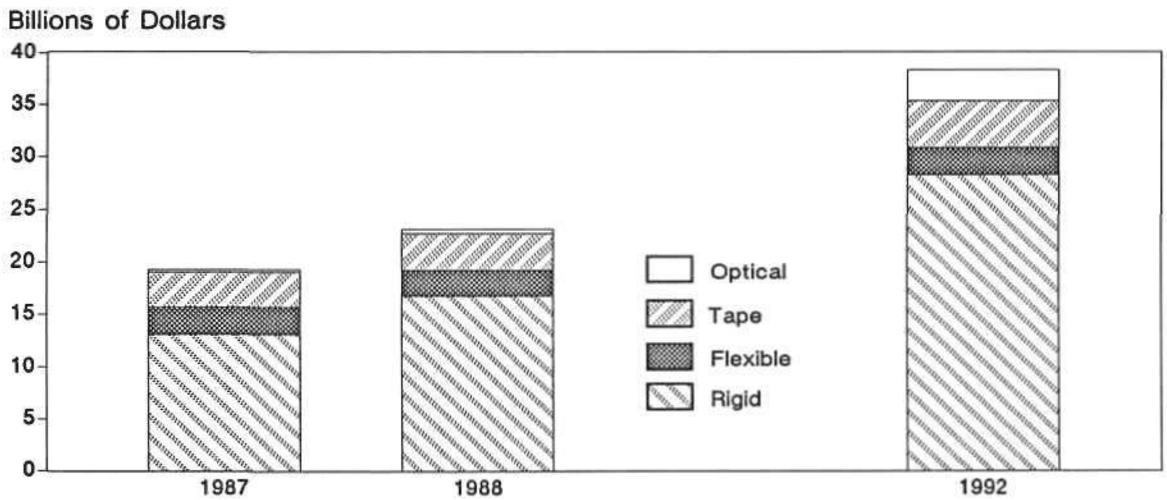
- Workstations are the fastest growing platforms.
- The style of computing is changing from host-based systems to server-based systems.
- RISC architecture is penetrating the technical computer industry.
- Competition between Digital Equipment and IBM is becoming fierce, as their product lines become more directly competitive.
- Continued need for connectivity is enhancing modular growth, whether this means adding more CPU boards or adding new peripherals.
- Continued integration of functionality by PC manufacturers onto the system board. Likely additions include networking, facsimile, and graphics.
- VGA graphics will become the new standard for PC graphics.

Storage

The computer storage market is forecast to grow from $19.3 billion in 1987 to $23.1 billion in 1988, an increase of 21.5 percent. The CAGR for the years 1988 through 1992 is expected to be 14.7 percent, reaching $38.4 billion by 1992. Figure 6 shows Dataquest's forecast for the computer storage market.

Figure 6

Computer Storage Market
Estimated U.S. Revenue
(Millions of Dollars)



Source: Dataquest
June 1988

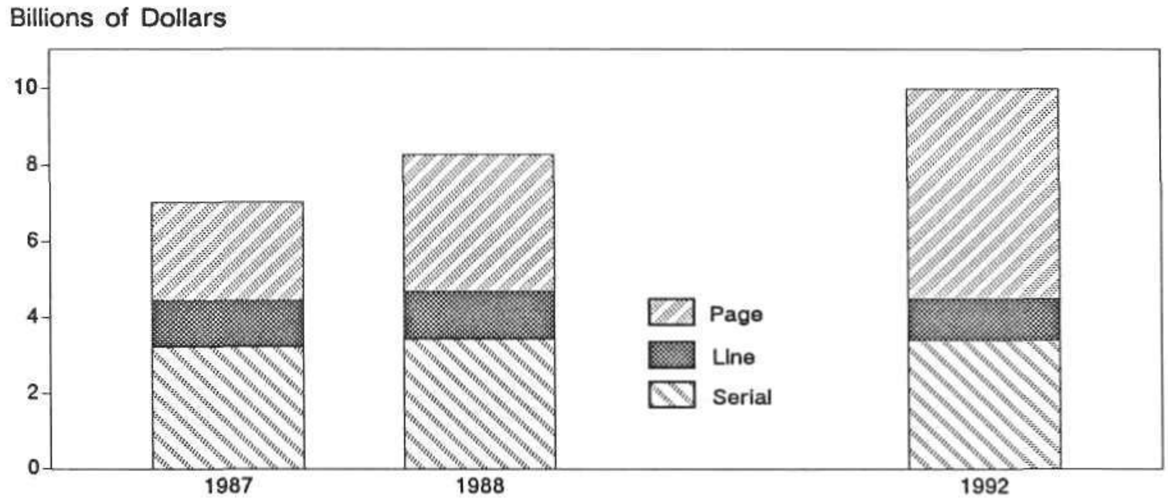
While the flexible disk drive market is almost static, the optical disk drive market is forecast to grow at an astounding 65 percent CAGR through 1992. Tandy's announcement last week of an erasable optical disk may make even that forecast conservative. The device that Tandy announced is expected to be available within 18 months to two years. Although a relatively slow data transfer rate means that it is unlikely to compete with the Winchester disk as the primary means of storage, its use as a backup medium could seriously impact the tape drive market.

Printers

In 1987, the printer market rebounded, and continued growth is expected up to 1992. Dataquest expects page printers to continue to increase market share at the expense of serial and line printers. Figure 7 shows Dataquest's electronic printer forecast.

Figure 7

Electronic Printer Market
Estimated U.S. Revenue
(Millions of Dollars)



Source: Dataquest
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An interesting about-face sees U.S. electronic printer manufacturers moving production back onshore. Japanese vendors are also setting up manufacturing plants in the United States to avoid prohibitive trade barriers. Extremely low labor content in printer manufacturing makes low labor rates overseas a less significant factor in production.

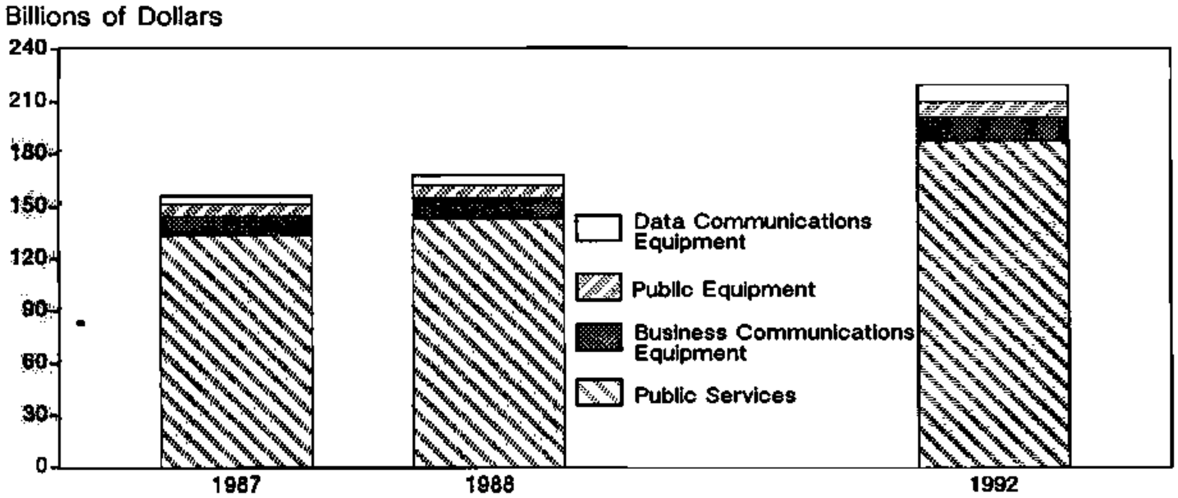
Laser printers continue to constitute the fastest-growing printer segment. This should continue as performance is enhanced due to new chip sets and controllers announced in 1988.

Telecommunications

The total telecommunications market is expected to grow from $156.1 billion in 1987 to $219.5 billion in 1992. By far the largest segment of this is the public services segment, which should grow from $133.3 billion in 1987 to $187.1 billion in 1992. The data communications segment is the fastest-growing part of the market, with a forecast CAGR of 12.7 percent. Figure 8 shows Dataquest's forecast for the telecommunications market.

Figure 8

Telecommunications Market
Estimated U.S. Revenue
(Billions of Dollars)



Source: Dataquest
June 1988

The generalization of these categories, however, makes for some spectacular growth in niche markets. The fax market, for example, grew a staggering 123 percent in 1987 over 1986; 1988 growth is expected to be 65 percent.

There is also a strong probability of integration of facsimile machines into other products such as copiers. The market is dominated by Japanese suppliers, with Sharp moving from number four to number one last year. Despite this domination, plenty of potential is still in the market. We estimate market penetration at less than 10 percent of the total available market, with an installed base of fewer than 1 million.

The major trends in telecommunications are those described earlier as megatrends. We are seeing substantial consolidation: the AT&T/Sun joint venture, DCA and Cohesive, Tandem/Ungermann-Bass, Unisys and Timeplex, to name a few. Even more significantly, we are seeing very few start-ups in the telecommunications arena.

Standards are a significant issue in telecommunications. Again, this is driven by the demands of the user who is unwilling to be tied to a single vendor. Customers, indeed, are the driving force in the telecommunications industry. So much technology is available that success is dictated not by being first, but by giving customers what they want.

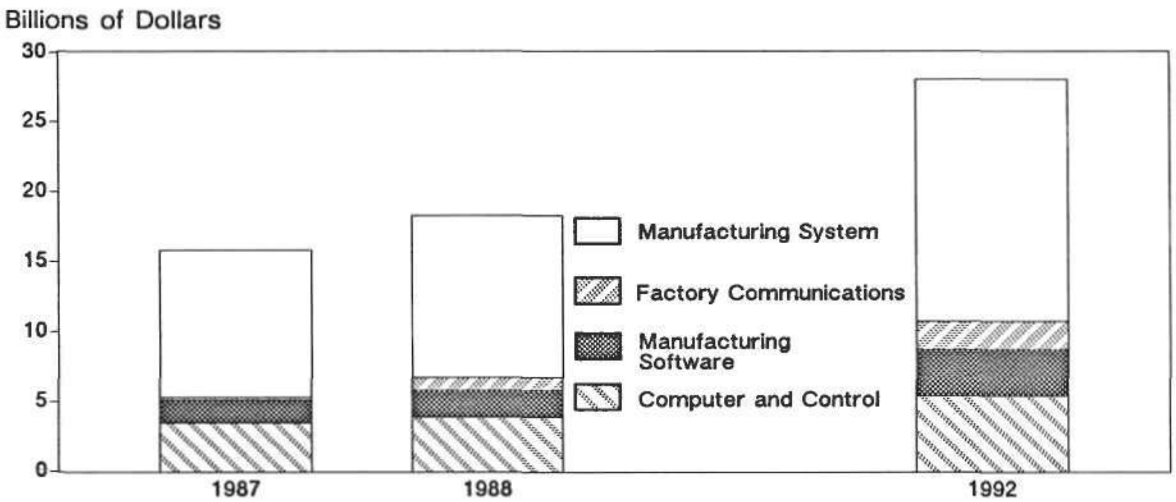
ISDN seemed in danger of being always about to happen, but the standards are now in place and we expect to see real growth in this area. The industry has settled into a period of slow but sustained growth, with areas of excitement including voice messaging, local area networks, and facsimile.

Manufacturing Automation

We estimate that manufacturing automation revenue in 1988 will be $18.3 billion, a growth rate of 15.8 percent over 1987. We forecast the market to grow to $28 billion by 1992, almost doubling from last year. In 1987, both the trade and business press focused on automation as critical to the ability of U.S. manufacturing companies to regain their competitiveness in the world market. This attention to competitiveness is largely a result of concern over the worst trade deficit in the history of the United States. So far, this has resulted in more tire kicking than actual purchases. Figure 9 shows Dataquest's manufacturing automation forecast for the U.S. market.

Figure 9

Manufacturing Automation Market
Estimated U.S. Revenue
(Billions of Dollars)



Source: Dataquest
June 1988

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The United States is making product quality the primary goal, both to reduce costs due to rework and to improve customer relationships. For these reasons, U.S. companies are concentrating on the manufacturing side of the equation. Fewer companies are buying software to integrate their factories than manufacturers in Europe and Japan.

DATAQUEST CONCLUSIONS

Our broad coverage of the electronics industry has allowed us to see how all pieces of the industry are interrelated. From that knowledge, we have found recurring themes or megatrends in each segment of the electronics industry. These trends are: standardization, alliances, intellectual property, and competitiveness. All of these issues will continue to affect semiconductor users and manufacturers in the way that they compete in their own industries and operate as vendors and buyers.

David Norman

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Research Newsletter

SUIS Code: 1988–1989 Newsletters: April–June
1988–23

SEMICONDUCTOR PRICE SURVEY: SUPPLIES TIGHT, PRICES FLAT TO RISING

SUMMARY

Pricing of semiconductors during the first quarter of 1988 has ranged from the ridiculous to the sublime. The situation has ranged from a balanced supply–demand situation for many standard logic products to a very unbalanced DRAM supply crunch. The DRAM shortage has caused like–process SRAMs to be affected, as vendors convert SRAM capacity to more profitable DRAMs, reducing overall SRAM supplies. Microprocessor prices have remained flat in the face of steady demand, while supply increases of high–speed microprocessors have come on–line. This newsletter will cover highlights of the latest price survey and forecast.

STANDARD LOGIC TRENDS

Prices for standard logic products have remained relatively stable over the past three months, with lead times ranging from 6 to 12 weeks. Demand for the high–volume LS and HC families has kept prices firm, yet there is a wider spread in the price range for the LS products, reflecting a softness in this area. Lead times are between six and eight weeks for these parts. The newer ALS and AS families lead times range from 8 to 10 weeks and also reflect a firm price trend. Figure 1 compares a similar product of all four families to illustrate this trend.

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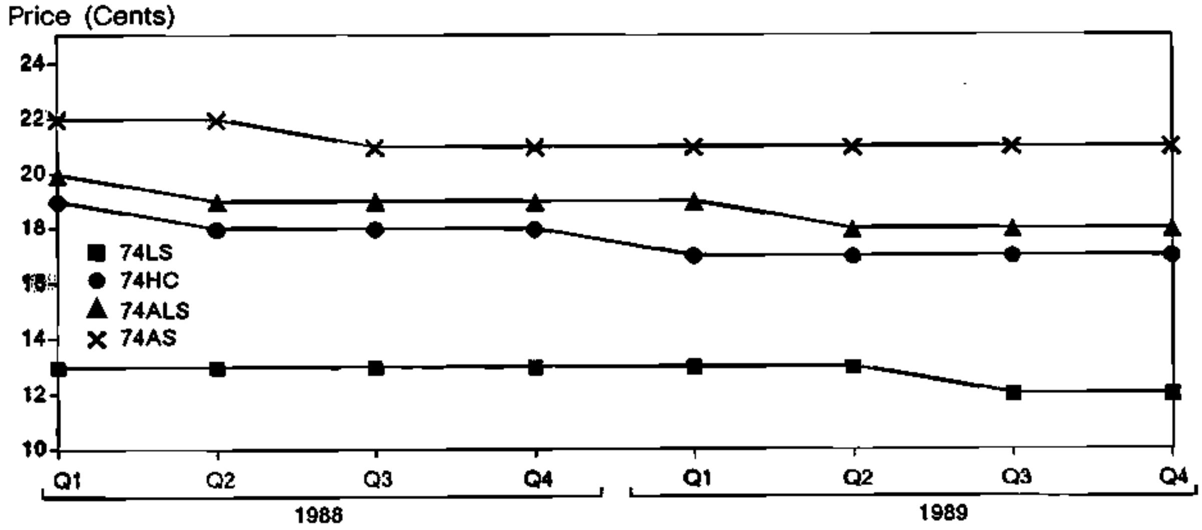
Figure 1

Standard Logic Price Trends



Source: Dataquest June 1988

MICROPROCESSOR TRENDS

Microprocessor prices have remained steady, as the demand for 10-MHz and higher than 12-MHz, 16-bit parts has begun to increase. The demand for 32-bit microprocessors has kept prices firmer than we forecast last quarter. Strong demand for new-generation personal computers and workstations that these parts require will keep prices flat for the remainder of this year. The DRAM shortage has affected demand for microprocessors, as lower memory supplies have constrained shipments of some systems utilizing these microprocessors. Supplies for all microprocessors are expected to be adequate, as capacity put in place late last year has now come into production.

MEMORY TRENDS

The memory market is still being influenced by decisions made in the second quarter of 1987. That was when MITI resorted to production "advisories," reducing supplies and propping up prices above constructed Foreign Market Value (FMV) levels. DRAM products have been affected directly by past controls, but the scramble for capacity to meet demand has crimped video and static RAM capacities, as vendors have shifted some capacity to more profitable DRAMs. The 256K DRAM will rise slightly in price, as seen in Figure 2, then will flatten out by the end of this year, as demand shifts in response to the increasing supplies of 1Mb densities. The 1Mb parts will begin their price declines late this year, once yields and the number of large-volume competitors increase. The prices shown in Figure 2 reflect data collected in the first quarter. Due to the volatile nature of this market, overall prices for DRAMs may rise, pending the outcome of our current survey. However, the trend for the 256K and 1Mb DRAMs remains the same. Any radical departure from this trend will be analyzed in a research bulletin.

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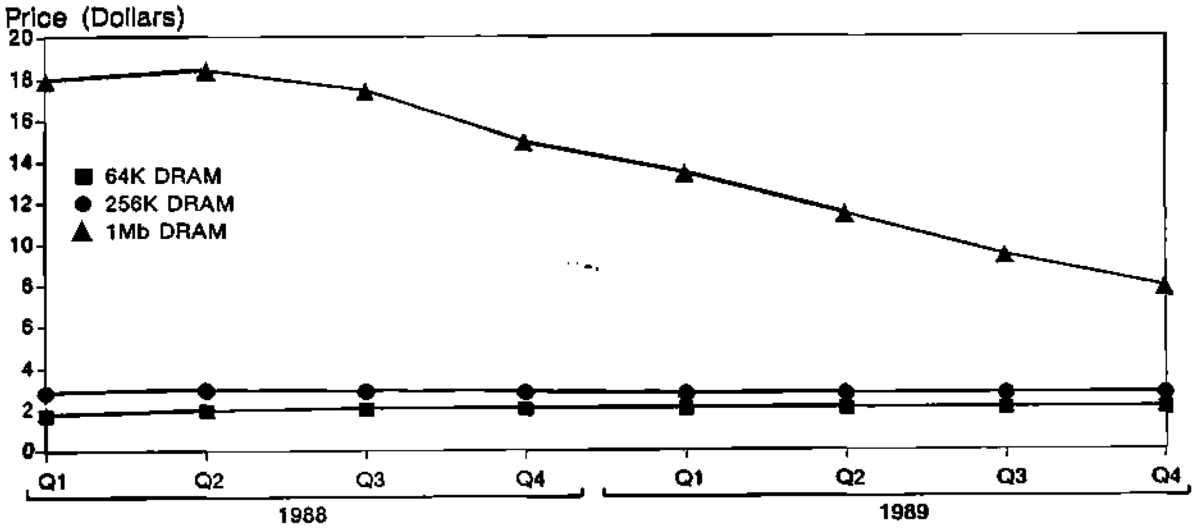
Figure 2

DRAM Price Trends



Source: Dataquest
June 1988

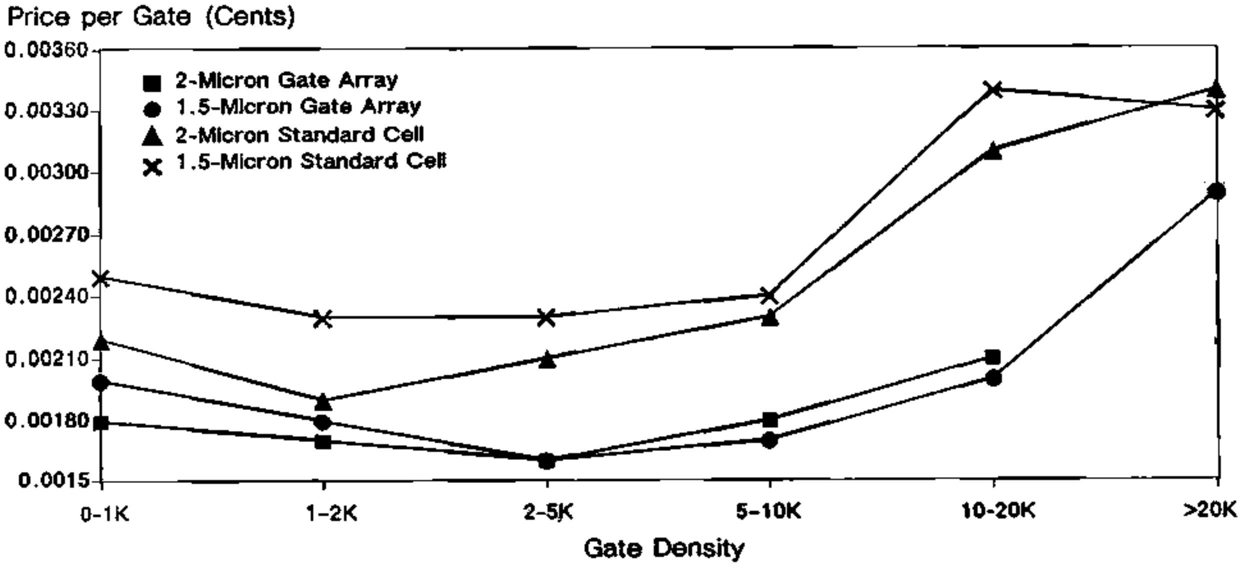
Fast static RAM prices will continue to be flat in the face of strong demand and increased competition. Low-density (lower than 16K), slow SRAMs are being phased out. Users of these older products should communicate their long-term needs to their suppliers while redesigning newer parts into their systems. EPROMs have remained comparatively plentiful in the 256K and higher densities. The reduced vendor base of sub-256K-density EPROMs has led to increases in prices and long lead times, especially for the 128K device.

ASIC TRENDS

Prices for ASIC parts have remained relatively unchanged since our last price survey. This is in response to strong demand and a shift of vendor competition to variables other than price alone. Service and availability have taken precedence as primary factors in determining the top vendors, now that prices per gate have stabilized somewhat. As seen in Figure 3, gate arrays continue to hold a price edge over cell-based designs. This is due primarily to the CAD and production work that are intrinsically more costly for these high-speed/density devices. We expect to see increased competition from Japanese vendors in the ASIC arena over the next two to five years. Although the Japanese are currently viable suppliers, improvements in Japanese software packages and design verification tools will enhance their positions in this high-growth market.

Figure 3

1988 ASIC Price Trends



Source: Dataquest
June 1988

DATAQUEST RECOMMENDATIONS

The current strong demand for electronic hardware is expected to continue through the first half of next year. Semiconductor supplies put in place to meet this demand, in aggregate, will begin to improve the current shortages by early in the fourth quarter of 1988. Overall supply is expected to be in balance with demand by mid-1989, as memory yields and volumes increase in the absence of government intervention. Semiconductor prices for the remainder of this year will remain flat for the most part, and in some cases will rise slightly (i.e., 256K DRAM, slow SRAMs, 64K/128K EPROMs). Availability of key products depends on close involvement of buyers with vendors, with each communicating accurate long-range forecasts and availability schedules, respectively.

Mark Giudici

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Research Newsletter

SUIS Code: 1988–1989 Newsletters: April–June
1988–22

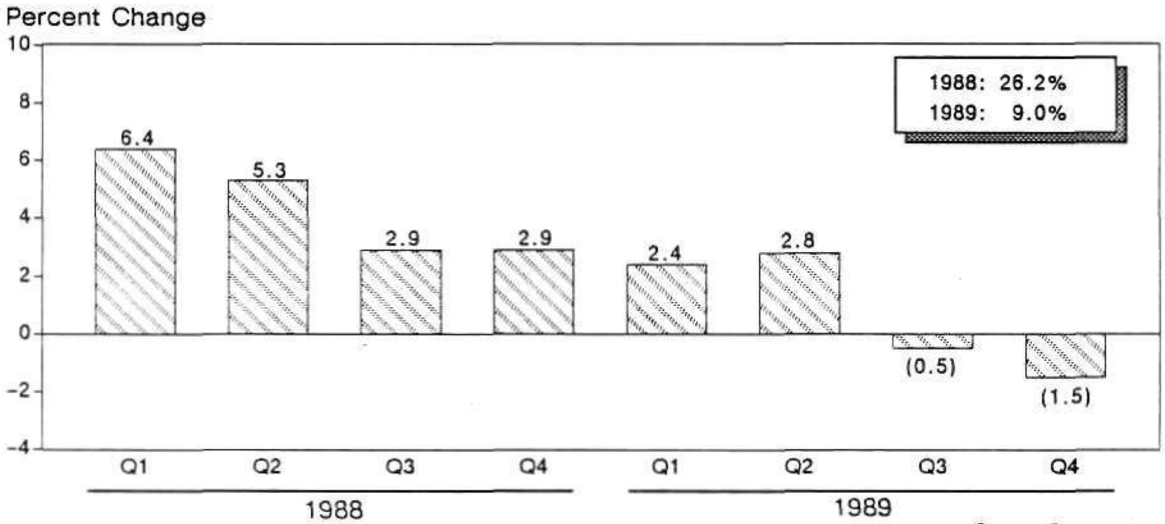
QUARTERLY UPDATE: SEMICONDUCTOR RECOVERY GATHERS MOMENTUM

SUMMARY

The recovery in the worldwide semiconductor market should be stronger in 1988, as the Japanese and European markets continue to recover following the lead of the North American and Rest of World markets. Dataquest forecasts that the worldwide semiconductor market will grow 26 percent in 1988, stacked on top of the 23 percent growth in 1987. The bookings momentum and the shortages in leading-edge products suggest that the strength in shipments should continue through the first half of 1989. The Dataquest world semiconductor forecast is summarized in Figure 1 and Tables 1 and 2.

Figure 1

World Semiconductor Forecast



Source: Dataquest
May 1988

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Table 1

Estimated World Semiconductor Market
(Billions of U.S. Dollars)

	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
North America	11.9	14.7	15.6	15.2	18.0	22.3	13.5%
Japan	14.3	18.2	19.9	18.8	21.1	25.4	12.1%
Europe	6.4	7.6	8.1	8.3	9.2	10.4	10.3%
Rest of World	3.9	5.5	6.6	7.1	8.9	11.4	23.6%
Total World	36.5	46.0	50.2	49.4	57.2	69.5	13.8%

Table 2

Estimated World Semiconductor Market
(Percent Change, U.S. Dollars)

	1987	1988	1989	1990	1991	1992
North America	19%	24%	6%	(2%)	18%	24%
Japan	21%	27%	9%	(5%)	12%	21%
Europe	16%	20%	6%	2%	10%	13%
Rest of World	67%	39%	22%	7%	26%	28%
Total World	23%	26%	9%	(2%)	16%	22%

Source: Dataquest
May 1988

The short-term outlook is very strong, in spite of shortages in memory chips and increasing demand for high-end microprocessors and ASIC devices consumed in the production of data processing equipment. Overall capacity utilization is estimated to be 82 percent by the end of 1988, up from 78 percent in 1987. Capacity is tight for the leading-edge products, with capacity utilization in excess of 90 percent for the finer geometries in the 1.5-micron range. Capital spending is expected to rise 40 percent in 1988 in both the United States and Japan.

As new plants are brought on stream, capacity utilization for high-integration devices should ease a bit later this year. High-end microprocessors should soon cease to be supply limited, but microprocessor demand in 1988 is constrained by memory shortages. Although we expect demand to exceed supply for DRAMs in 1988, we expect supply to catch up in 1989 as a result of increased capacity and improved yields for 1Mb DRAMs, putting downward pressure on prices.

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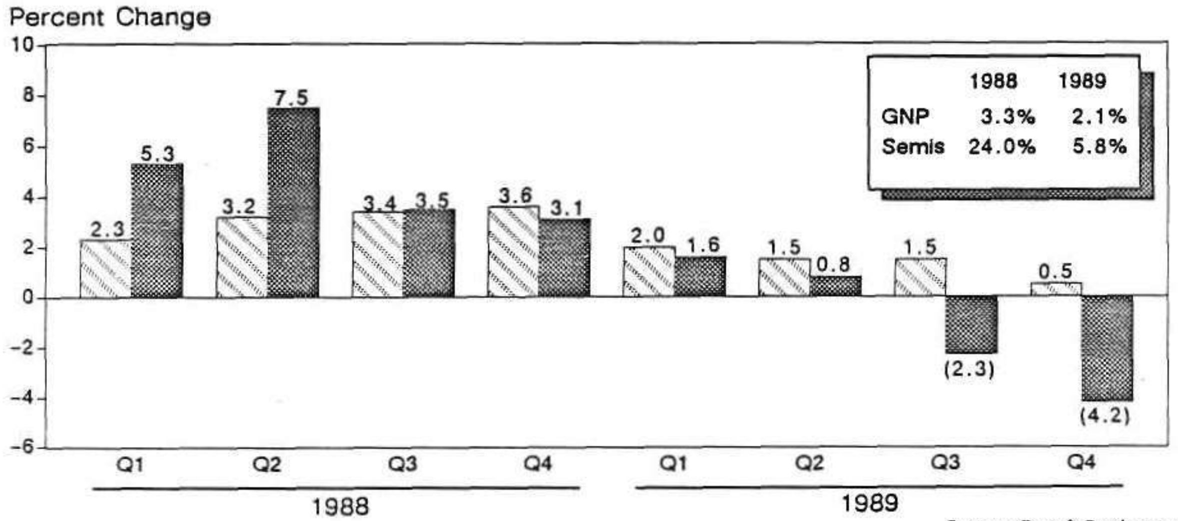
NORTH AMERICAN SEMICONDUCTOR MARKET

In the North American Semiconductor market, the strength in bookings continued in the first quarter of 1988 as confirmed by the SIA reports of robust book-to-bill ratios in the 1.15 to 1.17 range. The bookings and billings levels are now in striking range of beating the records set in 1984. The broad-based strength in data processing equipment production is driving the semiconductor demand, and demand for PCs, technical computers, and business computers continues to be strong. The resulting shortages in memory chips and high-end micros have put upward pressure on prices. Supporting the health of the industry, Dataquest's Semiconductor Application Markets (SAM) service surveys suggest that end-user inventories of semiconductors are below their target levels. Dataquest projects that the North American semiconductor market will grow 24 percent in 1988.

A mild chip recession is anticipated by mid-1989, coincident with a mild recession in the U.S. economy (see Figure 2). As the growth in U.S. real GNP slows from 3.3 percent in 1988 to 2.1 percent in 1989, worldwide electronic equipment production is expected to slow down. In particular, U.S. computer and data processing equipment production is expected to slow down from a 10.0 percent pace in 1988 to an 8.0 percent pace in 1989 and a 6.0 percent pace in 1990 (see Figure 3).

Figure 2

U.S. Economy versus Semiconductors



Source: Dun & Bradstreet
Dataquest
May 1988

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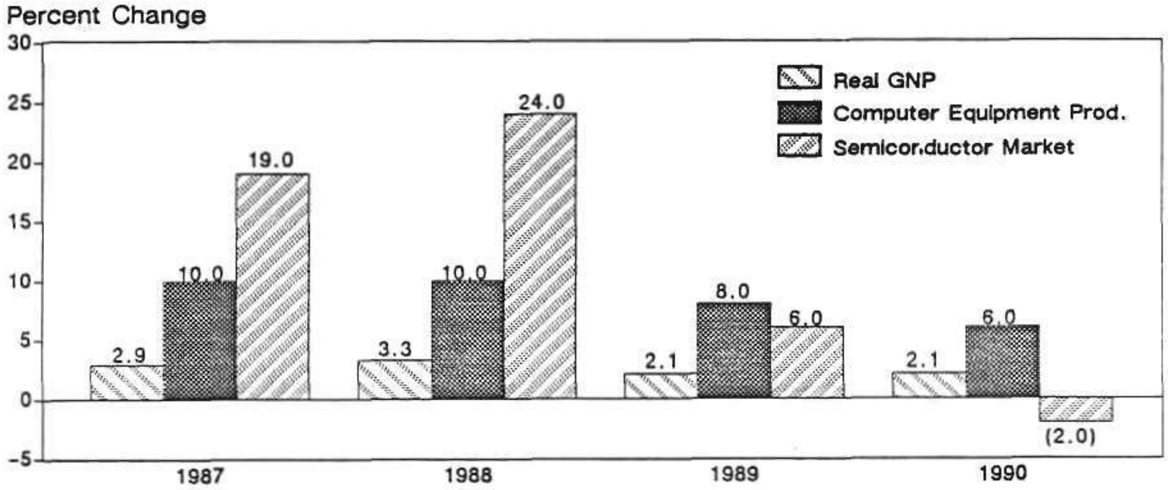
Figure 3

U.S. Economy versus Equipment versus Semiconductors



Source: Dun & Bradstreet
Dataquest
May 1988

The chip recession is signaled by a virtually flat semiconductor market forecast for the second quarter of 1989 in North America. This should be followed by four to five quarters of mild contraction spanning the second half of 1989 and the first half of 1990, resulting in an annual growth of 5.8 percent in 1989 and a decline of 2.2 percent in 1990 in the North American semiconductor market.

The stagger chart shown in Table 3 compares our current forecast to our prior forecasts. A significant change from our prior forecast is the timing of the next chip recession. Some of the strength in 1988 is now anticipated to spill over into early 1989 because of the memory shortage. The mild downturn is now projected to span second half of 1989 and first half of 1990.

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Table 3

North American Semiconductor Market
Stagger Chart
(Percent Change, U.S. Dollars)

Forecast Date	1987	1988	1989	1990
October 1986	12%	30%	(5%)	11%
January 1987	13%	23%	(5%)	11%
April 1987	15%	22%	(0%)	12%
July 1987	18%	22%	(1%)	12%
October 1987	21%	20%	(2%)	13%
January 1988		21%	(1%)	14%
April 1988		24%	6%	(2%)

Source: Dataquest
May 1988

The North American product detail forecasts are shown in Tables 4 and 5. MOS memory is the fastest growing product area in the North American market, growing 49.0 percent in 1988. MOS logic (including ASICs) and MOS microcomponents are also strong, growing 32.0 percent and 29.0 percent, respectively. The long-term forecast is for a robust 13.5 percent compound annual growth rate (CAGR) from 1987 through 1992 for the North American semiconductor market. MOS memory leads with 20.4 percent CAGR, followed by MOS logic with 17.0 percent CAGR and MOS microcomponents with 14.4 percent CAGR. High-end microprocessors and denser memories push up the average selling price of these high-integration devices. The replacement of discrete devices and standard logic by ASICs transfers value from board real-estate and wire traces to ICs. Bipolar memory is a declining market because the proportion of TTL PROMs getting replaced by MOS EPROMs and EEPROMs outpaces the growth in the high-speed ECL RAM market. Linear (analog) ICs are strong, with 11.2 percent CAGR due to fast-growing segments such as linear arrays and telecom ICs.

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Table 4

Estimated Semiconductor Shipments to North America by Quarter (Millions of Dollars)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988	Percent Change 1987-1988
Total Semiconductor	$11,869	$3,395	$3,651	$3,779	$3,895	$14,720	24.0%
Total IC	9,991	2,908	3,140	3,264	3,370	12,682	26.9%
Bipolar Digital	2,072	510	561	590	608	2,269	9.5%
Memory	279	65	72	76	84	297	6.5%
Logic	1,793	445	489	514	524	1,972	10.0%
MOS Digital	6,128	1,928	2,086	2,171	2,239	8,424	37.5%
Memory	2,347	815	862	892	916	3,485	48.5%
Micro	1,817	533	584	609	623	2,349	29.3%
Logic	1,964	580	640	670	700	2,590	31.9%
Linear	1,791	470	493	503	523	1,989	11.1%
Discrete	1,442	377	396	396	404	1,573	9.1%
Optoelectronic	436	110	115	119	121	465	6.7%

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989	Percent Change 1988-1989
Total Semiconductor	$14,720	$3,956	$3,988	$3,898	$3,734	$15,576	5.8%
Total IC	12,682	3,424	3,453	3,377	3,240	13,494	6.4%
Bipolar Digital	2,269	616	617	587	555	2,375	4.7%
Memory	297	82	77	72	70	301	1.3%
Logic	1,972	534	540	515	485	2,074	5.2%
MOS Digital	8,424	2,275	2,303	2,273	2,187	9,038	7.3%
Memory	3,485	941	950	935	895	3,721	6.8%
Micro	2,349	632	633	623	612	2,500	6.4%
Logic	2,590	702	720	715	680	2,817	8.8%
Linear	1,989	533	533	517	498	2,081	4.6%
Discrete	1,573	408	409	397	373	1,587	0.9%
Optoelectronic	465	124	126	124	121	495	6.5%

Source: Dataquest
May 1988

Table 5

Estimated Semiconductor Shipments to North America
by Year
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
Total Semiconductor	$11,869	$14,720	$15,576	$15,236	$17,993	$22,355	13.5%
Total IC	9,991	12,682	13,494	13,079	15,655	19,762	14.6%
Bipolar							
Digital	2,072	2,269	2,375	2,245	2,528	2,924	7.1%
Memory	279	297	301	291	275	265	(1.0%)
Logic	1,793	1,972	2,074	1,954	2,253	2,659	8.2%
MOS Digital	6,128	8,424	9,038	8,664	10,582	13,794	17.6%
Memory	2,347	3,485	3,721	3,499	4,287	5,936	20.4%
Micro	1,817	2,349	2,500	2,375	2,890	3,558	14.4%
Logic	1,964	2,590	2,817	2,790	3,405	4,300	17.0%
Linear	1,791	1,989	2,081	2,170	2,545	3,044	11.2%
Discrete	1,442	1,573	1,587	1,642	1,753	1,904	5.7%
Optoelectronic	436	465	495	515	585	689	9.6%

Source: Dataquest
May 1988

WORLDWIDE SEMICONDUCTOR MARKET

The Japanese semiconductor market experienced slow growth of only 4 percent in 1987 measured in yen, although the yen appreciation translated this to 21 percent growth measured in U.S. dollars. The Japanese market is now projected to recover in 1988 to 15 percent growth measured in yen. At a constant exchange rate of 130 yen to the U.S. dollar, compared with the 1987 rate of 144 yen, this translates to 27 percent growth measured in U.S. dollars. Despite the slowdown in consumer electronics production in Japan for export to the United States due to the yen appreciation, semiconductor consumption in Japan is shifting more and more into the telecom and data processing application markets. Electronic equipment production in Japan is expected to grow 7 percent in 1988.

Real GDP growth in Japan is expected to slow from 3 percent in 1988 and 1989 to 2 percent in 1990. A slow third quarter in 1989 signals the chip recession in Japan. This should be followed by three to four quarters of mild decline, resulting in an annual growth of 9 percent in 1989 and a mild decline of 4 percent in 1990 in the Japanese semiconductor market.

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The European semiconductor market declined 1 percent in 1987, measured in local currency, though this translates to 16 percent growth when measured in U.S. dollars. The European market is now projected to recover to 12 percent growth in 1988, measured in local currency. At a constant exchange rate of 117 European Basket Currency Units, compared with the 1987 rate of 125 Units, this translates to 20 percent growth measured in U.S. dollars. Though European electronic equipment production continues to stagnate with only 5 percent growth expected in 1988, semiconductor demand is spurred by growth in selected areas such as PCs, workstations, and telephones. In addition to the production increase of such U.S. computer companies as Digital Equipment, Hewlett-Packard, and IBM, some Japanese electronics manufacturers are opening facilities in Europe to be closer to the markets they serve. The long-term projection is for continued modest growth in the European semiconductor market with the usual summer doldrums. The outlook is for 6 percent growth in 1989, slowing to 2 percent growth in 1990.

The Rest of World (ROW) semiconductor market, including the Asia/Pacific region (Korea, Taiwan, Singapore, Hong Kong, China) boomed in 1987, growing a whopping 67 percent. We expect this growth to "moderate" to 39 percent in 1988 in this fastest-growing region of the world. While the 1987 growth came from relocation of electronic equipment production by U.S. companies, this trend has slowed considerably. However, Japanese electronics manufacturers are now reported to be relocating plants to Asia/Pacific, sustaining growth in the region. As the U.S. economy slows, the growth in the ROW semiconductor market should flatten during the second half of 1989. The long-term outlook is for growth slowing to 22 percent in 1989 and 7 percent in 1990 in the ROW semiconductor market. As we move into the 1990s, semiconductor consumption in the ROW region should be sustained more and more by electronic equipment produced for local consumption in potentially vast markets such as China. Dataquest estimates that the ROW semiconductor market will surpass the European market in size by 1992, accounting for more than 16 percent of worldwide semiconductor consumption (see Figure 4).

The Worldwide semiconductor shipment forecasts are shown in Tables 6 and 7. The relative product trends are similar to the North American market. MOS memory leads the pack with 42.0 percent growth in 1988, followed by MOS logic growing 33.0 percent and MOS microcomponents growing 28.0 percent. Linear (analog) ICs and optoelectronic devices will grow 20.0 percent, faster than the North American pace, with Japanese and ROW markets contributing to the growth. The long-term outlook is for a strong 13.8 percent CAGR for the world semiconductor market from 1987 through 1992. MOS memory leads with 17.7 percent CAGR, followed by MOS logic with 17.3 percent CAGR, MOS microcomponents with 14.3 percent CAGR, and linear with 13.3 percent CAGR. Optoelectronics will grow at 11.7 percent CAGR because of fast-growing segments such as laser devices used in compact discs (CDs), charge-coupled device (CCD) sensors used in imaging, and fiber-optic couplers used in telecommunications.

In summary, Dataquest forecasts the world semiconductor market to grow 26.0 percent in 1988, measured in U.S. dollars. Due to the cyclical downturn caused by slowing demand and capacity buildup, growth should decelerate to 9.0 percent in 1989, followed by a mild 1.5 percent decline in 1990. The industry should then enter the recovery cycle, topping 22.0 percent growth by 1992.

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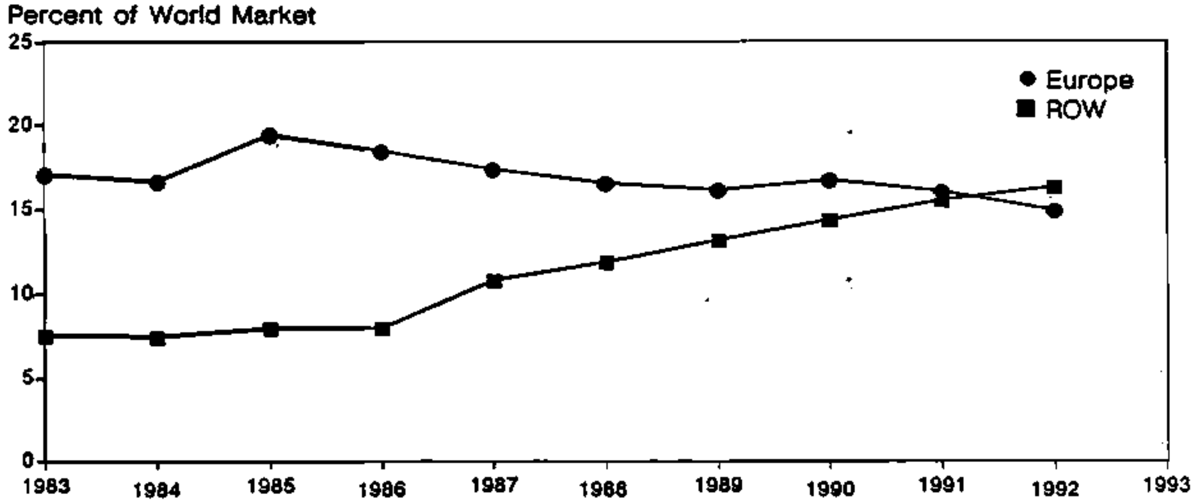
Anthea Stratigos
Joseph Borgia

Figure 4

**Semiconductor Markets:
The Emergence of Rest of World**



Source: Dataquest
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Table 6

Estimated Worldwide Semiconductor Shipments
(Millions of U.S. Dollars)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988	Percent Change 1988
Total Semiconductor	$36,498	$10,831	$11,404	$11,736	$12,077	$46,048	26.2%
Total IC	28,668	8,602	9,098	9,399	9,707	36,806	28.4%
Bipolar Digital	4,672	1,263	1,364	1,424	1,480	5,531	18.4%
Memory	565	143	153	158	167	621	9.9%
Logic	4,107	1,120	1,211	1,266	1,313	4,910	19.6%
MOS Digital	16,788	5,285	5,580	5,783	5,973	22,621	34.7%
Memory	6,019	1,999	2,099	2,184	2,246	8,528	41.7%
Micro	4,819	1,435	1,531	1,579	1,609	6,154	27.7%
Logic	5,950	1,851	1,950	2,020	2,118	7,939	33.4%
Linear	7,208	2,054	2,154	2,192	2,254	8,654	20.1%
Discrete	6,112	1,734	1,797	1,814	1,840	7,185	17.6%
Optoelectronic	1,718	495	509	523	530	2,057	19.7%
Exchange Rate Yen/$	144	130	130	130	130	130	(9.7%)
European Basket/$	125	117	117	117	117	117	(6.4%)

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989	Percent Change 1989
Total Semiconductor	$46,048	$12,368	$12,713	$12,649	$12,464	$50,194	9.0%
Total IC	36,806	9,960	10,241	10,181	10,019	40,401	9.8%
Bipolar Digital	5,531	1,506	1,526	1,469	1,400	5,901	6.7%
Memory	621	165	164	156	151	636	2.4%
Logic	4,910	1,341	1,362	1,313	1,249	5,265	7.2%
MOS Digital	22,621	6,139	6,332	6,339	6,263	25,073	10.8%
Memory	8,528	2,332	2,421	2,425	2,405	9,583	12.4%
Micro	6,154	1,643	1,697	1,704	1,699	6,743	9.6%
Logic	7,939	2,164	2,214	2,210	2,159	8,747	10.2%
Linear	8,654	2,315	2,383	2,373	2,356	9,427	8.9%
Discrete	7,185	1,864	1,911	1,907	1,891	7,573	5.4%
Optoelectronic	2,057	544	561	561	554	2,220	7.9%
Exchange Rate Yen/$	130	130	130	130	130	130	0
European Basket/$	117	117	117	117	117	117	0

Source: Dataquest
May 1988

Table 7

Estimated Worldwide Semiconductor Shipments
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991	1992	CAGR 1987-1992
Total Semiconductor	$36,498	$46,048	$50,194	$49,446	$57,152	$69,533	13.8%
Total IC	28,668	36,806	40,401	39,572	46,253	57,203	14.8%
Bipolar							
Digital	4,672	5,531	5,901	5,731	6,492	7,572	10.1%
Memory	565	621	636	613	578	534	(1.1%)
Logic	4,107	4,910	5,265	5,118	5,914	7,038	11.4%
MOS Digital	16,788	22,621	25,073	24,291	28,621	36,179	16.6%
Memory	6,019	8,528	9,583	8,967	10,327	13,608	17.7%
Micro	4,819	6,154	6,743	6,603	7,742	9,382	14.3%
Logic	5,950	7,939	8,747	8,721	10,552	13,189	17.3%
Linear	7,208	8,654	9,427	9,550	11,140	13,452	13.3%
Discrete	6,112	7,185	7,573	7,613	8,339	9,341	8.9%
Optoelectronic	1,718	2,057	2,220	2,261	2,560	2,989	11.7%
Exchange Rate Yen/$	144	130	130	130	130	130	
European Basket/$	125	117	117	117	117	117	

Source: Dataquest
May 1988

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FERRAM: THE MEMORY THE MARKET ALWAYS WANTED

SUMMARY

New developments in semiconductor memory products always raise the interest of designer and procurement organizations in end-user companies. This newsletter analyzes a promising technology of nonvolatile IC memory. Users of current memory products should be aware of this technology and designers can inquire about application benefits for future systems from the companies involved.

The ferroelectric RAM, or FERRAM, memory technology provides all the performance features that the market wants. It is nonvolatile, radiation hard, compatible with MOS, GaAs, and bipolar processing, and offers fast read and write together with longterm data storage in the absence of applied power. If there are no unforeseen technical glitches, FERRAMs should have significant memory market impact.

This newsletter uses a learning curve analysis to forecast the FERRAM market for the next five years. During this period, the FERRAM will compete primarily with EEPROMS, reaching total sales of an estimated $350 million in 1992.

Ferroelectric technology is not new, but two start-up companies, Krysalis and Ramtron, have applied the technology in a novel way. This newsletter describes the technology and provides brief profiles of both companies.

THE MEMORY HIERARCHY

Today, many technologies are used to supply the needs of the memory market. No one technology supplies all needs, and as a result, market niches exist that are supplied by specialized memories. The FERRAM promises to be the one technology for all applications, since it combines fast read and write with nonvolatility. In spite of this promise, FERRAMs are new and must compete with existing technologies that have been in manufacture for some time and are well down the learning curve. For most memories, learning curves are such that the selling price is multiplied by a factor of 60 percent to

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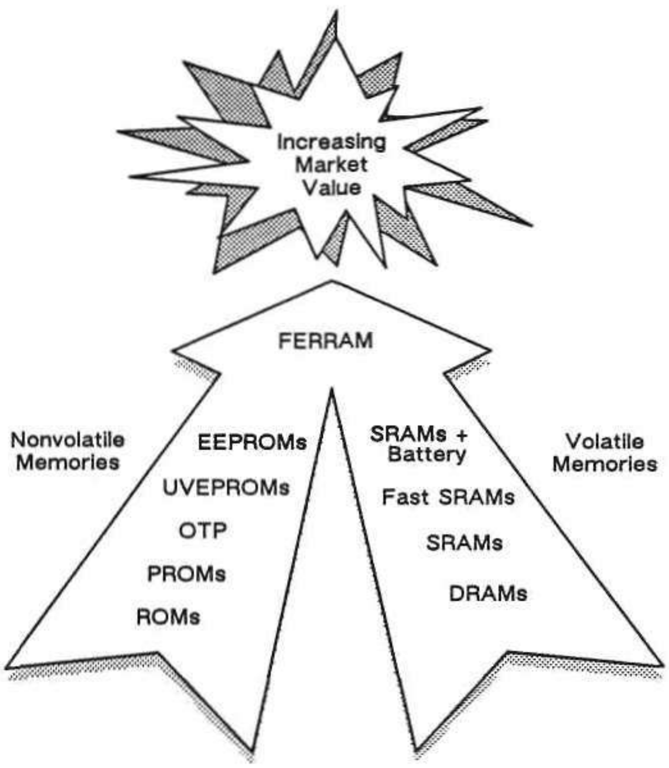
80 percent every time the cumulative volume doubles. For this reason, a memory manufactured in high volume is likely to have a much lower selling price than a low-volume memory.

FERRAM memories are currently in the embryonic stage—manufacturing volumes are essentially nil. The key question is whether the FERRAM can capture enough of some memory market segment to begin proceeding down its own learning curve.

The memory hierarchy is shown graphically in Figure 1. Here, memory technologies are shown in ascending order of performance. Note that this figure divides the memory market into its two segments: volatile and nonvolatile. FERRAM is shown at the intersection of the two segments because it satisfies the needs of both.

Figure 1

The Memory Hierarchy



Source: Dataquest May 1988

The feature content of the various technologies in the nonvolatile hierarchy can be described as follows:

- ROM: Read only
- OTP/PROM: Read only, write once

- UVEPROM: Read only, write once, UV erase
- EEPROM: Read fast, write slowly
- FERRAM: Read fast, write fast, extended wear-out

Each member of the hierarchy has a significant advantage over the inferior technology. OTPs and bipolar PROMs can be programmed by the user; ROMs can be programmed only by the manufacturer. EPROMs can be erased and reprogrammed; OTPs and PROMs can be programmed only once. EEPROMs can be electrically erased so that they can be used in applications that require in-socket reprogramming; EPROMs cannot. FERRAMs are superior to EEPROMs because they have fast write and can be rewritten many more times than EEPROMs before they wear out.

The feature content of the various technologies in the volatile hierarchy can be described as follows:

- DRAM: Slow, needs refresh
- SRAM: Faster, no refresh
- Fast SRAM: Faster still, no refresh
- SRAM and Battery: All SRAM features plus battery backup
- FERRAM: All SRAM features, nonvolatile without battery

As with the nonvolatile hierarchy, each member of this hierarchy has sigzificant advantages over the inferior technology. SRAMs tend to be faster then DRAMs and need no refresh. Fast SRAMs have a speed advantage over SRAMs. SRAMs with battery backup should have all the performance of the best SRAM and offer data storage during power outage as well; although they have gained wide acceptance, many users are suspicious of battery reliability. FERRAMs are superior to SRAMs with batteries because users are likely to prefer nonvolatility that can be accomplished without a battery.

It is significant that the FERRAM is at the top of both memory hierarchies from a feature point of view. If it could be manufactured for a low enough price, it would undoubtedly replace all the market segments in both hierarchies.

Table 1 shows estimated 1989 bit prices and bit shipments for memories in the nonvolatile hierarchy. Note that the most desirable memories have the highest bit prices, whereas the lowest-priced memories have the highest bit volumes. The OTP is an exception to this rule since it has lower bit shipments than UVEPROM; because it is an exception, it is gaining market share from UVEPROM. This will be further explained in the next section.

Table 2 shows estimated 1989 bit prices and bit shipments for memories in the volatile hierarchy. In this hierarchy, the most desirable memories have the highest prices and lowest bit shipments as would be expected.

Table 1

Estimated Nonvolatile Memory Market Highlights, 1989

Type	Bit Price (Millicents)	Bit Shipments (Billions)	Market (Millions of Dollars)
EEPROM	12.80	3,360	$ 429
UVEPROM	0.97	112,932	1,097
OTP	0.61	20,897	128
ROM	0.37	132,710	493
Total			$2,147

Source: Dataquest
May 1988

Table 2

1989 Volatile Memory Market Highlights

Type	Bit Price (Millicents)	Bit Shipments (Billions)	Market (Millions of Dollars)
Fast SRAM	5.85	8,955	$ 524
SRAM	0.98	42,992	422
DRAM	0.35	887,279	3,110
Total			$4,056

Source: Dataquest
May 1988

HIERARCHICAL CANNIBALISM

Hierarchical cannibalism occurs when one memory technology usurps the market of a technology next to it in the hierarchy. Currently, this is occurring as OTP replaces UVEPROM. In the late '70s, cannibalism occurred when bipolar PROMs replaced bipolar ROMs. Today, there are no bipolar ROMs in the marketplace.

This section describes the circumstances under which cannibalism is likely to occur. Most of the discussion is based on learning curve theory; it tends to overlook factors that might be important in a more detailed analysis. Such factors might include the strategies of different participants in the market, their financial strength, or their marketing prowess.

A comparison of relative price and relative market share of various technologies is given in Figure 2. Here, data is plotted for technologies that are next to each other in the memory hierarchy. The ratio of the bit shipments of these paired technologies is given on the horizontal axis and the ratio of their bit prices is given on the vertical axis. Paired memory technologies are indicated on the figure. For instance, the point EEPROM/UVEPROM illustrates the relative situation between these two technologies.

Two things are of special interest in Figure 2. First, the slope of the trend envelope is such that the relative prices decrease about 20 percent every time the relative volume doubles. This seems to be related to the 80 percent learning curve that is exhibited by most memory technologies. Second, the lower part of the envelope passes through bit parity when the superior technology is at a 40 percent price premium. At the upper side of the envelope, this premium expands to more than 300 percent. This spread in price premium is a measure of the relative superiority of one technology over another. All the market estimates for FERRAM in this newsletter assume the more conservative price premium of 40 percent at bit parity.

As Figure 2 shows, the only two paired technologies jockeying for market position are UVEPROM and OTP. In recent years, the price of OTP has been declining more rapidly than that of UVEPROM. As a result, OTP bit shipments have been increasing more rapidly than UVEPROM bit shipments; this drives the bit ratio of the UVEPROM down as compared with OTP, causing the data points to migrate in the manner shown from 1984 to 1987.

Why is it that cannibalism is occurring in the case of UVEPROM/OTP? Table 3 provides the answer to that question. In the period 1984–1989, OTP increased in bit shipments by 98.11 to 1, while UVEPROM increased in bit shipments by only 8.88 to 1. In other words, OTP decreased more in selling price because it increased relative bit shipments much more than UVEPROM.

Cannibalism occurs when a new technology (e.g., OTP) is introduced near price parity with an older technology (e.g., UVEPROM), but at much lower bit shipments. In this situation, the new technology need garner only a small fraction of the bit shipments of the older technology to double and redouble its bit shipments. The new technology can thus run rapidly down its learning curve and lower its relative price substantially, until eventually it captures the bulk of the market from the older technology.

Why are the other technologies in Figure 2 not cannibalistic? They are simply too far apart in price for cannibalism to occur. To put it more precisely, they are priced so that little change in relative bit shipments is likely. That is why movement is observed only for the pair UVEPROM/OTP. This pair plotted near the parity price point in Figure 2 in 1984. If technologies are far apart in price, they can be thought of as occupying separate, defensible market niches. In this situation, users buy the superior technology only when it is absolutely required, and relative bit prices can be quite high. However, when relative bit prices approach parity, users will use the superior memory even when they do not absolutely need the extra features so long as the premium paid is not too great.

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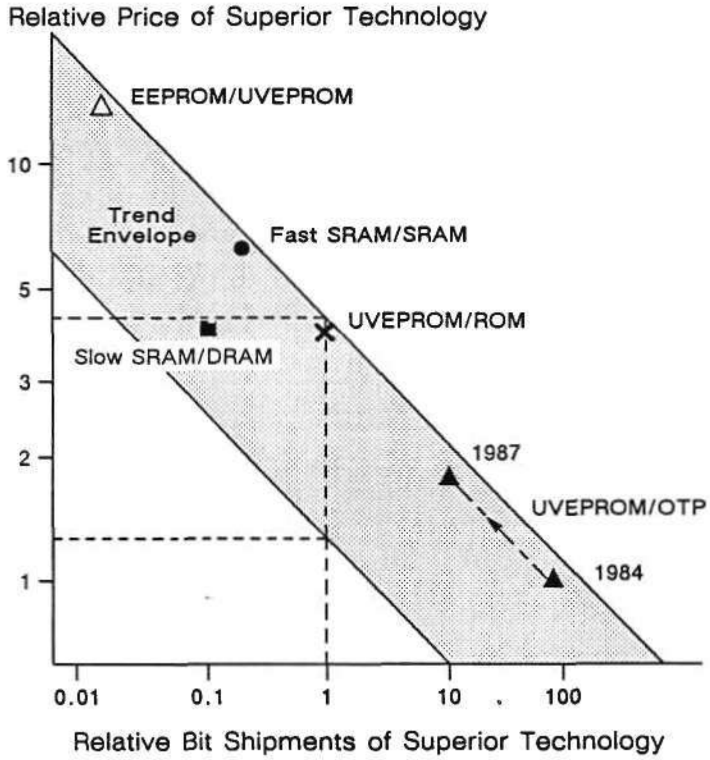
Figure 2

Relative Market Share of Competing Memory Technologies (1987 Data, unless Indicated)



Source: Dataquest May 1988

Table 3

Comparison of UVEPROM and OTP

Type	1989 Bits/1984 Bits	1989 Price/1984 Price
UVEPROM	8.88	0.105
OTP	98.11	0.064

Source: Dataquest
May 1988

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FERRAM MARKET SHARE ESTIMATES

Dataquest's estimates for the FERRAM make the following assumptions:

- The FERRAM can be introduced at a bit price near that of EEPROM.
- Early shipments are limited by market dynamics.
  - The time required to educate the market
  - The time required to build shipments
- The FERRAM takes market only from EEPROM.
- FERRAM technology is used only to store data when power is off.
- FERRAM pricing follows a 60 percent learning curve.

All of these assumptions are conservative. FERRAM prices near those of SRAMs should be possible, since FERRAMs can be built using an SRAM process with only three additional mask layers.

It is assumed that FERRAM will take market share only from EEPROM. It is possible that FERRAM can gain additional market share from other memories such as bubble memories and SRAMs.

It is assumed that FERRAM technology is used to store data only when power is turned off. A circuit to accomplish this with SRAM technology can easily be built by adding only the aforementioned three mask layers. In this case, the FERRAM is cycled only when the power is turned off. The wear-out mechanism in FERRAM is good for at least 10 to a factor of 10 cycles, which provides memory life in excess of 10,000 years if power is cycled twice a day.

There is also a good possibility that the wear-out could be extended to 10 to a factor of 15 cycles. This would make it possible to cycle the FERRAM every time the memory is read without wear-out occurring. As a result, FERRAM could achieve something close to SRAM performance using a single-transistor FERRAM cell. This technology would be much less expensive than the SRAM technology assumed in Dataquest's forecast.

A 60 percent learning curve is assumed. Since the FERRAM will be introduced at a premium to EEPROM prices (which are assumed to be 12.8 millicents per bit in 1989, as shown in Table 1) but built with SRAM technology (.98 millicents per bit in 1989 as Table 2 shows), this entire premium is used to pay for the three extra FERRAM masking layers. All other things being equal, the premium should be proportional only to the number of mask layers. This means a premium of 3/13 equals 23 percent if there are 13 SRAM layers and 3 FERRAM mask layers. Thus, it is reasonable to assume that FERRAM prices proceed along a 60 percent learning curve rather than the 80 percent learning curve typical for most memories, since all the learning can be focused on only the three extra mask layers.

Both vendors project that in the future, FERRAMs will need only one additional mask layer. This would make the above assumptions even more conservative.

Figure 3 gives Dataquest's estimates for FERRAM and EEPROM bit prices for the period 1988 through 1992. FERRAM prices are kept relatively high through the beginning of this period because shipments are limited mostly by market dynamics rather than relative price.

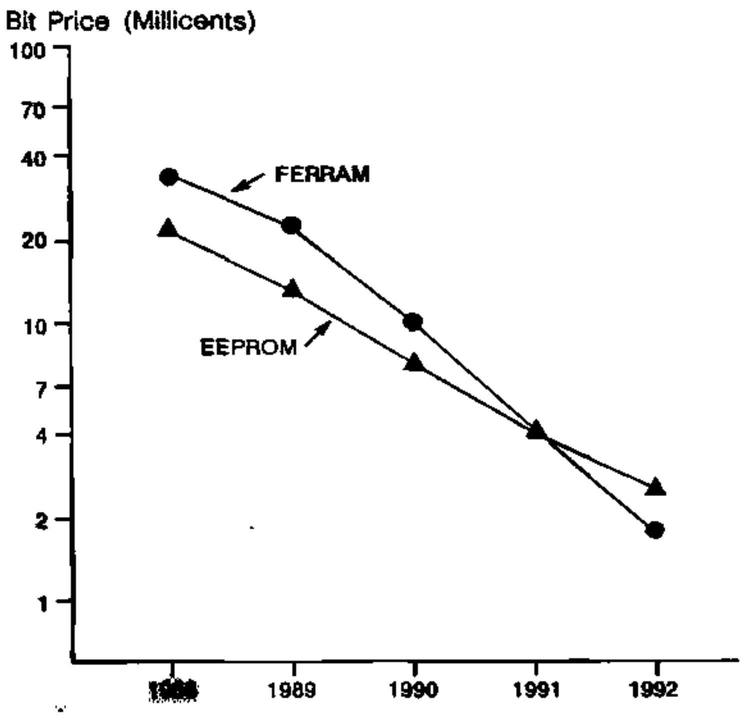
Figure 4 gives the relative dollar shipments of FERRAM and EEPROM. In this figure, the hollow bars indicate the EEPROM shipments before FERRAM, whereas the shaded areas indicate EEPROM shipments after FERRAM. Note the significant impact that FERRAM has in 1991 and 1992.

Dataquest's scenario that accompanies this forecast assumes the most complex part is a 256K FERRAM in 1988, with shipments of this device ramping in 1989. Introduction of a 1-megabit FERRAM using a single-transistor cell is assumed in 1990. If this part is not introduced, however, the forecast of Figure 4 would be little changed.

Dataquest also anticipates that a 4-megabit FERRAM will be introduced sometime in the early to mid -1990s. This part should be very interesting, because there is a good chance that it may be easier to build than a 4-megabit DRAM. This is possible because the ferroelectric capacitors used in FERRAMs have dielectric constants hundreds of times higher than silicon dioxide. This means that a storage capacitor can easily be built without resorting to the need for the trench capacitors currently contemplated for that generation of DRAM.

Figure 3

Forecast EEPROM and FERRAM Bit Prices



Source: Dataquest
May 1988

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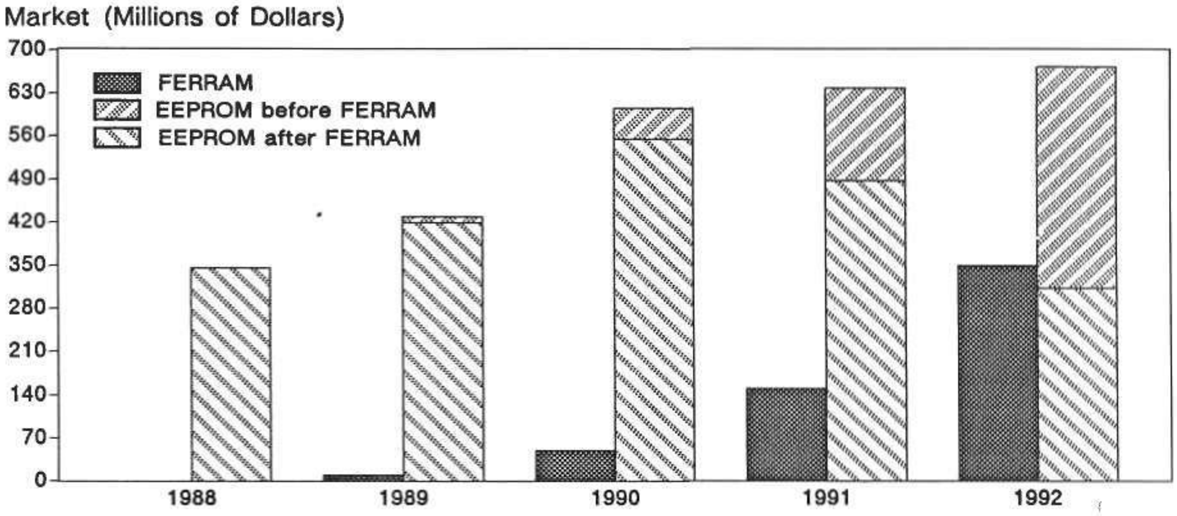
Figure 4

Forecast EEPROM and FERRAM Markets



Source: Dataquest
May 1988

TECHNOLOGY

Ferroelectric technology has been around for some time. Thirty years ago, ferroelectric technology was being considered as an alternative to magnetic core technology. That line of research was abandoned for many reasons. Important among these was the fact that ferroelectric memories could not be addressed by a combination of voltages on the row and column lines in the same way that magnetic memories could be addressed by coincident row and column currents.

Later, a great deal of research was done on ferroelectrics because of the other properties of these materials. Among other things, ferroelectric materials exhibit an index of refraction that can be controlled by an applied voltage. This makes them useful for modulating beams of light.

Ferroelectric materials are also often piezoelectric. Some attempts to use these materials have floundered because the piezoelectric effect caused them to flex mechanically and eventually fatigue.

Today, hundreds or even thousands of ferroelectric materials are known. These all have different properties, and only a few are suitable for semiconductor applications.

The current breakthrough in ferroelectric memories seems to be due to several factors. First, several groups realized that a ferroelectric device could be addressed using semiconductor technology rather than coincident voltages. This greatly relieved constraints on the ferroelectric material.

Secondly, two companies began working with a ferroelectric material that is effectively a ceramic. With proper processing, this material is robust and compatible with semiconductor processing.

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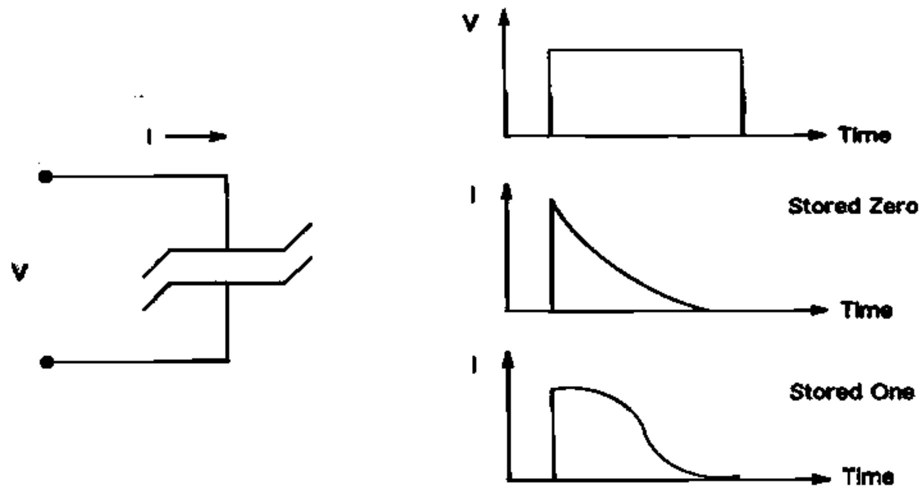
Finally, deposition techniques have advanced to the point where it is possible to reliably deposit reproducible thin films of this material. Deposition is still somewhat tricky because the exact mixture of elements must be maintained or the material will not exhibit ferroelectric properties.

When a ferroelectric material is used as the dielectric in a capacitor, it exhibits some interesting properties. As the capacitor is charged, the bipolar (+ on one end, - on the other) molecules in the ferroelectric material align themselves with the electric field. If the capacitor is discharged, these molecules stay aligned. If a subsequent voltage is applied in a direction opposite to the first voltage, these molecules have to realign themselves in the opposite direction, and a high current flows. If, on the other hand, the second voltage is applied in the same direction as the first, only a small current flows since the bipolar molecules are already aligned in that direction.

This is illustrated in Figure 5, where a voltage is applied to a ferroelectric capacitor. If a zero is stored in the capacitor, its molecules are already aligned in the same direction as the applied voltage. If, on the other hand, a one is stored, the molecules are aligned in the opposite direction, and a higher current flows.

Figure 5

Memory in a Ferroelectric Capacitor



Source: Dataquest May 1988

These capacitors can be used in conjunction with conventional memory circuits. In an SRAM, one capacitor is attached to each side of each memory flip-flop when the power to the chip begins to go off. One side of the flip-flop is high, and this side causes that memory capacitor to polarize. The other memory capacitor does not polarize because that side of the flip-flop is low. When the power is turned back on, less current will flow in the polarized capacitor than in the capacitor tied to the other side of the flip-flop. This will cause the flip-flop to return to its original state.

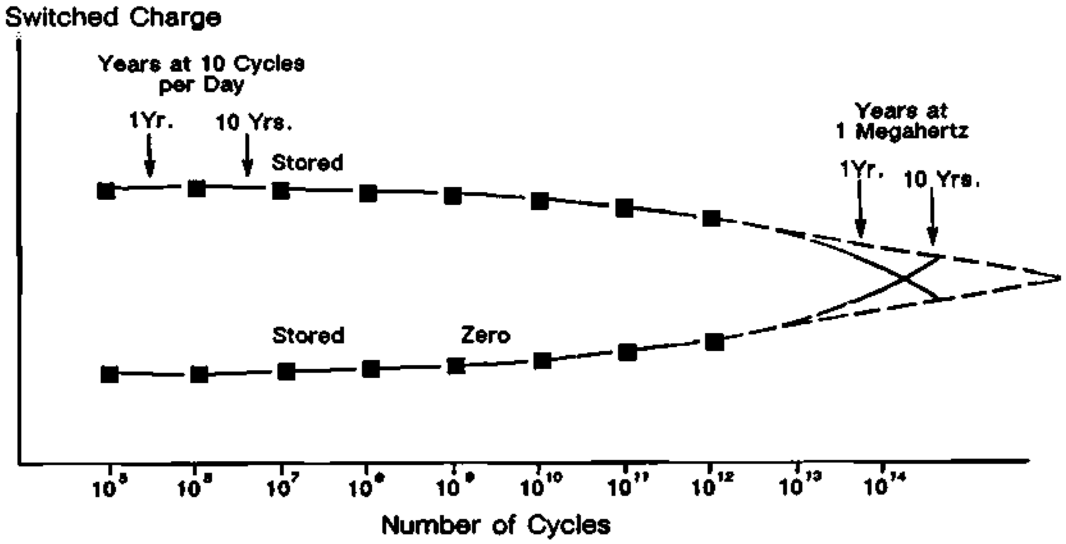
Alternatively, a ferroelectric capacitor can be used as the storage capacitor in a DRAM. This capacitor is alternately charged and discharged every time a bit is read, just like in a conventional DRAM. However, data storage in the DRAM is permanent because the polarization of the ferroelectric capacitor stores the data when the power to the chip is turned off.

Ferroelectric capacitors also have an advantage in DRAM circuits because they have several hundred times as much capacitance per square micron as the silicon dioxide capacitors now used in today's DRAMs. This means that a smaller capacitor will generate a much higher output voltage. Conceivably, ferroelectric capacitors could eliminate the need for trench capacitors in the 4-megabit DRAM while simultaneously providing nonvolatility as an added bonus.

Figure 6 shows the way that the ability of a ferroelectric capacitor to store charge deteriorates as the memory is cycled. Initially, the charge stored for a one is 1.5 to 2.0 times as great as the charge stored for a zero. As the capacitor is read and rewritten, there is a tendency for some of the bipolar molecules to become "stuck" so that they no longer turn around when a reverse voltage is applied. This reduces the ratio of the amount of charge stored for a one and a zero, gradually causing the capacitor to be useless after repeated cyclings.

Figure 6

Endurance Testing of FERRAMs



Source: Dataquest May 1988

Currently, 10 to the 10th power cycles have been achieved, and one vendor is claiming 10 to the 14th cycles. If the SRAM technology is used and the ferroelectric capacitors are cycled only when power to the memory is lost, 10 to the 10th cycles is far more than adequate. On the other hand, if the DRAM circuit is used, a 10-year life would require 10 to the 14th cycles if the memory cycle is 1 microsecond and 10 to the 15th cycles if the memory cycles in 100 nanoseconds. This may be achieved in the near future, since progress in improving this wear-out has been rapid so far.

For comparison, the number of cycles achieved by EEPROMs before wear-out is 10 to the fifth or less. Ferroelectric capacitors are already far superior. In addition, the ferroelectric capacitor seems able to retain its memory in the presence of radiation, a fact of interest to the military.

Ferroelectric capacitors have also been tested to see how long they retain data when they are stored without being cycled. Current data suggests that long-term storage does not present a problem. This conclusion is based on the fact that no measurable deterioration is seen in a period of months.

Ferroelectric capacitors are compatible with MOS processes, so it appears likely that they would also be compatible with GaAs and bipolar processing. This should offer some interesting product opportunities, since no nonvolatile memory is available in either of these technologies.

COMPANIES

Two companies, Krysalis and Ramtron, are currently in the start-up phase of FERRAMS production. Krysalis is located in Albuquerque, New Mexico. The firm has had two infusions of capital and has produced a 512-bit sample memory. It is working on 16-Kbit and 256-Kbit memories. Krysalis has recently installed a processing area for adding the extra ferroelectric layers to base wafers produced in a foundry.

Ramtron is located in Colorado Springs, Colorado. Its early ferroelectric work was done at the University of Colorado, and the ferroelectric layers are still being applied in the university wafer fab. Ramtron has just finished a 256-bit device and is working on both 16K and a 256K devices. Initial financing for Ramtron came from a venture capital firm in Australia. Recently, a license was negotiated with an Australian semiconductor start-up.

Both firms appear to be using the same ferroelectric material, though it appears that they apply it in a different manner. Both are actively adding to their patent portfolios and both plan to pursue an active licensing program for this technology.

DATAQUEST CONCLUSIONS

Dataquest believes that FERRAMs represent a significant new memory technology. If unforeseen production or reliability problems do not crop up, FERRAMs should garner a growing share of the memory market. This share is may grow dramatically in the next five years if the FERRAM technology achieves its anticipated cost and technology developments. Beyond that, FERRAMs could continue gaining share as they begin to take market share from SRAMs. Our most optimistic scenario suggests that FERRAMs are the technology of choice at the 4-megabit DRAM level. This would result in FERRAM achieving a significant share of the entire memory market.

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Research Newsletter

SUIS Code: 1988-1989 Newsletters: April-June
1988-20

THE 1988 PROCUREMENT DILEMMA: COORDINATING SYSTEM AND SEMICONDUCTOR LIFE CYCLES

SUMMARY

This newsletter focuses on a specific challenge for supply base managers—sourcing devices that are in the latter stages of their product life cycles. For vendors, continuing support of the user's need for older parts can translate into a profitable opportunity. Main points include:

- A new source of 64K DRAMs
- System redesign/no redesign strategies for users of 74HC/HCT

Dataquest strongly recommends that users and vendors strike closer relations such as initiating special procurement contracts for semiconductor products that stand beyond the maturity/saturation stage of their life cycles. Dataquest also recommends that North American, European, and certain Japanese vendors return to or increase their semiconductor <u>memory</u> production, including, but not limited to, 64K DRAM devices.

THE CHALLENGE FOR SUPPLY BASE MANAGERS

Procurement managers, component engineers, and other supply base managers in systems companies typically face three product challenges:

- To design <u>only</u> viable new semiconductor products into systems
- To pay the "right" price for mainstream products—not too high, but also not so low as to force supportive suppliers from marketplace
- To procure supplies of older devices for use in profit-generating systems in order to avoid costly and unnecessary system redesigns

This newsletter focuses on the third challenge.

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Systems manufacturers can use semiconductor product life cycle curves and related techniques to track products that have moved beyond the mainstream maturity/saturation stage of the life cycle. Using knowledge of their system's life cycle and semiconductor life cycle, the user must ascertain whether a system redesign is necessary and feasible.

For systems manufacturers, there are at least two cases in which system redesign is impractical. The first is, when there is no competitive replacement system for a given manufacturers' system. The second case occurs when a manufacturer's system stands at the growth or maturity stage of the life cycle despite the fact that vital portions of the semiconductor content are hitting the latter stages of the cycle.

If system redesign is not feasible, systems manufacturers that have not already done so should negotiate special procurement contracts with vendors for critical parts. The current trade environment provides a unique opportunity for North American, European, and some Japanese semiconductor vendors to win profits in a less-competitive environment.

THE VITAL PRODUCTS

Based upon recent inquiries received by Dataquest, the older semiconductor memory and standard logic products listed in Table 1 remain vital to a host of systems manufacturers in North America and Europe. Table 1 also provides information on prospective long-term suppliers of each of the critical products.

Table 1 must be read very carefully. First, it does not say that users are experiencing or should expect a a critical situation regarding supply of the listed products. What the table does say is that Dataquest clients have experienced difficulty or expressed concern about sourcing these devices.

Furthermore, the table does not infer that any supplier has immediate availability of the listed product. The table identifies the potential longer-term/larger-order suppliers.

With this background in mind, both users and vendors should realize that the downside of the semiconductor life cycle curve represents neither a seller's market or a buyer's market. If vendors push too hard on price or prove too soft on dependability, systems manufacturers might force themselves to make premature and costly system redesigns. Conversely, although a main point of this newsletter concerns the wide range of possible supply sources for these older parts, the supplier base for the products listed in Table 1 is subject to shrinkage should vendors see no profitable demand.

Given the mutual risk associated with these devices—users need them for profit-generating systems while vendors look to larger profit streams from newer products—closer user-vendor relationships in the form of special procurement arrangements can provide an efficient tool for allocating supply and demand.

Based upon recent inquiries received by Dataquest, two products exemplify the route for satisfying user demand for these older products to the mutual benefit of users and vendors.

Table 1

Sourcing Older
Semiconductor Memory & Logic Products

Product	Prospective Suppliers
Memory	
64K DRAM	Inmos, Micron, Mitsubishi, Oki, TI
16K SLOW SRAM	GE Solid State, Goldstar, MOSel, Oki, Samsung, Seiko-SMOS, Sony
16K EPROM (low speed)	AMD, Intel, National Semiconductor, SGS-Thomson, TI
32K	AMD, Intel, National Semiconductor, SGS-Thomson, TI
Standard Logic	
74/74L	AMD, National Semiconductor, Philips-Signetics, TI
74C/4000	GE Solid State, Motorola, National Semiconductor, Philips-Signetics
ECL 10K	AMD, Motorola, Philips-Signetics
74S	Goldstar, National Semiconductor, Philips-Signetics, TI
74LS	AMD, Motorola, National Semiconductor, Philips-Signetics, Texas Instruments
74HC/HCT	GE Solid State, Motorola, National Semiconductor, Philips-Signetics, TI (74HC only)

Source: Dataquest
May 1988

64K DRAM Products

The trade press hoopla surrounding the market for 256K/1Mb/4Mb DRAMs has overshadowed the users' concern over the continued availability of 64K DRAMs. Nevertheless, the systems manufacturers that subscribe to Dataquest services hammered home their concern during the first quarter of 1988.

At least five vendors—Inmos, Micron, Mitsubishi, Oki, and TI—are prospective suppliers of 64K DRAMs. Undeniably, users face a challenge during the current trade environment in terms of securing 64K DRAMs from North American suppliers like Inmos, Micron, and TI and Japanese vendors like Mitsubishi and Oki. Closer user-vendor arrangements will make it easier to acquire this older device. Systems manufacturers that really need 64K DRAMs (or any other vital older products) must buttress the vendors' interest in serving demand for these devices through longer-term contracts and other special purchase agreements.

Some readers will be surprised to learn of Inmos' role as a supplier of 64K DRAMs. Inmos has responded to the opportunity created by U.S.-Japanese trade tension by producing these devices. However, Inmos apparently will serve only orders of 50,000 pieces and more. Given current demand levels, the company should earn good profit levels by making a risky return to producing DRAMs.

74HC/HCT Devices

This older standard logic product clearly illustrates the redesign/no redesign challenge that confronts supply base managers. Systems manufacturers have contacted Dataquest as to whether they should redesign their systems and replace 74HC/HCT with other logic products like FACT, FCT, or application-specific integrated circuits (ASICs), or if they should avoid system redesign and continue sourcing this older product.

Supply base managers can make their decisions regarding redesign/no redesign on the basis of the following information. Regarding price/performance tradeoffs, systems manufacturers who <u>must</u> maintain a competitive edge in performance should strongly consider paying the price in terms of system redesign and higher semiconductor average selling price that comes with the migration from 74HC/HCT to FACT or ASICs. Conversely, systems manufacturers that do not need and do not want to pay for the speed advantage of FACT/ASICs (vis a vis 74HC/HCT) should decide against system redesign. For redesigns down the road, users should note that FACT is pin-for-pin compatible with 74HC/HCT.

Supply base managers who reject system redesign can turn to several North American and European giants of the semiconductor industry for longer-term support of their need for 74HC/HCT (see table 1). Firms like National Semiconductor and Philips-Signetics have expressed interest in profitably serving demand for this older product over the long term. Supply base managers can also look to GE Solid State, Motorola, and TI (74HC only) for long-term support.

DATAQUEST RECOMMENDATIONS

Dataquest recommends that users and vendors move into closer relations like specialized procurement contracts concerning semiconductor products that stand beyond the maturity/saturation stage of the life cycle.

Special procurement arrangements should enable systems manufacturers to obtain a dependable supply of vital older devices for use in profit-generating systems, thus avoiding costly and unnecessary systems redesigns. For semiconductor vendors continual support of users' needs for older parts like 64K DRAM and 74HC/HCT should translate into a profitable opportunity. Vendors serving demand for these devices encounter less competition, higher profit margins, and the opportunity to develop special procurement relationships with key accounts.

Dataquest also strongly recommends that North American, European, and some Japanese vendors return to or increase semiconductor memory production. We believe that there is clear opportunity in meeting demand for the range of DRAM, EPROM, and SRAM products.

DATAQUEST CONCLUSIONS

A major challenge for supply base managers centers on sources of older semiconductor products like 64K DRAMs. For systems manufacturers, devices like this one are used in profit-generating systems for which redesign is a premature alternative.

Right now, users are focusing their procurement activities on a host of older semiconductor products. For users of 64K DRAMs, Inmos can be put on the board of suppliers. For manufacturers of systems that use 74HC/HCT, system redesign can be avoided unless premium performance is required. If premier performance is the major requirement, migration to FACT, FCT, or ASICs should begin.

We believe that at present there is profitable opportunity for vendors to supply the full range of memory products in addition to a host of older semiconductor devices.

Ronald A. Bohn

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Research *Bulletin*

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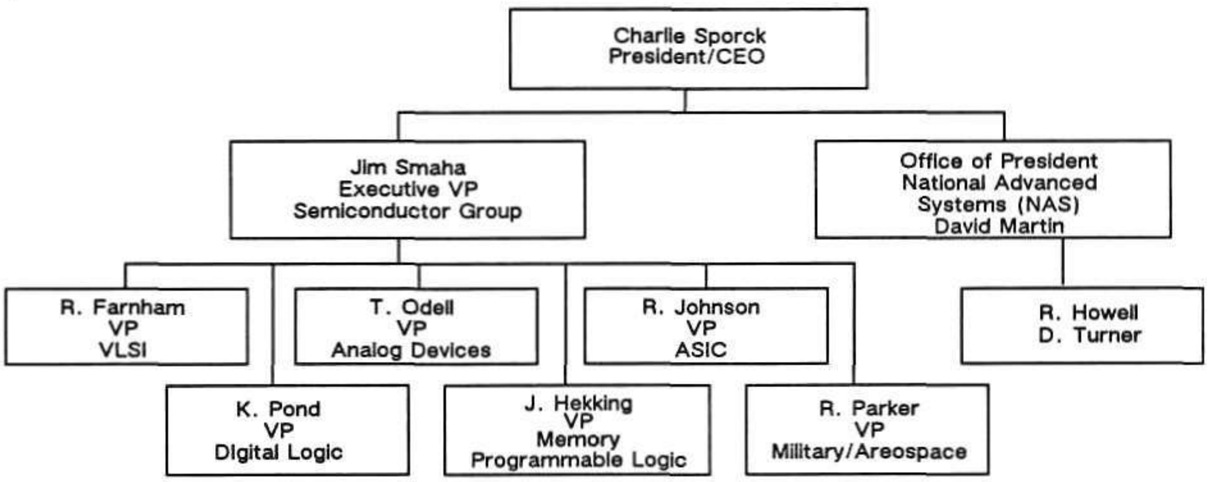
NATIONAL SEMICONDUCTOR RESTRUCTURES

National Semiconductor has undergone a tremendous amount of change in its struggle to identify a structure that will result in profitable operations. Organizationally, the most significant outcome of these efforts so far has been the shedding of its nonsemiconductor-related lines of business, allowing the company to focus entirely on the successful positioning of its components products. Figure 1 illustrates the revised organizational structure of National Semiconductor in the wake of announcements made during the past two months. Because of the number and nature of these announcements, Dataquest offers this Research Newsletter to our Semiconductor User clients in order to bring them up to date on National's restructuring efforts.

Figure 1

National Semiconductor Organizational Structure
(As of March 1989)



0003724–1

Source: National Semiconductor

In December 1988, National Semiconductor announced the sale of its retail systems unit, Datachecker Systems, to a U.K.–based company, ICL. This move was followed in mid–January 1989 by an agreement with Memorex Telex to form a joint venture in which

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each company would own a 50 percent interest in National Advanced Systems (NAS). Memorex Telex, a Dutch company, is a $2 billion supplier of plug-compatible computer equipment and accessories. The deal with Memorex Telex called for National to receive a cash payment of $250 million and 4 million shares of Memorex Telex common stock. In addition to its 50 percent share of NAS, the agreement gave Memorex Telex an option to purchase the remaining stock in the organization, which would be operated as a separate entity headquartered in Santa Clara, California. At the end of February 1989, National broke off its tentative agreement with Memorex Telex, which had apparently encountered difficulties in financing the buyout of NAS. Instead, National has accepted a $398 million cash offer from Hitachi Ltd. of Japan and Electronic Data Systems (EDS), a subsidiary of General Motors Corporation. Under the agreement, NAS will be sold to a joint venture created by Hitachi and EDS. NAS acts as a distributor of IBM-compatible, large and medium-size computers and peripherals made by Hitachi.

Shortly after the initial disclosure of its deal with Memorex Telex, National announced that it would lay off 2,000 employees. The work force reduction affects all levels of staff in Asia, Europe, and the United States, and took place through March 1989. The number represents about 5 percent of the corporation's reported head count as of the close of fiscal year 1988. National, which reported a loss of approximately $56 million for the first half of its fiscal year 1989, has said that the reductions are necessary to bring the company's staffing levels and cost structure into alignment with its current business environment.

As evidence of its renewed emphasis on its core semiconductor businesses, National recently announced the formation of a new VLSI division, which comprises the company's microprocessor, microcontroller, advanced peripherals, and interface groups. This new division will report to vice president Ray Farnham. The memory and programmable logic groups will be combined under John Hekking. The military and aerospace group will report to Randy Parker. National intends to strengthen its position in the military market, in which it became a more powerful contender through its acquisition of Fairchild. All of these groups will report to James Smaha, executive vice president of the semiconductor group. Clark Davis will be in charge of the newly formed function of worldwide strategic planning. The strategic market development group will be headed by Walt Curtis. These last two individuals will report to Joe Van Poppelen, vice president of semiconductor marketing.

National's information systems group, of which NAS is the major part, accounted for approximately 43 percent of National's fiscal 1988 revenue of $2.5 billion. Its 1988 fiscal year ended May 29. The divestiture of NAS signals a major change in National's strategy, and a significant impact will be felt on the company's revenue. Nevertheless, National should see an improvement in profitability as a result of the sale of NAS. Partly due to the yen appreciation during the past few years, which has affected the cost of its equipment purchases from Hitachi, NAS has experienced increased pressure on its profit margins. By increasing its reliance on its semiconductor products, however, National becomes more vulnerable to the boom/bust cycles that have up to now typified the semiconductor industry. Just how National goes about positioning its broad line of components products will bear watching as the company stakes its future on being a pure-play semiconductor company.

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Research *Bulletin*

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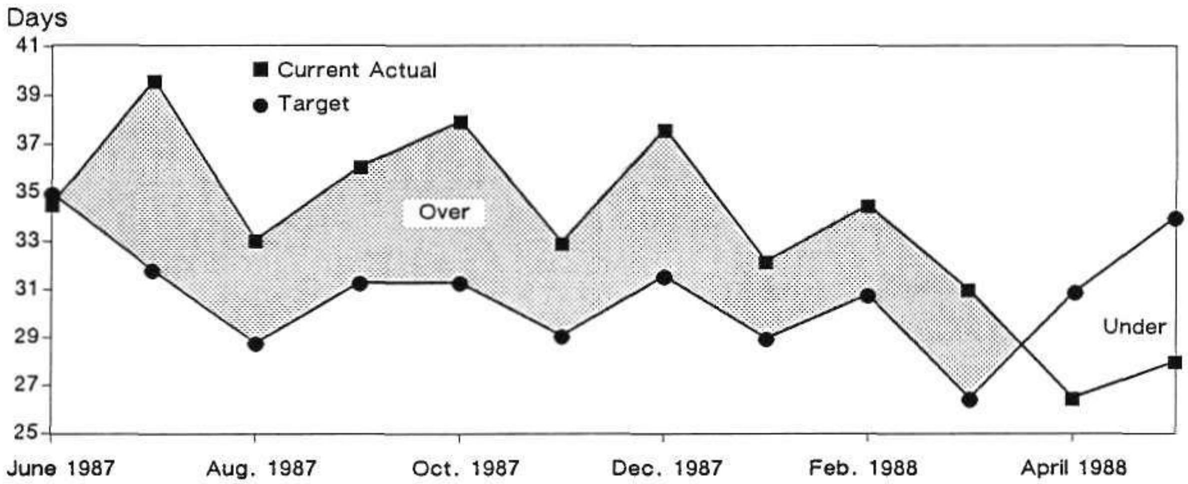
MAY PROCUREMENT SURVEY: SALES ARE UP, BUT INVENTORIES ARE MIXED

Sales of North American electronic systems are expected to continue rising throughout the month of May. Overall inventories, both targeted and actual, rose by three and two days, respectively (see Figure 1). DRAM availability has become worse since our last survey. SRAMs, video RAMs, and some discrete parts (diodes, in particular) are still in short supply and are expected to remain difficult to procure through the rest of this year. Long-term supplier agreements should straighten some of the curves in the procurement pipeline, however. The increases in inventory levels reflect shipment restraints due to DRAM shortages and the reaction of companies to increase inventories where possible to better weather upcoming shortages of raw materials.

Figure 1

Current Actual versus Target Inventory Levels (All OEMs)



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May 1988

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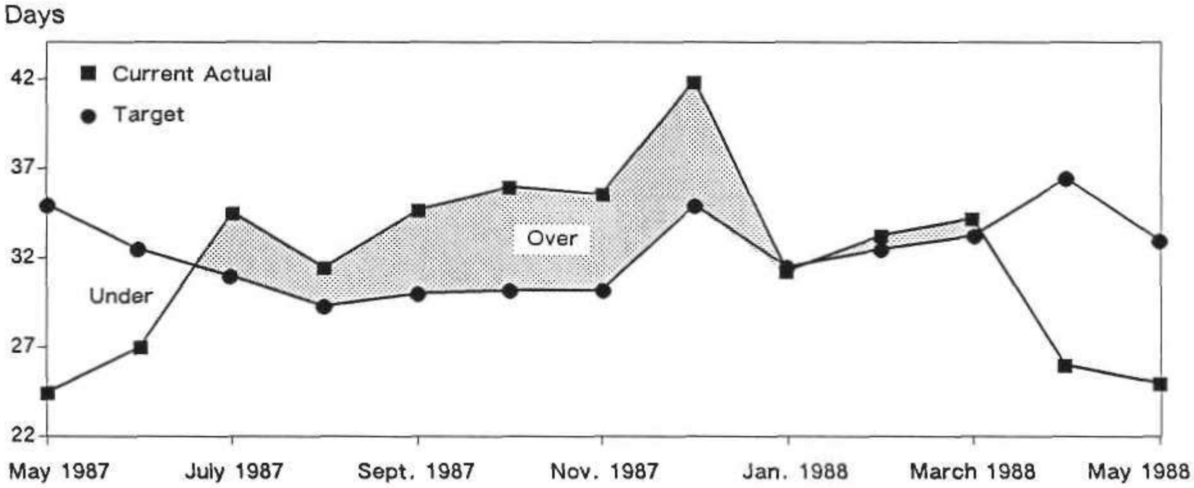
Figure 2 reflects the trend that began last month with low actual inventories in the face of component shortages for computer manufacturers. Targeted inventories also have declined somewhat since our last review.

Figure 2

Current Actual versus Target Inventory Levels (Computer OEMs)



Source: Dataquest May 1988

Overall, pricing has risen approximately 3 percent since our last survey, and lead times have remained stable. Distribution sales are expected to increase slightly in May due to shortages of key components.

Mark Giudici

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Research *Newsletter*

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A SAMPLING OF SUB–1.5–MICRON DEVICES

INTRODUCTION

For some time now, users of semiconductors have been hearing about the next generation of sub–2–micron geometry products becoming more predominant in the marketplace.

For the past year and a half, another research group in the Dataquest Components Division, the Semiconductor Equipment and Materials Service (SEMS), has been maintaining a log of public announcements of semiconductor devices that are fabricated with 1.5–micron or lower geometries. The log is not the result of an exhaustive literature search but, rather, a serendipitous recording of information when one happened across it. The intent of this newsletter is to present this sampling to our clients to indicate the range of sub–1.5–micron products presently on the market. The date at the end of each entry is the date on which the information was noted.

Procurement departments have become more involved in the availability of current and future products. A listing such as this, although not exhaustive, can quickly inform one where a given vendor currently stands relative to technology trends and the market.

MICROPROCESSOR, MICROCONTROLLER, AND PERIPHERAL PRODUCTS

- Motorola will introduce its new line of reduced–instruction–set computer (RISC) microprocessors in the second quarter. The processor unit is a three–circuit set containing a primary processor and two cache memory management units (MMUs). The RISC set is manufactured in 1.5–micron HCMOS. (2/22/88)

- Trident Microsystems is sampling its first product, a video graphics array (VGA) fabricated in 1.5–micron CMOS under a foundry arrangement with Toshiba. (2/1/88)

- Hitachi will sample the Gmicro–200, a 32–bit microprocessor based on the TRON (the real operating nucleus) real–time operating system, in the second quarter, with production scheduled for the third quarter. It is designed with 1–micron CMOS design rules, with a double–metal process. It measures 14mm x 14mm and contains 730,000 transistors. (1/25/88)

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- Advanced Micro Devices is sampling its 17-mips (millions of instructions per second), 32-bit RISC microprocessor. Called the Am29000, it is fabricated in 1.2-micron CMOS at the Austin, Texas, facility. (11/23/87)

- United Technologies has introduced an MMU, the UT1750, fabricated in 1.5-micron CMOS. (11/23/87)

- Motorola is designing a 1-micron successor to its 68HC11 controller. The new controller will be shipped in 1989. (11/23/87)

- National Semiconductor is sampling its new 32532 32-bit microprocessor. It is fabricated in 1.25-micron, double-metal, silicon-gate CMOS and has 370,000 transistors. (11/2/87)

- LSI Logic's affiliate, G-2 Inc., is shipping the GC201 graphics controller fabricated in 1.5-micron HCMOS design. (10/12/87)

- LSI Logic has qualified its two-device microprocessor set for 1750A military applications. The device set consists of the L64500 CPU and the L64550 MMU peripheral. They are fabricated in 1.5-micron HCMOS. (10/12/87)

- Mitsubishi will sample four models of a new 16-bit, single-chip micro-controller, as of December 1, 1987. The Melps family will be fabricated in 1.3-micron design rules. Chip size is 5.55mm x 7.50mm, and each chip contains 220,000 transistors. (10/5/87)

- LSI Logic's affiliate, G-2 Inc., will offer an AT-compatible chip set that runs at 16 MHz. The set consists of three devices: the GC101, which is a systems controller, peripheral controller, and memory controller; and two buffer devices, both called the GC102, which have address and data functions. The chip set is fabricated with a 1.5-micron HCMOS process. G-2 also plans a three-device, AT chip set that will run at 12.5 MHz and will be fabricated with the same 1.5-micron HCMOS process. (9/21/87)

- Texas Instruments will release a cache tag MMU designed for the 68030 microprocessor. The BICMOS device will use a 2.0-micron bipolar Impact process and a 1.5-micron CMOS process. (9/14/87)

- AT&T has unveiled a second-generation, floating-point digital signal processor. The new DSP32C will be fabricated in 0.9-micron, double-metal CMOS and will be available in the second quarter of 1988. (7/27/87)

- Motorola's new 68030 microprocessor will be fabricated in single-layer metal, with a silicide process. It will be done originally according to 1.3-micron design rules, with a shrink to 1.2 microns. (7/27/87)

- Fujitsu, Bipolar Integrated Technology, and Cypress are licensing Sun's SPARC microprocessor technology. Fujitsu's SPARC processor is using a 20,000-gate, 1.5-micron CMOS gate array. Cypress will implement the SPARC architecture in a CMOS chip set, using Cypress' 0.8-micron, double-metal CMOS process. (7/13/87)

- Texas Instruments is introducing a family of bus interface devices, the SN74BCT, which are its first circuits using a combined bipolar/CMOS process. The process combines TI's 2.0-micron Impact process with a 1.5-micron CMOS process. (6/22/87)

- Motorola expects to sample an LAPD controller. Designed primarily for ISDN applications, the MC68606 will be fabricated with a 1.5-micron HCMOS process. (6/1/87)

- Hewlett-Packard will build the Weitek 2264-65 floating-point chip set. HP will license the technology to fabricate the chip set in 1.2-micron CMOS at HP's Corvallis, Oregon, facility. Weitek maintains a foundry agreement with VLSI Technology, which produces the chip with a 1.5-micron process. (5/18/87)

- Advanced Micro Devices will produce an integrated data protocol for ISDN use. It will be fabricated with a 1.2-micron, double-metal CMOS process. (4/13/87)

- NEC will sample, next June, the V70 32-bit microprocessor fabricated in 1.5-micron CMOS and incorporating 385,000 transistors. (4/13/87)

- National's 32532 32-bit microprocessor is fabricated with a 1.5-micron, double-metal, silicon-gate CMOS process. It incorporates 370,000 transistors. (4/6/87)

- Fujitsu and Hitachi samples of the jointly developed 32-bit microprocessor for TRON will be available by the end of 1988 or early 1989. Fabricated in 1.3-micron CMOS with 700,000 transistors, it is called the F32-200 by Fujitsu and the H32-200 by Hitachi. Ultimately, a 1-micron process will be used. (4/6/87)

- Texas Instruments is developing a third-generation digital signal processor, the TMS320C30. It is fabricated with a 1-micron CMOS technology developed in TI's DRAM program. (3/30/87)

- Motorola will sample, in early 1988, an ISDN controller designed with a 1.2-micron, double-metal, HCMOS process used with its other ISDN devices. (3/16/87)

- Intel's 80386 microprocessor and 80387 floating-point units are fabricated with a 1.5-micron CMOS III process. (2/16/87)

- Analog Devices has introduced two sets of IEEE floating-point multipliers and arithmetic logic units. The ADSP-3211/ADSP-3201 and the ADSP-3221/ADSP-3202 sets are fabricated in 1.5-micron design rules. Pin-compatible upgrades for the new parts, using 1-micron design rules, are slated for the first half of 1987. (1/12/87)

- AT&T is introducing its latest-generation 32-bit microprocessor, the WE 32200, fabricated in 1-micron CMOS. The 32200 has 230,000 transistors. AT&T also introduced the 32201 MMU, which has 400,000 transistors and is fabricated with the same 1-micron process. The 32206 math accumulator unit has 233,000 transistors. (12/8/86)

- Inmos is introducing a 20-MHz version of its Transputer T800 fabricated with a 1.5-micron CMOS process. (12/1/86)

- Performance Semiconductor's 1750 16-bit military microprocessor is fabricated in submicron technology to allow 200,000 transistors on a die that measures less than 0.25 inch on a side. (12/1/86)

- LSI Logic is introducing a series of DSP products drawn with 1.5-micron CMOS design rules. Products include a 32-bit floating-point unit and a multiplier accumulator. (11/24/86)

- LSI Logic is using 1.5-micron CMOS design rules on its L64500 16-bit microprocessor. (11/10/87)

- Weitek has designed a family of floating-point microprocessors. The Accel family, which consists of three CMOS processors, the 8000, 8032, and 8064, is fabricated with a 1.5-micron, N-well, double-metal CMOS process. (10/27/86)

- Hitachi has announced a 1.3-micron CMOS 32-bit microprocessor called the H32. Chip size is 10.4mm x 12mm. (10/13/86)

- Motorola's MC68030 is an enhanced version of the 68020 32-bit microprocessor. It will be fabricated in a 1.5-micron, single-layer metal HCMOS with a silicide process. Sampling will be in the second quarter of 1987. Die size will be 400 mils on a side, compared with 320 mils on a side for the 68020. When in production, Motorola will shrink the 68030 to 1.2-microns and 380 mils. (9/22/86)

- Motorola will introduce an enhanced floating-point coprocessor designed with a 1.5-micron HCMOS process and measuring 287 mils on a side. (9/22/86)

- Intersil has introduced a 16 x 16 CMOS multiplier accumulator designed with 1.5-micron geometries. (9/22/86)

- Motorola's new 25-MHz, 32-bit microprocessor, the MC68020, is fabricated in 1.5-micron HCMOS using a single-layer metal and polycide process. (7/28/86)

- WaferScale is sampling the WS59032D, a 20-MHz version of its 32-bit microprogrammable CMOS bit-slice processor. It is fabricated in 1.2-micron CMOS. (7/28/86)

- Hitachi will introduce, in 1987, a proprietary 32-bit microprocessor. It will be done with 1.3-micron design rules and will incorporate more than 300,000 transistors. (6/30/86)

- Intel announced its graphics coprocessor, the 82786, which is fabricated with a 1.5-micron CHMOS III process. (5/19/86)

- AT&T is planning on a third-generation, 32-bit microprocessor, the 20-MHz WE32200, which will be fabricated with 1-micron design rules. (5/19/86)

- Integrated Device Technology will introduce, this fall, two generations of floating-point chip sets, the 72064/65 and the 72265/65 sets, that will be fabricated with IDT's 1.2-micron process. (5/12/86)

MEMORY PRODUCTS

- National has introduced a 256K BICMOS SRAM, with ECL I/O, called the NM5100. The device is fabricated with the BICMOS III process, which is a 1-micron, 16-mask, twin-well, double-poly, double-metal process. It measures 213 x 386 mils, and will be fabricated at the Puyallup, Washington, bipolar facility. (2/22/88)

- Alliance Semiconductor is sampling a family of 64K CMOS SRAMs fabricated with a 1.2-micron technology. (2/1/88)

- Excel Microelectronics is shipping a 1.5-micron 64K CMOS reprogrammable PROM, called the XL46HC64 Speedprom. It is the first of a new line of memories from Excel. (2/1/88)

- IBM has donated its memory recipe for the 4Mb DRAM to Sematech. The chips are 0.5 inch x 0.25 inch and are fabricated with 0.7-micron design rules. AT&T's contribution to Sematech is a 64K SRAM fabricated with a 0.7-micron, double-metal CMOS technology. (2/1/88)

- Texas Instruments is shipping a 1Kx9 FIFO memory, the SN7ACT7202, fabricated with a 1-micron process. (12/21/87)

- NEC is sampling the uPD42601, a 1-micron CMOS silicon file. The device, which uses the same technology and has the same pinout as NEC's 1Mb DRAM, is designed to replace hard disks and to eliminate the need for a backup disk in personal computers and other computers. (12/14/87)

- Toshiba is sampling a 4Mb DRAM fabricated with a 0.9-micron, twin-tub, single-aluminum, triple-poly CMOS process with trenches. The die measures 111 square mils and will be shipped in a 400-mil DIP. In the first quarter of 1988, Toshiba will sample a version fabricated with a 0.8-micron process that will give a die size of 97.4 square mils for shipment in 350-mil SOJ packages. In the first quarter of 1989, it will sample a second-generation part fabricated in 0.7-micron CMOS for a die size of 81 square mils. The part will be packaged in a 300-mil DIP or SOJ and will be available in volume in the third quarter of 1989. (11/23/87)

- Texas Instruments will sample its 4Mb DRAM. The device will be fabricated at its Miho, Japan, facility, with a 1-micron, double-metal CMOS process utilizing trench capacitors for both the transistor and capacitor. (9/14/87)

- Intel has available a 35ns 64K SRAM, the M51C98, which is fabricated with Intel's 1-micron, double-poly CHMOS-IV process. (6/22/87)

- AMD/Sony's first products will be SRAMs fabricated with a 1.2-micron CMOS process. AMD currently has a 1.4-micron CMOS process for its 64K and 256K SRAMs. (6/1/87)

- Fujitsu has available a fast 64K SRAM (25 to 35ns), which is fabricated in a 1.3-micron, double-metal, double-poly, polycide gate CMOS process. (5/87)

- Hitachi has available a 12ns 64K ECL I/O SRAM, the HM10490CG-12, fabricated in 1.3-micron BICMOS. (4/20/87)

- Cypress Semiconductor is shipping a 16Kx8 reprogrammable power-switched PROM, the CY7C251, fabricated with a 1.2-micron, floating-gate, CMOS process. (4/13/87)

- Thomson Components-Mostek is offering the MK41H80, a 16K cache tag SRAM fabricated with a 1.2-micron, double-metal CMOS process. (3/2/87)

- VLSI Technology is offering a 1K SRAM, the VT7C122, with 1.5-micron design rules. (3/2/87)

- Oki's 1Mb DRAM is designed with a 1.2-micron CMOS process. (2/23/87)

- Motorola's fast 16K and 64K SRAMs are fabricated with a 1.5-micron, double-metal, double-poly CMOS process. (12/15/86)

- Intel will try to qualify for VHSIC parts. This requires that the 51C98 64K CMOS SRAM be shrunk to 1.1 microns. (11/10/86)

- VLSI Technology is producing 16K SRAMs with 1.5-micron design rules. SRAMs with 1.2-micron rules will be produced in 1987. (10/27/86)

- Cypress has introduced a CMOS EPROM, which is a version of Monolithic Memories' 22V10, called the PALC22V10. It will be manufactured under license from MMI with 1.2-micron design rules. (10/13/86)

- Fujitsu has developed a 16K ECL RAM with a 10ns access time, making it the fastest of its kind in the world. The product is designed with 1-micron rules and scheduled for mass production in January 1987. (10/86)

- Motorola will release its fast 256K SRAM that uses 1.2-micron design rules. (9/15/86)

- RCA is offering EPROMs with 1.2-micron design rules. (9/5/86)

- Toshiba's new UV EPROM is designed with 1.2-micron rules with a 200-angstrom gate oxide. The cell size is 50 square microns, compared with a 20-square-micron stacked design. (9/4/86)

- Saratoga Semiconductor's 16K and 64K ECL SRAMs and 64K TTL SRAMs are fabricated with 1.5-micron design rules. Saratoga will produce 256K devices with 1.2-micron rules within a year. (8/18/86)

- Integrated Device Technology has introduced two parallel I/O FIFOs with 35ns access times. The IDT7201 is a 512 x 9 FIFO, and the IDT7207 is a 1,024 x 9 FIFO. The parts are fabricated with a 1.2-micron CMOS process. (7/28/86)

- Performance Semiconductor is sampling a 64K SRAM, the P4C188, which is based on a submicron CMOS design. The device, which has speeds down to 20ns, is a six-transistor design that incorporates more than 400,000 transistors. Metal pitch is 2.75 microns, and the chip has an effective channel length of 0.8 micron. (5/26/86)

- Cypress Semiconductor's 4K 14ns CMOS SRAM, the CY7C150, is fabricated with a channel length of 0.8 micron. Its 25ns 4K SRAM is designed with 1.2-micron rules. (5/26/86)

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ASIC AND LOGIC PRODUCTS

- Toshiba America has introduced a series of gate arrays using a 1.0-micron CMOS process that cuts gate delays by up to 35 percent. The TC120G Series, which offers typical gate delays of 400ps, has a range of 37,392 to 129,042 raw gates in a channel-less (sea-of-gates) architecture. The new series is compatible with Toshiba's channel-less TC110G Series, which is fabricated with a 1.5-micron CMOS process and offers gate delays of 600ps. The TC110G Series ranges in complexity from 3,400 to 129,042 raw gates. (2/26/88)

- Applied Micro Circuits and Plessey Semiconductor have signed an agreement to jointly develop a family of high-performance ECL gate arrays. The arrays will have up to 14,000 gates and will be produced initially at Plessey's Swindon, England, facility, using Plessey's new 1-micron, triple-metal HEI bipolar process. (2/22/88)

- National is taking designs for a nine-member 1.5-micron CMOS gate array family that has densities of up to 14,892 gates. The SCX6B00 family has effective channel lengths of 1.1 microns. National is also in the process of migrating its 2-micron standard cell library to a 1-micron process. (2/8/88)

- United Technologies Microelectronics Center has introduced its UTD-R family of radiation-hardened gate arrays with up to 11,000 equivalent NANDs. They are fabricated with a 1.5-micron CMOS process. Included are the UT1553 multiprotocol bus controller remote terminal, the UT1553B bus controller remote terminal interface, and the UT1553M version with monitor function. (1/18/88)

- Yamaha has obtained a license to manufacture and sell gate arrays based on Integrated Logic System's technology, which consists of a family of six 1.5-micron arrays ranging from 3,000 to 40,000 gates. Usable number of gates ranges from 1,500 to 20,000. (12/14/87)

- Motorola has introduced a series of 1-micron CMOS gate arrays fabricated in triple metal. The family consists of 10 parts ranging from 6,000 to 104,832 gates. (11/23/87)

- LSI Logic is offering a family of gate arrays, with 50,000 to 100,000 usable gates, fabricated with a 0.7-micron channel length with a 1.0-micron HCMOS process. The LCA100C has 236,880 total gates and has three layers of metal. (10/26/87)

- Mitsubishi Electronics America's semiconductor division has introduced two families of 1.3-micron CMOS gate arrays. The M6003X series has up to 47,000 gates, and the M6002X series has up to 2,400 gates. (10/19/87)

- Xilinix's XC2064 1,200-gate, programmable gate array and the XC2018 programmable gate array are both fabricated with a 1.2-micron process. (10/12/87)

- Raytheon is offering a family of VHSIC phase two-compatible gate arrays fabricated with a 1.25-micron CMOS process. The RAY1.25VG family consists of devices with 5,670 to 20,440 gates. (10/5/87)

- Fujitsu's AV series of CMOS gate arrays has densities of up to 8,000 gates, and densities of up to 12,000 gates are expected with 1.5-micron design rules. (8/31/87)

- LSI Logic has filled in its low-end, channel-free gate array (sea-of-gates) offering by introducing the LMA9000 Micro Array series and the LMb6000 Micro bASIC series gate array. Both series are fabricated with a 1.5-micron, double-metal HCMOS process. Densities range from 700 to 10,000 gates. LSI Logic introduced its channel-free architecture in 1985. (8/17/87)

- VLSI Technology is offering the VGT10 and VGT100 families of gate arrays fabricated, respectively, with 2-micron and 1-micron CMOS processes. The chips will be second-sourced by GE/RCA. (7/27/87)

- Fujitsu, Bipolar Integrated Technology, and Cypress are licensing Sun Microsystems' SPARC microprocessor technology. Fujitsu's SPARC processor will use a 20,000-gate, 1.5-micron CMOS gate array. Cypress will implement the SPARC architecture in a CMOS chip set using Cypress' 0.8-micron, double-metal CMOS process. (7/13/87)

- Texas Instruments has introduced its first bipolar gate array, an 8K ECL device using a 1.5-micron process derived from TI's Impact process. The TGE8000 gate array family will be fabricated in Houston, Texas. TI has also recently introduced a 1.2-micron CMOS gate array family. (7/6/87)

- Honeywell has produced working prototypes of a VHSIC implementation of the navy's AN UYS-2 standard signal processor. The three custom circuits included in the processor are a FIFO buffer, floating-point multiplier, and register arithmetic logic unit. Circuit complexities range from 17,500 to 32,000 equivalent gates fabricated with a 1.25-micron VHSIC bipolar process. Volume production is to take place at Honeywell's Colorado Springs, Colorado, facility. (6/29/87)

- Texas Instruments has introduced a family of bipolar PLA devices fabricated with a 1.5-micron Impact X process. The devices use trench isolation and have a 1.0-micron epitaxial layer. (6/29/87)

- Honeywell's Solid State Division will sell, under license from ETA Systems (a subsidiary of Control Data) a 20,000-gate array that was designed for the ETA-10 supercomputer. The device is fabricated with Honeywell's 1.25-micron CMOS VHSIC process. (5/25/87)

- Texas Instruments is beta-testing a series of quick-turn gate arrays fabricated with a 1.2-micron CMOS process. The TGC100 series has a range of 3,200 to 8,890 gates, and the TGC500 series has from 3,000 to 16,000 gates. The devices are the initial entries in a planned 1-micron CMOS gate array and standard cell library designed for TI's EPIC process. (5/11/87)

- Fujitsu has introduced a library of gate arrays, the UHB series, which has versions available with up to 12,734 gates. The devices are fabricated with a 1.5-micron, double-metal CMOS process. (3/9/87)

- Thomson Components-Mostek has had available, since 1986, 1.2-micron gate arrays with up to 10,000 gates and expects first silicon this month on a 20,000 sea-of-gates array with up to 57,000 usable gates. The sea-of-gates device will be fabricated with an HCMOS III process. (3/9/87)

- Texas Instruments will introduce 1-micron gate arrays and standard cells to be fabricated with TI's proprietary EPIC CMOS process at the Dallas, Texas, and Miho, Japan, facilities. TI will also introduce a new 1-micron bipolar ECL gate array library with up to 10,000 gates. The library will be fabricated with TI's latest bipolar technology, called TIPSA. (2/16/87)

- Toshiba is offering the TC19G channeled gate array family that has from 3,200 to 10,000 gates and the TC110G sea-of-gates family that has from 2,100 to 50,000 gates. Both families are fabricated with a 1.5-micron, double-metal CMOS process. (1/19/87)

- Plessey has developed a family of ECL gate arrays. The initial set consists of three arrays with 1,000, 2,900, and 4,500 gates. They are fabricated with a 1.5-micron bipolar process using three levels of metal. (1/12/87)

- Thomson Components-Mostek has converted its 2- and 3-micron gate array libraries to a 1.2-micron series called the TSGC. The TSGC series will be available in densities from 1,000 to 10,000 gates. (12/8/86)

- National will second-source Chips & Technologies devices at its Arlington, Texas, facility. Semicustom parts will be done with a 2-micron process, while full-custom parts will be done with a 1.5-micron process. The agreement calls for production of current and future logic lines, using National's gate array, standard cell, and custom tools. (11/3/86)

- VLSI Technology has introduced the VGT100 series of 1.5-micron CMOS gate arrays. The series has a range of 12,000 raw gates (9,000 usable) to 67,000 raw gates (50,000 usable). (10/13/86)

- Intel will offer 1.5-micron, double-metal CMOS gate arrays, originally developed by IBM. Intel also has had available cell-based designs fabricated with a 1.5-micron, single-metal CMOS process; this cell-based library has been enhanced with a 1.5-micron, double-metal process. (10/6/86)

- Texas Instruments will introduce a 1-micron CMOS gate array family in the first half of 1987, and will also introduce in 1987 a 1-micron standard cell line. Until now, TI has second-sourced 2- and 3-micron designs from Fujitsu at its Miho, Japan, facility. (9/22/86)

- RCA's standard cells are fabricated with a 1.2-micron channel length CMOS process. (9/5/86)

- VLSI Technology (VTC) is offering a 1-micron standard cell library, VL5000, that has 20,000 equivalent gate complexity. The devices are fabricated with VTC's double-metal CMOS II process. (9/4/86)

- Plessey is planning a 1-micron CMOS MEGACELL with up to 100,000 gates. (9/1/86)

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- General Electric is making 1.25-micron CMOS custom ICs at its Research Triangle Park, North Carolina, facility. (8/15/96)

- General Electric, Siemens, and Toshiba will have a 1.5-micron CMOS ASIC process. The 1.5-micron cell libraries are scheduled for late 1986, while the 1.2-micron process is scheduled for 1987 or 1988. (8/11/86)

- United Technologies Microelectronics Center has introduced a 1.5-micron CMOS gate array family with 11,000 usable gates. The family is aimed at the military and aerospace markets. (8/11/86)

- NEC has a 1.5-micron CMOS standard cell family that includes 130 megacells. Densities of up to 17,000 gates can be achieved. (7/86)

- Hitachi will produce Fairchild's FACT logic line with a 1.3-micron, double-metal, P-well CMOS process. (7/7/86)

- RCA's Advanced CMOS Logic (ACL) parts are fabricated with a 1.5-micron channel length and an N-well process. (7/14/86)

- Thomson Components-Mostek is producing 2- and 3-micron, double-metal HCMOS gate arrays and standard cells with densities of up to 4,000 gates with the 3-micron process and up to 10,000 gates with the 2-micron process. The company is migrating these parts to a 1.2-micron process. (6/30/86)

DISCRETE PRODUCTS

- Motorola has introduced a series of three low-noise NPN bipolar small-signal transistors, the MRF951 series. The parts are fabricated with 1.2-micron design rules, with silicon nitride passivation and gold metallization. Average selling price is $1.30. (2/22/88)

LINEAR PRODUCTS

- Datel has available the ADC-207 7-bit flash converter fabricated with General Electric's 1.2-micron AVLSI process. (9/29/86)

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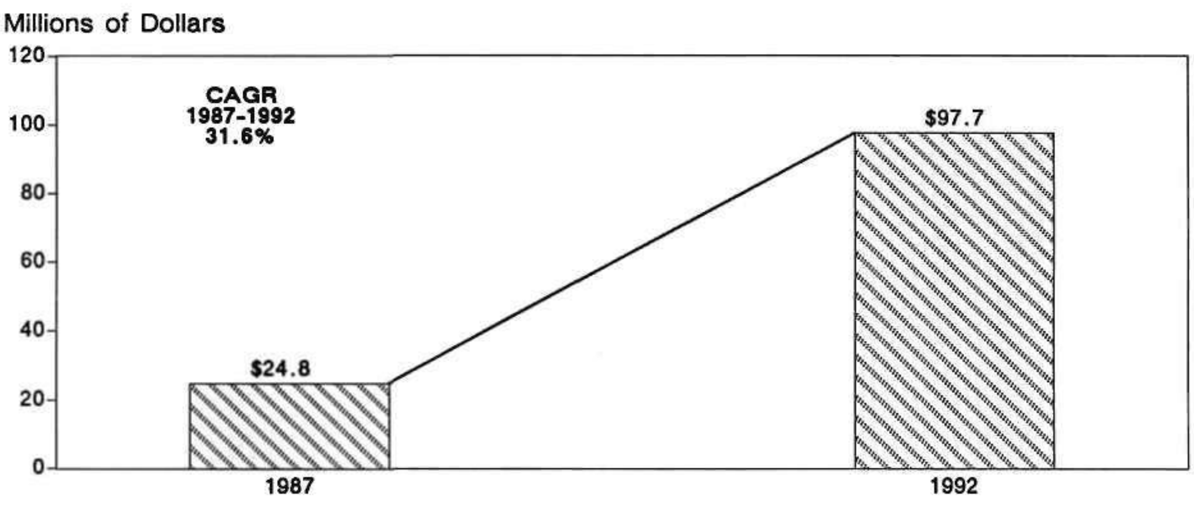
THE $100 MILLION HYBRID HEDGE IN THE INTELLIGENT POWER ARENA

SUMMARY

This third and final newsletter in Dataquest's series on intelligent power products looks at the hybrid segment. Suppliers of intelligent power hybrids should emerge as winners in this marketplace. Why? Because the history of the semiconductor industry has always been marked by user demand for high levels of performance that can only be met through hybrids. Figure 1 shows Dataquest's forecast of consumption of intelligent power hybrids as supplied by North American and European vendors. We expect the intelligent power hybrid market to approach $100 million by 1992. Thus, Dataquest foresees a profitable niche for vendors that supply intelligent power hybrids.

Figure 1

**North American and European Suppliers
Intelligent Power Hybrid Revenue
1987 and 1992**



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Many suppliers will be competing fiercely for a share of a business that we expect to expand at a 31.6 percent compound annual growth rate during the 1987 through 1992 period.

SUPPLIERS OVERVIEW

Table 1 provides information on current and prospective suppliers of intelligent power hybrids. GE Solid State, International Rectifier, and Unitrode are among the leaders as measured in revenue in the intelligent power hybrid marketplace. IXYS, National Semiconductor, Rifa, Silicon General, and Silicon Power Cube also supply these hybrids. Siliconix and Powerex plan to enter this market.

Table 1

North American and European Suppliers*
Intelligent Power Hybrids

1987 Ranking	Supplier	1987 Revenue ($M)
1	GE Solid State	N/S
2	International Rectifier	N/S
3	Unitrode	N/S
4	Silicon General	N/S
5	Rifa	N/S
6	IXYS	N/S
7	Silicon Power Cube	N/S
8	National Semiconductor	N/S
	Total Revenue	$24.8

*Future entrants: Powerex and Siliconix
No ranking is available for Motorola and Siemens
N/S = Not Specified

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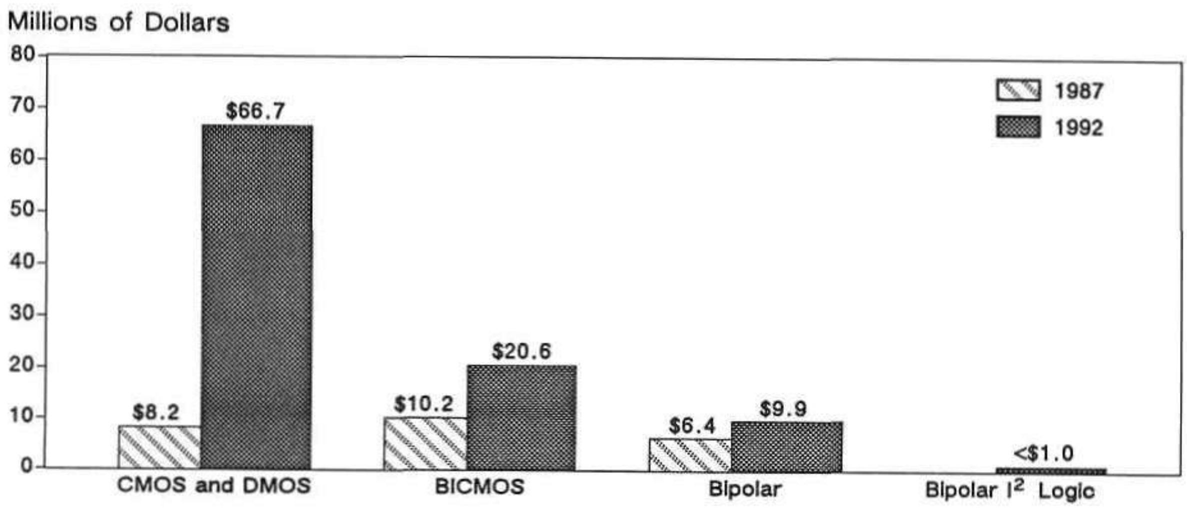
HYBRID TECHNOLOGY OVERVIEW

Figure 2 shows 1987 consumption of intelligent power hybrids by technology and illustrates Dataquest's hybrid technology forecast for 1992.

As shown in Figure 2, users can anticipate that the CMOS+DMOS approach will be a major technology of choice in the hybrid marketplace. In fact, Figure 2 reveals that intelligent power hybrids will be based on three technologies: CMOS+DMOS; BICMOS; and Bipolar. The CMOS+DMOS and BICMOS technologies should predominate in this market.

Figure 2

North American and European Suppliers
Intelligent Power Hybrids by Technology
1987 and 1992



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SEMICONDUCTOR APPLICATIONS MARKETS

Users must track suppliers of intelligent power hybrids as part of their supply base management programs. Table 2 provides information on current and prospective vendors of hybrids by the major semiconductor application markets to which they sell.

Table 2

North American and European Suppliers*
Intelligent Power Hybrids
1987 through 1992

	Semiconductor Application Market (SAM)					
1987 (Actual)	DP	Comm.	Indus.	Consumer	MIL/Aero.	Trans.
GE Solid State	O	O	C	O	O	O
International Rectifier	C	C	C	O	O	F
Unitrode	C	C	C	O	C	O
Silicon General	O	O	C	O	C	C
Rifa	O	O	C	O	O	F
IXYS	O	F	C	O	C	O
Silicon Power Cube	O	O	C	F	F	O
National Semiconductor	C	O	F	O	O	F
Powerex	F	O	F	F	F	O

*Excludes Motorola and Siemens; Siliconix also plans to supply intelligent power hybrids

C = Current supplier
F = Future entrant
O = Does not plan to supply

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Data Processing Application

As shown in Table 2, intelligent power hybrid vendors expect industrial and military/aerospace applications to require hybrid solutions more often than other applications.

Three firms—International Rectifier, National Semiconductor, and Unitrode—supply intelligent power hybrids for use in data processing applications. We expect Powerex to enter this semiconductor application market in the future.

Hybrids produced for data processing functions will be based on the CMOS+DMOS technology and, to a lesser extent, on the bipolar approach.

Communications Applications

Two vendors—International Rectifier and Unitrode—produce intelligent power hybrids for communications applications. Users should anticipate IXYS participation in this arena.

Because of the suitability of one version of the DMOS process in high-voltage applications, users can expect that derivatives of the DMOS technology will play an important role in intelligent power hybrids geared for this market.

Industrial Application

GE Solid State, International Rectifier, IXYS, Rifa, Silicon General, Silicon Power Cube, and Unitrode supply intelligent power hybrids for use in industrial applications. National Semiconductor and Powerex are also expected to produce hybrids for the industrial community.

Hybrids produced for industrial applications will be based on all three technologies: CMOS+DMOS, BICMOS, and bipolar.

Consumer Application

No firm supplied intelligent power hybrids during 1987 for use in consumer applications. Powerex and Silicon Power Cube plan to do so in the future.

Military and Aerospace Application

Three firms—IXYS, Silicon General and Unitrode—supply intelligent power hybrids for use in military and aerospace applications. Unitrode ranks as the leading supplier to military users. Users in this arena can expect Powerex and Silicon Power Cube to enter this business.

Hybrids produced for military and aerospace applications will be based on the CMOS+DMOS and bipolar technologies.

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Transportation Application

Silicon General is the only firm that supplied intelligent power hybrids to users in the transportation arena during 1987. Manufacturers of automobiles and other transportation equipment should expect additional firms to enter this business, namely, International Rectifier, National Semiconductor, and Rifa.

During 1987, hybrids for transportation equipment applications were based on the BICMOS process, with a long-term trend toward increasing use of the CMOS+DMOS technology.

HYBRIDS: A HEDGE STRATEGY FOR USERS

Systems manufacturers experience considerable risk whenever system life cycles are tied to the availability of undeveloped or unproven devices (here, power ICs). This is especially true when the number of suppliers is limited.

The intelligent power hybrid approach can be used as an alternative for getting systems into the marketplace should the IC approach prove infeasible. Even so, hybrids cost more and do not lend themselves to volume production, so the user's total system costs ultimately increase and profits decline.

DATAQUEST CONCLUSIONS

Current and prospective users and vendors of intelligent power products can look to hybrids as a hedge strategy. For North American and European suppliers, Dataquest expects the intelligent power hybrid arena to approach a $100 million business by 1992. For users, hybrids will always fill a need in systems either by user choice—given the extremely high performance requirements of systems—or by default, namely, the failure of power IC vendors to deliver. For suppliers, production of hybrids provides either a straightforward strategy—to focus on hybrids—or, given the challenge of packaging and technical constraints, a hedge strategy for responding to setbacks in the IC side of their intelligent power business.

Ronald A. Bohn

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Research Newsletter

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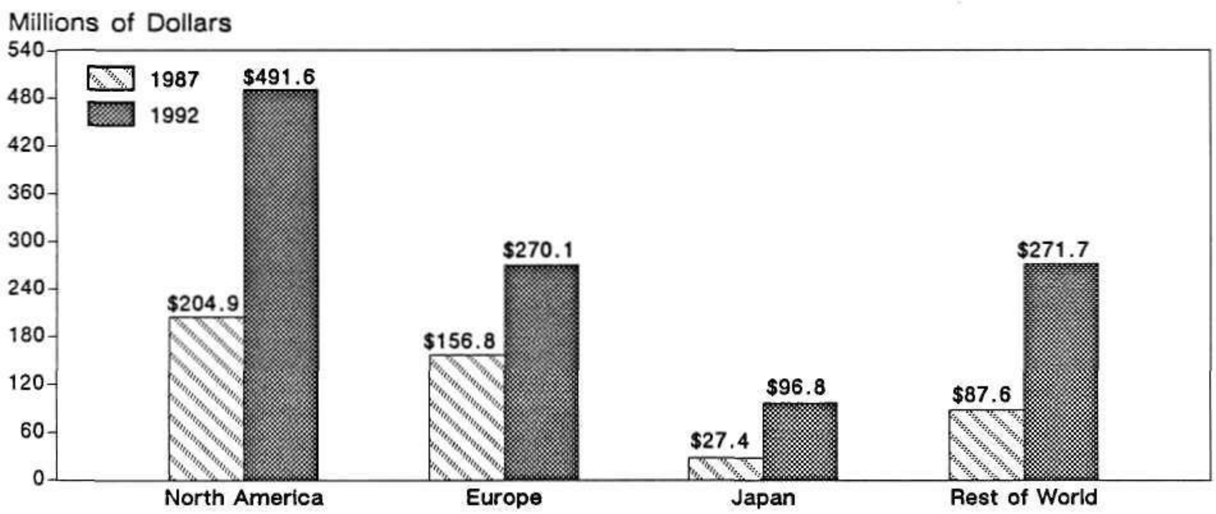
INTELLIGENT POWER SPELLS DOOM AND BOOM IN THE ELECTRONICS INDUSTRY

SUMMARY

Growth in the intelligent power marketplace means tremendous challenge and opportunity for players in the electronics industry. Figure 1 shows the dimensions of the opportunity on a global basis. This newsletter (the second in a series) examines the issue of prospective winners and losers from developments in this arena. Dataquest recommends that users migrate to the use of intelligent power products in electronic systems in order to win. Dataquest also recommends that close user-vendor relations be formed to facilitate this migration. Dataquest warns vendors of power semiconductors against underestimating the trend toward intelligent power ICS and hybrids in order to avoid losing.

Figure 1

North American and European Suppliers
Intelligent Power Products
by Region of World



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April 1988

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WORLDWIDE CONSUMPTION OF INTELLIGENT POWER PRODUCTS

Figure 1 shows that the North American and European regions provided the lion's share of 1987 revenue for North American and European vendors of intelligent power products. Revenue from Rest of World (ROW) countries for these vendors more than tripled the amount of sales into Japan.

As revealed in Figure 1, North American and European vendors and users of intelligent power products should not expect a drastic change regarding the Japanese slice of the global pie. A focus on Japan will not be a winning strategy for most non-Japanese vendors. Sales by North American and European vendors to customers in Japan are not expected to break the $100 million barrier by 1992. Certainly, suppliers like Motorola plan to do well by selling intelligent power products that are suitable for use by Japanese manufacturers (e.g., consumer electronics); however, most of these vendors should foresee greater opportunity in North America, Europe, and the ROW countries.

LONG-TERM WINNERS AND LOSERS

Rapid expansion of the intelligent power marketplace into a $1.1 billion arena for North American and European vendors by 1992 means that there will be big winners and losers throughout the electronics industry. Dataquest expects at least three displacements to occur as this market expands between 1987 and 1992. Each displacement gives rise to sets of winners and losers.

Table 1 presents Dataquest's preliminary 1987 worldwide rankings of suppliers of linear ICs and discrete semiconductors. Succinctly, vendors of these two products stand to make the greatest gains and to risk losing the most ground from the advance in intelligent power ICs and hybrids.

Three Displacements

Electromechanical Systems Manufacturers

Manufacturers of electromechanical equipment and components stand to lose market share by the development of electronic solid-state equipment. Intelligent power products will play a key role in the acceleration of the trend toward electronic equipment and subassemblies.

Manufacturers of electromechanical equipment are likely to be hard hit by developments in three main markets: data processing (printers, disk drives, and other peripherals); industrial (solid-state motor controls and drives, switch mode power supplies, and factory automation systems); and transportation (motor control and regulation). In a related development, Japanese manufacturers of consumer electronic equipment plan to ward off Korean and other ROW competition by incorporating intelligent power products into consumer equipment ranging from household appliances to cameras.

Table 1

Preliminary Worldwide Linear and Discrete Market Share Rankings (Based on Revenue)

Linear Market 1987 Rank	Supplier	Discrete Market 1987 Rank	Supplier
1	National/Fairchild	1	Motorola
2	Toshiba	2	Toshiba
3	Matsushita	3	Hitachi
4	NEC	4	NEC
5	Philips-Signetics	5	Philips-Signetics
6	Texas Instruments	6	Matsushita
7	Sanyo	7	Mitsubishi
8	Motorola	8	Rohm
9	Hitachi	9	Sanyo
10	SGS Thomson	10	Fuji Electric
11	Mitsubishi	11	SGS Thomson
12	Analog Devices	12	International Rectifier
13	Sony	13	Siemens
14	Rohm	14	Sanken
15	Harris	15	ITT
16	Fujitsu	16	GE Solid State
17	GE Solid State	17	General Instrument
18	Burr-Brown	18	Powerex
19	Siemens	19	Telefunken Electronic
20	Sanken	20	Semikron
21	New JRC	21	National/Fairchild
22	Sprague	22	Sony
23	Silicon Systems	23	Fujitsu
24	Precision Monolithics	24	Texas Instruments
25	AMD/MMI	25	KEC
26	Telefunken Electronic	26	Hewlett-Packard
27	Siliconix	27	Siliconix
28	Sharp	28	ASEA-BBC
29	ITT	29	TRW
30	Samsung	30	Unitrode
31	Linear Technology	31	Solitron
32	Mitel	32	Samsung
33	Exar/Exel	33	Ferranti
34	Plessey	34	New JRC
35	Ferranti	35	TAG
36	Fuji Electric	36	VQSI (Varo)
37	Gold Star	37	MEDL
38	Cherry Semiconductor	38	Sprague
39	Raytheon	39	Acrian
40	Unitrode	40	Raytheon
41	Oki		
42	KEC		
43	TRW		
44	General Instrument		
45	Interdesign		
46	Solitron		
47	Teledyne		
48	Seiko Epson		
49	VTC		
50	Micro Power Systems		

Source: Dataquest
April 1988

Discrete Semiconductor and Linear IC Manufacturers

Most vendors of discrete semiconductors and linear voltage regulators plan over the long term to enter or expand participation in the market for intelligent power products. Not all vendors will successfully make the migration, however. Those firms that do not weather the transition face lost market opportunities or even extinction. The first shakeout should occur by 1990.

Regarding the bipolar linear segment, the giants of the semiconductor industry, as shown in Table 1 (Motorola, National Semiconductor, and SGS-Thomson, among others), will fight a bruising battle to maintain and expand shares in a maturing marketplace. These firms face another fierce battle: The world is moving toward digital technology and away from analog technology in its pure form, as marked by the trend toward switch-mode power supplies and away from linear supplies.

Vendors of discrete semiconductors face the same intense pressure. Discrete semiconductor products, such as bipolar power transistors and power MOSFETs, are precisely the kinds of devices that intelligent power ICs intend to displace from system applications. Giants like SGS-Thomson and Motorola are everywhere in these markets—bipolar voltage regulation, power transistors, and intelligent power ICs—which creates a stiff long-term challenge for other suppliers of discrete semiconductors.

Pitfalls of Technological Nonmigration. In terms of intelligent power technologies, some vendors naturally tend to stay with the technology with which the firm is most familiar. There is a clear potential problem with the "one technology for all application markets" strategy: the technology that best serves one set of applications (for example, data processing) might be unsuitable for other applications such as industrial or transportation usages. Vendors like International Rectifier, Linear Technology, and Supertex, which plan to concentrate on one technology, run the risk of limiting future market opportunities.

Pitfalls of Technological Migration. Conversely, vendors that develop multiple technologies for a given semiconductor application market (SAM) run the risk of misallocating engineering resources. These firms could miss the mark by targeting the SAMs with the wrong technology. Broad-based vendors like SGS-Thomson, Motorola, GE Solid State and Sprague face time-critical decisions in determining which technology best serves which SAM.

Linear Power Supplies Manufacturers

A major trend in the power supply business that directly relates to the trends in equipment (from electromechanical to electronic) and semiconductors (from power discretes/bipolars to newly evolving power ICs) involves the displacement of linear power supplies in system applications with switch mode power supplies.

Specifically, many systems manufacturers keep a power supply expert on staff to interact with linear power suppliers regarding the custom design and production of power supplies. Essentially, manufacturers of data processing equipment and other electronic systems become drawn into the power supply manufacturing process. Furthermore, linear power supplies are bulky and unreliable devices vis-à-vis switch mode power supplies.

In turn, intelligent power ICs play a key role in the enhanced convenience and reliability of standard switching mode power supplies. For systems manufacturers the trend toward increasing consumption of switching mode power supplies (and intelligent power products) converts the power supply "make or buy" decision into a decision to "buy." For users, the former involved decision to "custom make" linear supplies through a so-called private-label manufacturer becomes the less-complicated decision to buy and connect them.

Linear power supplies manufacturers stand to lose as a result of the developments in the intelligent power arena.

PROSPECTIVE WINNERS

For every loser there will be a winner. Growth in the intelligent power arena, however, is more than a zero sum game. For every loser, there stands to be multiple winners, including consumers who will pay less for more efficient and convenient products. Even so, the following players stand to gain a great deal by development of the intelligent power marketplace.

Systems Manufacturers that Migrate to Solid State Electronics

Systems manufacturers that migrate to solid state electronics will be winners from the development in intelligent power products. The new systems should operate more reliably, offer more functions, use energy more efficiently, cost less to produce, conserve space, and thus remain competitive against systems from low-cost manufacturing sources.

Seagate Technology

The data processing market provides a cogent example. Seagate Technology's fortunes ride on the efficient and competitive production of computer peripherals. This equipment used to be largely electromechanical systems that incorporated a lot of discrete semiconductors and standard logic devices. Through the former Integrated Power Semiconductors (IPS), Seagate began the migration to solid state electronics. Seagate fully realizes the vital role that intelligent power products play in its current and future systems. When IPS's existence became threatened, Seagate responded by acquiring its former supplier.

Automobile manufacturers now stand where Seagate stood just a few years ago: in the process of converting from less-reliable electromechanical systems into more-reliable solid-state electronic systems. Manufacturers in the transportation Semiconductor Application Markets that make the transition to intelligent power products could zoom to technological leadership in the 1990s.

General Electric

Another way of looking at possible winners is to examine a lost past opportunity that could be converted to a future success.

General Electric (GE) has ranked among the leaders in consumer electronics equipments, including household appliances. GE also enjoyed an early leadership role in intelligent power. However, the vertically integrated supplier never fully coordinated these twin advantages. Even so, GE now stands in an excellent position to exploit the firm's long years of experience in consumer/household electronics and intelligent power.

Key to this prospect is GE's recent aggressive and successful effort to acquire Roper Corporation. In terms of intelligent power, the acquisition gives GE an expanded position in the appliance motor business including outdoor power appliances. In turn, GE Solid State could develop an outlet in the consumer application market for motor control ICs that are now being developed and targeted for industrial applications.

Vendors of Discrete Semiconductors that Migrate to Intelligent Power

All manufacturers of discrete semiconductors (see Table 1)—ranging from giants like GE Solid State, Motorola, Philips-Signetics, SGS-Thomson, and Siemens; through formidable competitors like International Rectifier, Sprague Electric, and Unitrode; to start-ups like Powerex—must make the move to intelligent power products. These firms know this reality and though disagreement exists as to the time frame for full migration—now or the early 1990s—they can read the writing on the wall. Discrete semiconductors will not disappear; however, with a few exceptions like power MOSFETs, discretes are becoming products of the past.

An emerging consensus that derives from the participants in the power semiconductor industry holds that the intelligent power leaders of tomorrow will emerge directly from the ranks of the power technology leaders of today. Undoubtedly, firms like Motorola and SGS-Thomson will be formidable competitors over the long term. Nevertheless, the marketplace remains wide open and includes room for new entrants.

Growth in intelligent power consumption represents both a challenge and an opportunity for suppliers of standard logic and application-specific integrated circuits (ASICs). The challenge: that intelligent power products will displace these logic products in selected applications. The opportunity involves a migration by vendors of standard logic and ASICs to intelligent power over the long term.

IC Vendors that Migrate to Power ICs

Many of the linear IC vendors listed in Table 1 will also win by migrating to the newly evolving segments of the intelligent power market.

Clearly, some of the winners of tomorrow will have had more experience in IC manufacturing than in discrete semiconductors. For example, the primary strength of National Semiconductor and Texas Instruments has been in ICs. Although these vendors face a stiff technical challenge, either or both could emerge as leaders in the intelligent power marketplace.

Many other firms—Cherry Semiconductor, Harris Semiconductor, IXYS, Linear Technology, Micrel, Silicon General—bring a lot to the marketplace. Rifa already wins a favorable reputation among users, although the firm is not yet well known outside of Europe. As noted, Seagate Microelectronics' future now looks favorable after its past travails.

Manufacturers of Switch Mode Power Supplies

Manufacturers of switch mode power supplies will be winners from and will contribute to the move from bipolar linear regulators to intelligent power products. One of the most likely winners will be Cherry Semiconductor, which produces both switch mode power supplies and intelligent power ICs that are incorporated into these supplies.

Manufacturers of Intelligent Power Hybrids

Producers of intelligent power hybrids should also emerge as winners in this marketplace. The prospect for vendors of intelligent power hybrids will be the topic of the third newsletter in this series.

DATAQUEST'S RECOMMENDATIONS

Dataquest makes the following recommendations to market participants that are now being affected by developments in the intelligent power market:

- Systems manufacturers must schedule now for the replacement of the electromechanical systems with electronic systems.
- Systems manufacturers should use supply base management techniques to assess the flow of products and technologies from the vendor base.
- Vendors of discrete semiconductors and bipolar power ICs must prepare for the shift by users from these mature products to newly evolving intelligent power ICs and hybrids.
- Users and vendors should remain committed to forming close long-term alliances to facilitate in tandem incorporation of intelligent power products into systems.

DATAQUEST'S CONCLUSIONS

North American and European vendors of intelligent power products should aim at local markets as well as ROW countries in their efforts to secure a share of a business that Dataquest expects to grow to $1.13 billion by 1992.

Three displacements are expected: manufacturers of electronic systems should displace producers of electromechanical systems; vendors of discrete semiconductors and bipolar power ICs are expected to lose ground to vendors of newly developing intelligent power products and technologies; and suppliers of linear power supplies face displacement by suppliers of switch mode power supplies.

A possible winning hedge strategy will be the production of intelligent power hybrids. Dataquest examines this issue in the third and final newsletter in this series.

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Research Newsletter

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SUPPLY BASE MANAGEMENT IN ACTION

SUMMARY

This newsletter illustrates the use of supply base management as a semiconductor procurement technique in the context of a practical example—tracking developments in the 4-, 6-, and 8-bit video digital-to-analog converter (DAC) marketplace. Supply base management (defined below) offers the prospect of long-term benefits for both users and vendors of semiconductors. Dataquest recommends that semiconductor users institute a supply base management program, and points out that failure to do so can result in a host of long-term problems including costly and avoidable system redesigns.

INDUSTRY MEGATRENDS

Dataquest identifies the move by semiconductor users and their vendors toward closer partnerships as a major trend in the semiconductor industry. Strategic alliances, including those with start-ups, are corollaries to this trend. Since 1985, in fact, Dataquest has recommended that users and suppliers form these expanded relationships, and industry trends since then confirm the recommendation's validity.

SUPPLY BASE MANAGEMENT

Users are under great pressure (given the constraint of shorter system product life cycles) to more quickly and efficiently identify the best semiconductor product, vendor, and price for use in their electronic systems. A powerful tool for achieving this goal is a strong commitment by users to developing a supply base management system.

A supply base management system can be defined as any systematic approach for collecting and using information on semiconductor products, vendors, and pricing toward the goal of designing and procuring parts on a dependable, cost-effective basis. The ultimate goal of a supply base management system is the production of electronic systems that are competitive in terms of cost and performance in international markets.

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The Challenge of Managing Conflicting Goals

A constant organizational challenge for users is bringing design engineers and procurement managers into agreement regarding semiconductor content for system designs and redesigns. Design engineers need to be creative and freewheeling when selecting prospective vendors—or putting them "on the board"—and in designing parts into systems. Conversely, semiconductor buyers and materials managers must be relatively aggressive in terms of taking vendors "off the board" and in keeping nonviable newer parts out of systems. Materials managers must also remove older devices from systems prior to device obsolescence through the "design-out" process.

Supply base management, which enables users to coordinate system life cycles with semiconductor life cycles, can be a practical tool for bridging the often conflicting aims of design engineers and procurement managers toward the goal of building competitive systems at competitive costs. Component engineers also play a key role in this process.

A Practical Example of Supply Base Management

The development of closer user-vendor relationships and of an effective supply base management program requires patience and persistence. Events in the video DAC world provide a practical example of the realities and benefits of this procurement strategy.

The First Issue: Product Choice

The first issue in supply base management concerns the identification of the right product. In the following example, any semiconductor product could have been used as an illustration of the system in action. In effect, the choice of product in this case (video DACs) is a given. (The third issue in supply base management—semiconductor price—is not discussed in this newsletter).

The main point of the video DAC example is that supply base management enables users to effectively track semiconductor product availability and vendor qualifications, especially in the case of start-up suppliers and second-source alliances.

The Second Issue: Vendor Qualification

By early 1986, Brooktree, a start-up firm, had emerged as a technological leader in the video DAC business. Brooktree's stature as a start-up, however, instantly generated concern in users' minds regarding the second issue in supply base management—vendor qualification. Design engineers had included Brooktree on their list of suppliers. Now, procurement managers faced the question of whether the start-up firm should remain on the board or be removed because users needed to know whether Brooktree was a viable long-term supplier. Could this start-up, in fact, fill the bill? A significant subissue centered on second sources.

The second-source issue was tentatively resolved by mid-1986 with the announcement of a second-source alliance between Brooktree and what was then the Fairchild Semiconductor Corporation. Essentially, Brooktree's technical expertise in video DACS would be buttressed by Fairchild's fab strength. Because of the alliance, then, most procurement managers made the supply base decision to keep Brooktree on the board.

Vendor Qualification Continued: Tracking the Second-Source Alliance

For semiconductor users working with Dataquest on supply base management issues since the mid-1980s, tracking the evolution of the Brooktree-Fairchild alliance has been a challenging but manageable task. For prospective users that failed to use supply base management techniques, however, the practical challenge turned into a torturous and confusing headache.

Specifically, during 1987, Fujitsu's proposed acquisition of Fairchild completely overshadowed the Brooktree-Fairchild alliance. Indeed, the controversial Fairchild-Fujitsu deal generated uncertainty in the minds of North American and Japanese users of Brooktree's video DACs as to whether the second-source arrangement would survive. During this period, Dataquest responded to a series of inquiries regarding the status and future prospects of this alliance.

National Semiconductor's ultimate acquisition of Fairchild added to the confusion. In fact, users' worst fears materialized during 1987 with the lapse of the Brooktree-Fairchild alliance as National Semiconductor absorbed the former Fairchild entity into the fold.

NEW INFORMATION ON VIDEO DACS FOR SUPPLY BASE MANAGERS

For users who are tracking suppliers of 4-, 6-, and 8-bit video DACs through a supply base management program, a constant update is required.

First, a Brooktree-National Semiconductor second-source arrangement exists regarding 4- and 8-bit video DACs. Second and separately, National Semiconductor plans to introduce a line of 6-bit video DACs by mid-1988.

For current and prospective users of video DACs, this news translates into the following supply base management information: Brooktree should remain on the board as a supplier of 4- and 8-bit video DACs, with National Semiconductor as a second source. IDT also supplies users of 8-bit devices.

Next, National Semiconductor will soon emerge as an alternative to Inmos as a supplier of 6-bit video DACs. Most of Inmos's output will flow to IBM; however, Dataquest expects other firms to enter this marketplace.

The constant flow of product and vendor information like this keeps a supply base management system operating smoothly and effectively by keeping all parties aware of the key issues.

RECOMMENDATION

To restate the recommendation that was made at the beginning of this newsletter, Dataquest strongly recommends that semiconductor users institute a supply base management program in order to efficiently track semiconductor products, vendors, and prices. Furthermore, vendors must work with users so that users can efficiently coordinate electronic system life cycles with semiconductor product life cycles.

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DATAQUEST CONCLUSIONS

Supply base management benefits both users and vendors of semiconductors. For users, it converts the tension between design engineers and semiconductor buyers into a program for coordinating system product life cycles with semiconductor product life cycles. Supply base management provides users with a path not only for designing the right semiconductor product into systems at an early stage of the system life cycle, but also for choosing the right vendor and the right price. In essence, supply base management enables manufacturers of electronic systems to design and produce systems that can compete in global markets in both price and performance.

Semiconductor vendors should also benefit from users' adoption of supply base management techniques. Supply base management mandates closer user-vendor relations. For semiconductor vendors, this trend means that vendors should expect to supply a fewer number of customers over the long term. However, vendors can also anticipate that the streamlined customer base will buy larger quantities of semiconductors for a longer duration (typically, the full length of the system life cycle) from any single vendor. The upshot for semiconductor vendors is the long-term prospect of more predictable, manageable, and profitable semiconductor production that is geared for a smaller number of key accounts.

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Research *Bulletin*

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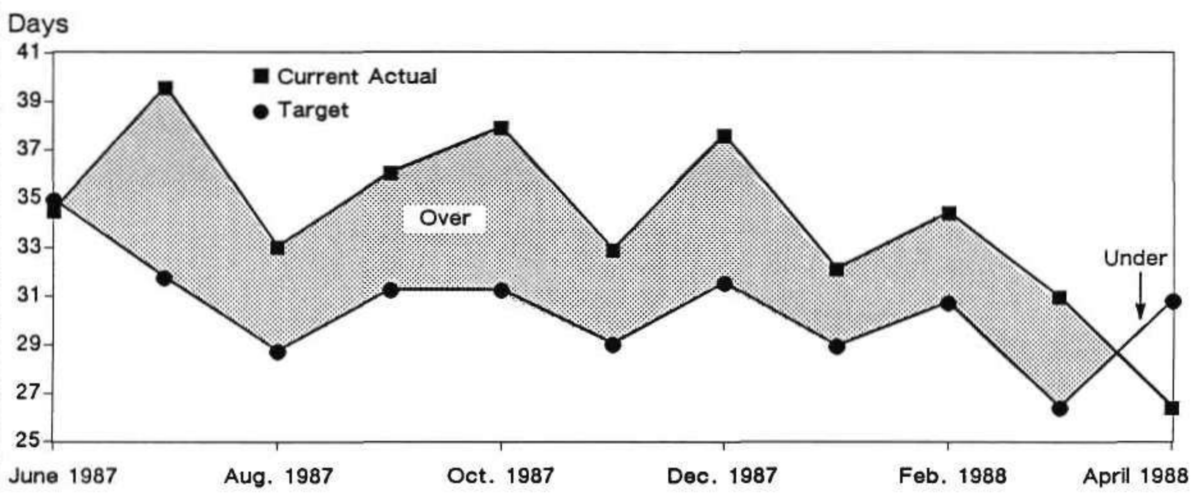
APRIL PROCUREMENT SURVEY: INVENTORIES DROP AS EQUIPMENT SALES RISE

North American electronic systems manufacturers expect rising sales during April, which should eat into current component inventories. DRAMs remain on allocation, and users report difficulty in obtaining other semiconductor products like SRAM, video RAM, linear ICs, discrete semiconductors, and optoelectronic devices. As shown in Figure 1, actual inventory levels are at their lowest level since we began this procurement survey. Figure 1 shows that manufacturers want to maintain or even increase inventory levels in order to meet projected high-growth rates.

Figure 1

Current Actual versus Target Inventory Levels (All OEMs)



Source: Dataquest
April 1988

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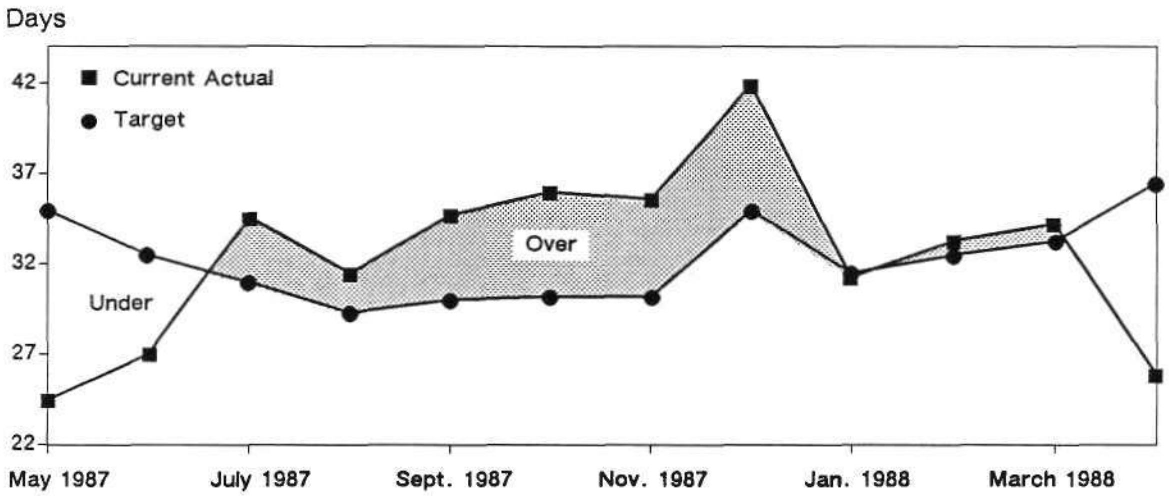
Figure 2 reveals that the same trends in actual and target inventories hold true in the computer OEM market. Indeed, actual inventories of computer OEMs fell to 26.0 weeks versus 26.5 weeks for all OEMs. Computer OEMs target 36.5-week inventory levels whereas all electronic OEMs aim at a 30.9-week level, a considerable difference.

Figure 2

Current Actual versus Target Inventory Levels (Computer OEMs)



Source: Dataquest April 1988

Overall, pricing has been stable and has firmed slightly upward. No changes are expected in terms of sales to OEMs from distribution.

DATAQUEST CONCLUSIONS

OEMs must make sure to not over order during this boom period. The greatest threat to market prosperity at this time would be poorly synchronized supply and demand.

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Gregory L. Sheppard

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Research *Newsletter*

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"INTELLIGENT" ICS POWER THEIR WAY INTO $1.1 BILLION SEMICONDUCTOR APPLICATION MARKET

SUMMARY

A Dataquest survey shows that North American and European vendors, led by SGS-Thomson, garnered more than $476 million in revenue during 1987 from sales of intelligent power products. This newsletter covers major trends in this vibrant marketplace. Table 1 provides product definitions, supplier rankings, and 1987 market size. The following are highlights of this newsletter:

- We believe that a dramatic 47 percent compound annual growth rate (CAGR) in the consumption of newly evolving bipolar/MOS technologies will push the market to $1.1 billion by 1992.

- Vendors must quickly translate newly developed technologies into reliable and cost-effective products, while users must ascertain which vendors, if any, offer viable products for their systems of the 1990s.

A SERIES OF NEWSLETTERS

This newsletter is the first in a series of newsletters being prepared by Dataquest on the issue of intelligent power products. Future newsletters focus on prospective winners and losers and on intelligent power hybrids. A main point of these newsletters is that Dataquest has developed a critical mass of information and insight regarding long-term trends in the intelligent power products marketplace in terms of supplier base, technologies, and semiconductor application markets (SAMs).

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Table 1

North American and European Suppliers*
Intelligent Power Products

1987 Ranking	Supplier	1987 Revenue ($M)
1	SGS-Thomson	$150.0
2	Motorola**	114.0
3	National Semiconductor#	100.0
4	Texas Instruments	42.0
5	Sprague Electric	10.3
6	GE Solid State	10.0
7	Unitrode	9.0
8	International Rectifier	7.5
9	Seagate Microelectronics	7.0
10	Silicon General	5.6
11	Cherry Semiconductor	5.5
12	Supertex	5.0
13	Linear Technology	4.0
14	Siliconix	3.0
15	Rifa	2.9
16	IXYS	<1.0
17	Micrel	<1.0
17	Silicon Power Cube	<1.0
	Total Revenue	$476.7

*Excludes Harris, Siemens, and Japanese vendors
**Estimated
#Estimated as to bipolar voltage regulator revenue

Definitions: An intelligent power integrated circuit (power IC) is a monolithic IC that incorporates a power element (with current of 1 amp or greater or with 100 volts or more) with a control/logic circuitry elements.

An intelligent power hybrid device contains two or more semiconductors in order to incorporate a power element and control-logic circuitry element, as specified for a power IC.

Source: Dataquest
April 1988

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THE SURVEY METHODOLOGY

The information in Table 1 results from a survey conducted during the first quarter of 1988. Seventeen North American and European semiconductor vendors provided detailed information. Three firms (Harris Semiconductor, Motorola, and Siemens) would not reveal complete financial information. As cited in footnotes, Dataquest developed estimates for the total revenue of Motorola and National Semiconductor, respectively. The survey did not extend to Japanese vendors. By definition, the survey excluded all discrete semiconductors.

NORTH AMERICAN AND EUROPEAN VENDORS: SUPPLIER BASE

As shown in Table 1, the North American and European supplier base for intelligent power integrated circuits (ICs) and intelligent power hybrids includes a host of familiar and unfamiliar firms. Suppliers like SGS-Thomson, Motorola, National Semiconductor, Texas Instruments, GE Solid State (which includes the former GE Semiconductor, RCA, and Intersil), and Siemens rank as giants in the global semiconductor industry. Producers such as Harris Semiconductor, International Rectifier, Siliconix, Sprague Electric Company, and Unitrode are well recognized as manufacturers of linear ICs and/or power semiconductors.

The following vendors aim to win a share in the intelligent power marketplace: Seagate Microelectronics (formerly Integrated Power Semiconductor), Silicon General, Cherry Semiconductor, Supertex, Linear Technology, and Rifa. At least three of the newer firms—IXYS, Micrel, and Silicon Power Cube—seek a share of the business. In addition, Dataquest expects other suppliers, such as Powerex, to enter the marketplace.

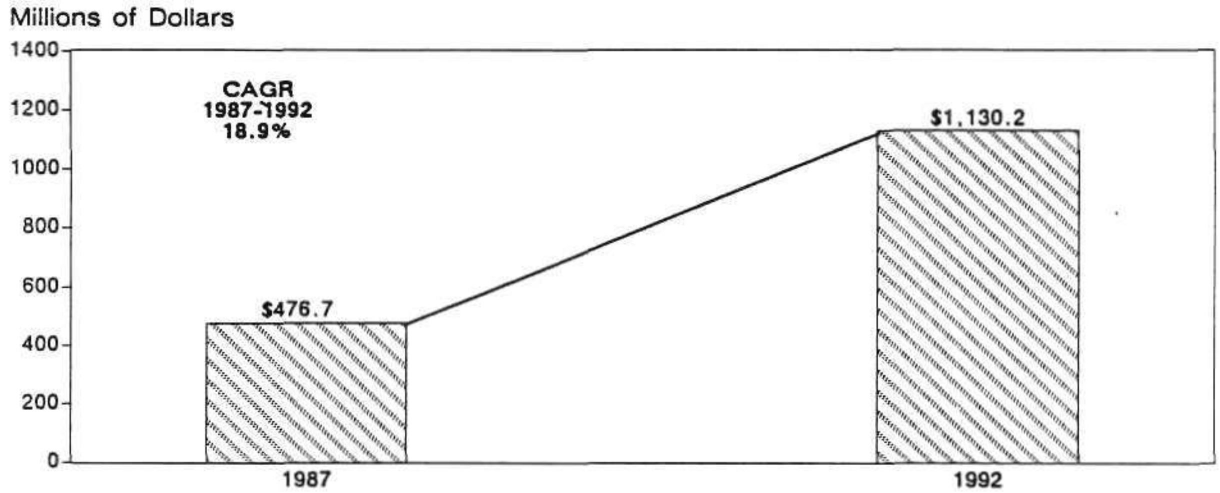
$1.1 Billion Marketplace by 1992

Figure 1 presents Dataquest's forecast for growth in intelligent power product consumption.

As shown in Figure 1, vendors should expect users' consumption of intelligent power products to expand at a healthy 18.9 percent compound CAGR during this period. Demand from users in the data processing, industrial, and transportation application markets drives growth.

Figure 1

1987 and 1992 Intelligent Power Product Revenue



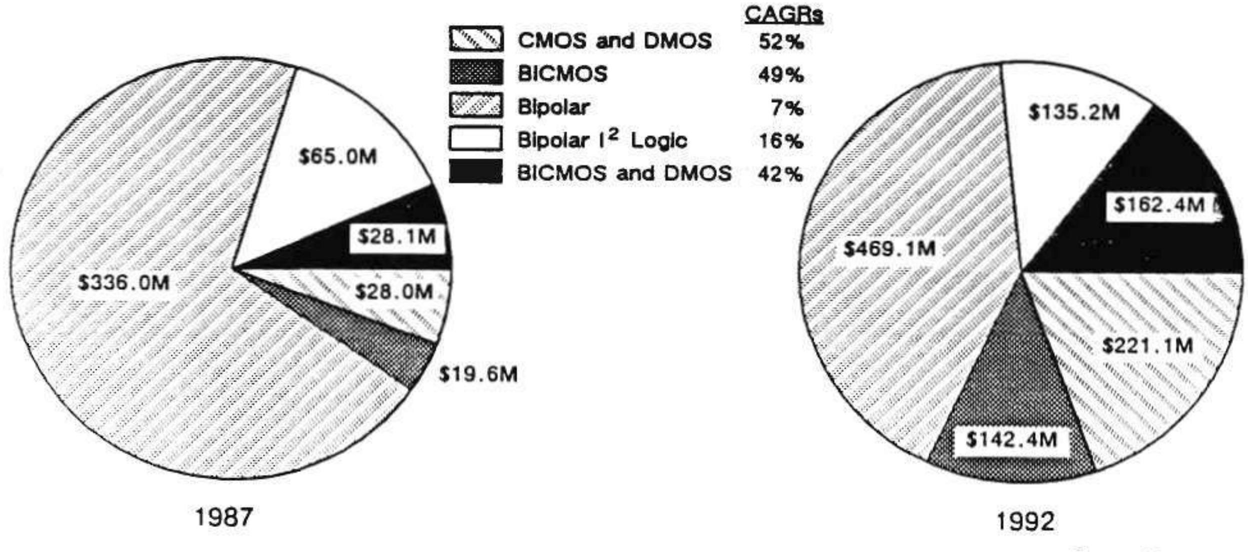
Source: Dataquest
April 1988

The Trends by Technology

Figure 2 presents Dataquest's 1987 through 1992 forecast for growth by technology in this marketplace. The figure clearly reflects the predominant trend in terms of intelligent power technologies: a shift from pure bipolar technology to mixed bipolar-MOS or mixed MOS technologies.

Figure 2

1987 and 1992 Intelligent Power Technologies (Millions of Dollars)



Note: CAGR covers 1987 through 1992.

Source: Dataquest
April 1988

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The Mature Bipolar Technology

Table 2 provides information on suppliers of pure bipolar devices. As noted in Figure 2, the bipolar technology segment accounted for $336 million in revenue during 1987, with growth expected at a CAGR of 7 percent from 1987 through 1992.

For users, many of these firms listed in Table 2 are quite familiar, because voltage regulators that draw more than 1 amp of current meet the definition of a power IC. Table 2 shows that several smaller firms—Cherry Semiconductor, Linear Technology, Rifa, Seagate Microelectronics, Silicon General, Harris Semiconductor, and Silicon Power Cube—also have stakes in this segment.

Table 2

North American and European Suppliers
Bipolar-Technology Intelligent Power Products

1987 Ranking	Supplier	1987 Revenue
1	SGS-Thomson	N/S
2	Motorola*	N/S
3	National Semiconductor*	N/S
4	Texas Instruments	N/S
5	Unitrode	N/S
6	Seagate Microelectronics	N/S
7	Cherry Semiconductor	N/S
8	Silicon General	N/S
9	Sprague Electric	N/S
10	Linear Technology	N/S
11	Rifa	N/S
12	Silicon Power Cube	N/S
	Total Revenue	$336

N/S = Not Specified
*Estimated ranking
Note: Harris and Siemens also produce these devices.

Source: Dataquest
April 1988

The Newly Evolving Technologies

Table 3 provides information on suppliers whose product portfolios include devices that are based on the newly evolving technologies (BICMOS, CMOS+DMOS, BICMOS+DMOS).

Users should anticipate that one or more of the technological leaders of tomorrow will emerge from the ranks of these suppliers listed in Table 3. By 1992, these technologies should represent a $525 million marketplace (47 percent CAGR).

Table 3

North American and European Suppliers*
Intelligent Power Products
1987 through 1992

	Technology			
Supplier	CMOS +DMOS	BICMOS	Bipolar I^2Logic	BICMOS +DMOS**
SGS-Thomson	F	F	C	C
National Semiconductor	F	O	O	O
Texas Instruments	F	F	O	O
Sprague Electric	F	O	O	C
GE Solid State	F	C	O	F
Unitrode	F	O	O	F
International Rectifier	C	O	O	O
Seagate Microelectronics	O	F	F	O
Silicon General	O	F	O	O
Cherry Semiconductor	F	O	F	O
Supertex	C	O	O	O
Linear Technology	O	O	O	O
Siliconix	C	O	O	C
Rifa	C	F	O	O
IXYS	C	F	O	O
Micrel	C	O	O	C
Silicon Power Cube	F	O	O	O
Harris	O	O	O	O
Powerex	F	F	O	O

*Excludes Motorola and Siemens
**See Table 2 regarding bipolar products. BICMOS+DMOS includes Bipolar-MOS and Bipolar+DMOS.
C = Current supplier
F = Future entrant
O = Does not plan to supply

Source: Dataquest
April 1988

CMOS+DMOS Technology

International Rectifier, Siliconix, and Supertex are establishing leadership positions in the CM0S+DMOS technology area. As depicted in Figure 2, consumption of intelligent power products based on the newly developed CMOS+DMOS technology is expected to expand into a $221 million marketplace at a 52 percent CAGR from 1987 through 1992.

Users should closely track the performance of Rifa, IXYS, and Micrel, because these firms could emerge as significant players in the CM0S+DMOS arena. The following vendors plan to migrate to this segment: Cherry Semiconductor, GE Solid State, National Semiconductor, Powerex, SGS-Thomson, Sprague Electric, Texas Instruments, and Unitrode.

BICMOS Technology

As depicted in Figure 2, the BICMOS segment is expected to expand at a 49 percent CAGR into a $142 million marketplace by 1992.

Table 3 reveals that GE Solid State supplies intelligent power products that are based on the BICMOS process technology. (Motorola also targets BICMOS as a key technology in its product portfolio.) Users can expect the following vendors to migrate to the BICMOS technology: IXYS, Powerex, Rifa, Seagate Microelectronics, SGS-Thomson, Silicon General, and Texas Instruments. Users can also look to GE Solid State and Powerex (and to a lesser extent, Rifa) as suppliers of BICMOS intelligent power hybrids.

BICMOS+DMOS Technology

As shown in Figure 2, consumption of intelligent power products that utilize the newly developing BICMOS+DMOS technology should grow at a 42 percent CAGR into a $162.4 million segment by 1992.

Table 3 shows that SGS-Thomson, Siliconix, and Sprague Electric Company are advancing to leadership positions in this marketplace. Micrel's ASIC product portfolio includes the BICMOS+DMOS technology. Users can also expect GE Solid State and Unitrode to enter this segment.

THE FUNDAMENTAL FORCE DRIVING GROWTH

The need for systems manufacturers to replace systems' electromechanical assemblies with electronic circuity is the fundamental force driving long-term growth. The incorporation of intelligent power products into users' systems should translate into enhanced reliability, greater functionality, new applications, space savings, efficient energy management, and reduced system-production costs.

Overcoming Barriers to Growth

Nevertheless, formidable barriers threaten to stall progress in this business. Vendors of intelligent power products face an engineering challenge in terms of building bridges between technologies. Similarly, a tremendous challenge remains in terms of packaging technologies. Vendors also confront a stiff challenge in accommodating users. A predominant trend in the global semiconductor industry is toward closer user–vendor relationships. Consequently, users are becoming more dependent on (and demanding of) the streamlined supplier base.

Given two specific forces—namely, vendors' high costs of developing intelligent power ICs and users' aims of streamlining the supplier base—strategic alliances have evolved as a major vehicle in the business.

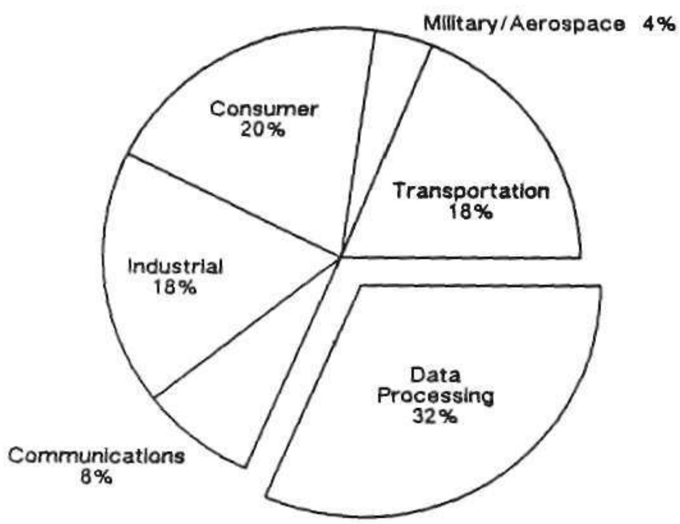
Perhaps the greatest barrier to growth in this marketplace could be a basic failure of vendors and users to communicate. Vendors must communicate to prospective users the potential benefits of intelligent power products. On the user side, system design engineers must work closely with procurement managers and vendors in assessing the relative benefits, costs, and applications of intelligent power products.

THE USER BASE: THE WORLDWIDE SEMICONDUCTOR APPLICATION MARKETS

As shown in Figure 3, data processing ranked as the leading SAM for intelligent power products (32 percent share) during 1987.

Figure 3

Intelligent Power Products by Semiconductor Application Market (Millions of Dollars)



Source: Dataquest April 1988

Figure 3 shows that other leading application markets during 1987 were consumer (20 percent), transportation (18 percent), and industrial (18 percent). The communications and military/aerospace markets are just starting to use intelligent power products.

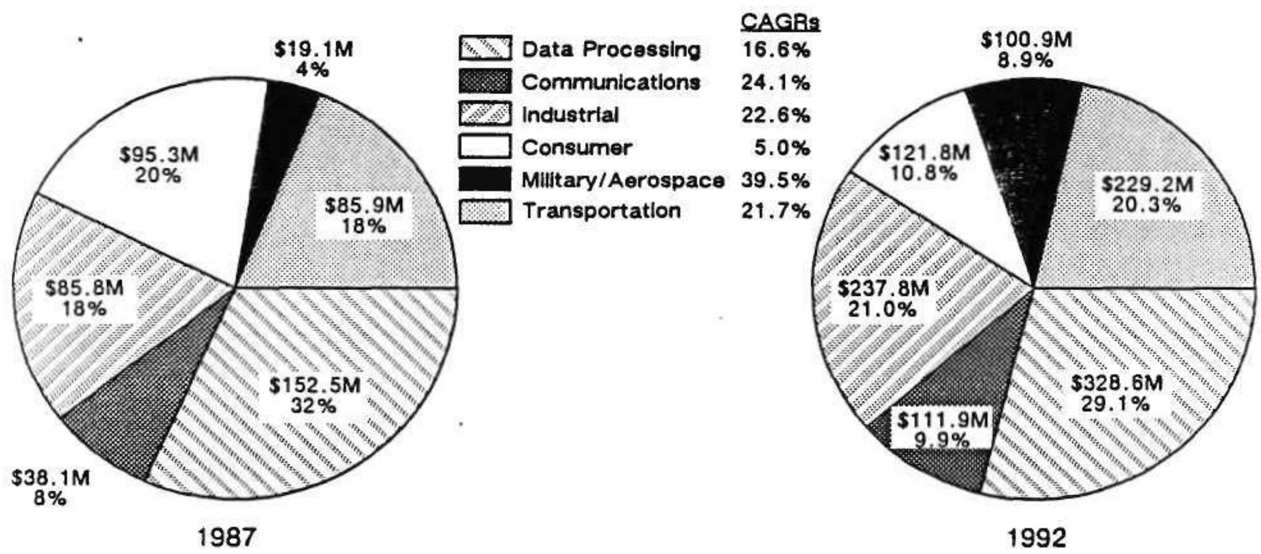
Figure 4 depicts the anticipated rate of growth in consumption of intelligent power products by SAM from 1987 through 1992.

As shown in Figure 4, data processing should remain the largest SAM ($328.6 million by 1992); however, other SAMs are expected to increase consumption of power products at faster rates.

Along with data processing applications (16.6 percent CAGR for an already big segment), the industrial and transportation SAMs should drive the intelligent power marketplace during the 1987 to 1992 time frame, to exploding into $200 million-plus segments by 1992.

Figure 4

1987 and 1992 Growth in Intelligent Power Products by Semiconductor Application Market



Note: CAGR covers 1987 through 1992.

Source: Dataquest April 1988

The Semiconductor Application Markets by Technology

A critical but unresolved issue concerns which technology or technologies will prove most suitable for which applications. As a "sanity check" on the future flow of intelligent power products by technology into the six SAMs, the Dataquest survey asked responding vendors the following question regarding actual 1987 revenue and anticipated 1992 sales:

> "To which semiconductor application market did your company sell the most CMOS+DMOS-based, BICMOS-based, Bipolar-based, Bipolar I^2 Logic-based, and BICMOS+DMOS-based intelligent power products?"

Table 4 presents the results.

As shown in Table 4, manufacturers of data processing equipment should expect vendors of intelligent power products to use at least five technologies over the long term in an effort to serve users' needs in computer and related applications. Two technologies are expected to flow to the industrial SAM, while three technologies should meet the needs of users in the other SAMs.

Table 4

Vendors' Estimate of Leading Intelligent Power Technology by SAM

	Semiconductor Application Market (SAM)					
1987 (Actual)	DP	Comm.	Indus.	Consumer	MIL/Aero.	Trans.
CMOS+DMOS	3	0	2	0	2.0	0
BICMOS	0	0	2	0	0.5	0.5
Bipolar	3	1	0	1	0	4.0
Bipolar I^2 Logic	1	0	0	0	0	0
BICMOS+DMOS	1	0	0	0	0	0

	Semiconductor Application Market (SAM)					
1992 (Expected)	DP	Comm.	Indus.	Consumer	MIL/Aero.	Trans.
CMOS+DMOS	4	1	3.5	0.5	0.5	4.5
BICMOS	1	1	2.0	0	0.5	2.5
Bipolar	2	1	0	1.0	0.5	4.5
Bipolar I^2 Logic	2	0	0	1.0	0	0
BICMOS+DMOS	4	0	0	0	0	0

Note: Several firms did not respond to this question. Some firms specified two leading SAMs for a few technologies.

Source: Dataquest
April 1988

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The Semiconductor Application Markets by Supplier

Table 5 shows prospective users of intelligent power products that vendors are serving or expect to serve in the six semiconductor application markets (as reported to Dataquest by survey respondents).

Table 5 tells users that numerous firms plan to enter or expand their roles in the intelligent power business over the long term. Table 4 signals the shift by suppliers from the pure bipolar technology to the mixed bipolar/MOS technologies, while Table 5 shows the anticipated move by suppliers to the transportation SAM (seven new entrants expected), consumer SAM (six entrants), and other SAMs (five to six entrants) over the long term.

Users should expect suppliers that serve data processing applications to expand their reliance on the CMOS+DMOS technology over the long term. The "dielectrically isolated" bipolar process technology should find use in high-voltage communications applications. Another approach for communications applications will be hybrid circuits based on the CMOS+DMOS technology.

Users in the industrial SAM can anticipate that suppliers will base intelligent power products for this SAM on the CMOS+DMOS or the BICMOS technology. Users should expect the bipolar technology to continue as the technology of choice in consumer electronics applications. As shown in Table 4, users of intelligent power products in the military and aerospace arena can expect devices based on either the CMOS+DMOS technology or the BICMOS process from suppliers specified in Table 5.

Users in the transportation equipment marketplace should expect the newly developed technologies (CMOS+DMOS and BICMOS), along with bipolar products, to flow their way over the long term.

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Table 5

Suppliers of Intelligent Power Products by Semiconductor Application Market 1987 through 1992

	Semiconductor Application Market (SAM)					
	DP	Comm.	Indus.	Consumer	MIL/Aero.	Trans.
SGS-Thomson	C	C	C	C	C	C
National Semiconductor	C	O	F	F	O	F
Texas Instruments	C	C	C	C	C	C
Sprague Electric	C	C	C	C	C	C
GE Solid State	F	F	C	F	F	O
Unitrode	C	C	C	C	C	F
International Rectifier	C	C	C	F	F	F
Seagate	C	O	O	O	O	O
Silicon General	O	O	C	O	C	C
Cherry Semiconductor	C	F	C	O	O	C
Supertex	C	C	C	C	C	O
Linear Technology	C	C	C	O	C	C
Siliconix	C	C	C	O	C	C
Rifa	C	O	C	O	O	F
IXYS	F	F	C	F	C	F
Micrel	F	F	F	O	C	F
Silicon Power Cube	O	O	C	F	F	O
Harris	F	C	F	O	F	F
Powerex	F	F	F	F	F	O

Note: Excludes Motorola and Siemens data. National Semiconductor's 1987 presence in these SAMs is per bipolar voltage regulators.
C = Current supplier
F = Future entrant
O = Does not plan to supply

Source: Dataquest
April 1988

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DATAQUEST CONCLUSIONS

The intelligent power marketplace is a large business for North American and European vendors—$476 million in revenue during 1987—with several segments poised to push total revenue to $1.13 billion by 1992. The newly evolving technologies (CMOS+DMOS, BICMOS, and BICMOS+DMOS) are expected to generate rapid rates of growth (47 percent CAGR) during the 1987 to 1992 period. By SAM, data processing leads the way and continues as the largest segment over the long term; however, the industrial and transportation SAMs are also expected to boom during the 1987 to 1992 time frame.

As noted at the outset, this newsletter is the first in a series of Dataquest newsletters on the vital topic of intelligent power. This newsletter lays out the critical mass of 1987 historical and 1992 forecast information regarding supplier base, technologies, and SAMs. The next newsletter examines the prospective winners and losers from developments in the intelligent power arena. The newsletter includes specific Dataquest recommendations on the strategic response for prospective and current users and vendors of intelligent power products. The third newsletter looks at the vendors that view intelligent power hybrids as a possible winning strategy.

Ronald A. Bohn

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July–September

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(Continued)

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ASIA'S SEMICONDUCTOR START-UP ACTIVITY

SUMMARY

During the last five years, Asia has seen the emergence of 15 semiconductor start-up companies. As shown in Table 1, Taiwan is the most active, with eight start-up companies and 40 chip design houses. The other start-up companies are located in Australia, Hong Kong, Singapore, and South Korea.

Table 1

Asian Semiconductor Start-Ups (1980–1988)

Year	Company	Location	Products
1987	Winbond Electronics	Taiwan	Telecom & consumer ICs
1987	UTIC	Taiwan	Consumer ICs
1987	Chartered Semiconductor	Singapore	CMOS & ASICs foundry
1987	Hualon Microelectronics	Taiwan	Linear, micros, ASICs
1987	Ramax	Australia	Ferroelectric memory
1986	AMPI Taiwan	Taiwan	Power MOSFETS
1986	Taiwan Semiconductor Manufacturing Co. (TSMC)	Taiwan	NMOS & CMOS foundry
1985	Quasel Taiwan (closed)	Taiwan	High-performance RAMs
1985	Sindo Electronics	South Korea	Transistors; diodes
1983	Opto Tech	Taiwan	GaAs/opto, silicon wafers
1983	Dionix Corp.	Taiwan	Diodes
1983	Korea Diode Co.	South Korea	Diodes, varistors
1983	Hua Ko Electronics Co.	Hong Kong	Wafers, IC assembly, consumer IC
1982	Elcap Electronics	Hong Kong	Memory, linear, ASICs
1982	Dong Sung Moolsan Ind.	South Korea	Diodes, varistors

Source: Dataquest
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In a recent Dataquest start-up report, "A Decade of Semiconductors," we observed the following trends in Asia:

- Asian start-ups are active in consumer ICs, discretes, foundry, and ASICs design.
- South Korea is still dominated by conglomerates such as Daewoo, Goldstar, Hyundai, and Samsung that are licensing much technology from U.S. companies.
- Several of the Taiwanese design houses will evolve into semiconductor companies with their own lines of products.
- Australia, Hong Kong, and Singapore are strengthening government support of the electronics industry.

Dataquest expects a gradual increase in semiconductor start-up activity in Asia because of strong electronic industry growth and the availability of financing and experienced engineers.

START-UP ALLIANCE ACTIVITY STILL SLOW

Semiconductor start-up companies are actively entering into alliances with U.S., European, and Japanese companies, but they appear reluctant to enter alliances with Asian companies. Since 1986, the 150 start-up companies have signed 191 agreements. However, as shown in Table 2, we have recorded only 10 alliances with Asian companies since 1986. We believe that there are several reasons for these few alliances:

- Fear among start-up companies of losing their technology because of weak enforcement of intellectual copyrights and patents in many Asian countries
- The emphasis of start-up companies on the large U.S., European, and Japanese markets
- The geographical distance and many cultural differences of Asian companies

Dataquest expects these attitudes to change over time as Asian countries enforce intellectual copyrights more rigorously and work to attract start-up companies. In the meanwhile, most start-ups such as Chips & Technologies and G-2 will remain content to supply chips to fast-growing Asian equipment makers.

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Mark Giudici
Sheridan Tatsuno

Table 2

Asian Alliances of Semiconductor Start-Up Companies (1986-1988)

Data	Asian Company	Start-Up	Agreement
12/87	AvanTech	G-2 (LSI Logic)	China/Hong Kong marketing
10/87	Austek	Zymos	Microcache for chip set
07/87	Ramax	Ramtron	Ferroelectric licensing
01/87	Samsung	Calmos	8200 Series for foundry
07/86	Samsung	Micron	Samsung SRAMs/EEPROMs
06/86	United Microelectronics (UMC)	SMC	Joint IC development
04/86	Daewoo	Zymos	47% acquisition of Zymos
02/86	Hyundai	MOSel	CMOS process; Hyundai fab
01/86	Samsung	Ixys	Smart power exchange
N/A/86	Goldstar	Barvon	Foundry, A/D CAD system

N/A = Not Available

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1989 SEMICONDUCTOR TECHNOLOGY TRENDS HIGHLIGHTED BY ADVANCE OF BICMOS

EXECUTIVE SUMMARY

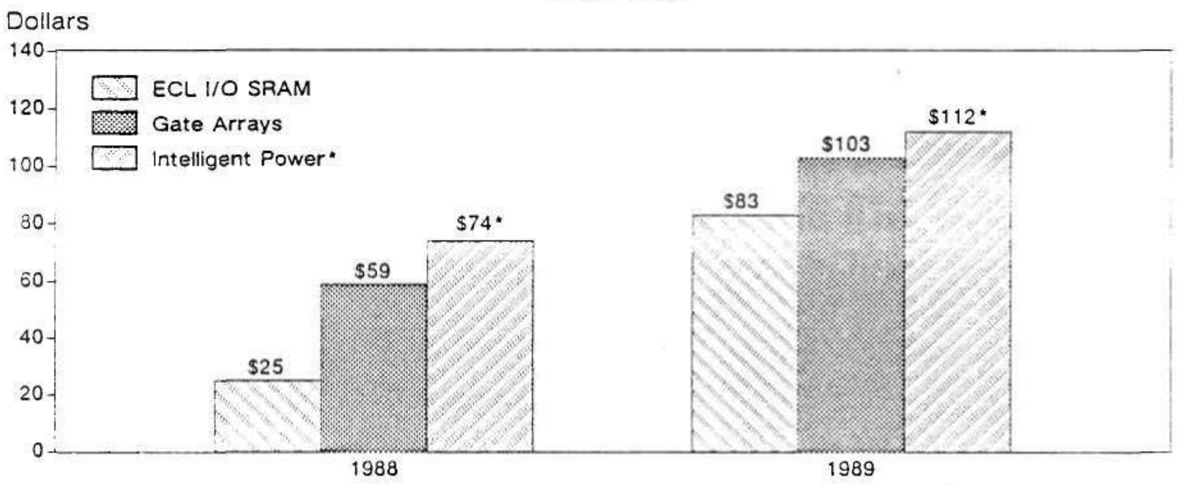
Three words summarize the semiconductor technology trends that will hit users during 1989: newer, faster, and denser. Examples are: new and unfamiliar integrated services digital network (ISDN) ICs, superfast 32-bit microprocessors, and megabit-density memory/modules. The emerging technology of 1989—BICMOS—is favorably viewed by both vendors and prospective users as a fast and risk-free process that evolves from the familiar CMOS and bipolar camps. To assist supply-base managers and strategic planners in gearing for 1989 procurement activity, this newsletter takes a look at the hot BICMOS products and other newly evolving product technologies, and at advances in existing semiconductor families.

1989: THE YEAR OF BICMOS

Figure 1 shows Dataquest's projection for three high-growth BICMOS products during 1989. As the figure shows, consumption of BICMOS intelligent power and BICMOS gate arrays should exceed $100 million next year.

Figure 1

BICMOS Technology Growth
1988-1989



*Includes BICMOS+DMOS

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BICMOS Application-Specific ICs (ASICs)

ASICs—in the form of gate arrays—will be among the products leading the BICMOS push during 1989. Generally, users can expect BICMOS gate arrays to be available in 20K gate-count (or less) devices; however, LSI Logic should push the 50K level. Currently, internal consumption by Hitachi and NEC accounts for a large share of the market.

BICMOS Intelligent Power Products

Intelligent power—the combination of high power and/or high voltage with logic on a chip—marks another BICMOS product that flows to users in growing volumes during 1989. Even so, 1989 continues as another year of extensive design-in activity and related negotiating between vendors and prospective users of intelligent power.

The range of suppliers that serve or target this segment—GE, IXYS, Micrel, Rifa, Seagate Microelectronics, SGS-Thomson, Silicon General, Siliconix, Sprague, Texas Instruments, and Unitrode—indicates the strategic significance of the BICMOS process to semiconductor vendors.

BICMOS Fast SRAMs

Users can look forward to the availability next year of 256K SRAM (x1, x4) that offers access times of 15-20ns. Already, 64K devices meet this performance specification. Fujitsu, Hitachi, and National Semiconductor have targeted BICMOS technology specifically as crucial to its long-term strategy for serving the memory marketplace.

HIGH-DENSITY CMOS MEMORY

DRAM

Dataquest foresees greater tightening of 256K DRAM supply during 1989 as the vendor base shifts to megabit DRAM. Under current demand levels, the supply of 1Mb DRAM should nearly equal the demand by second quarter 1989. Limited capacity and technical manufacturing challenge could make the sourcing of 4Mb DRAM a potential 1989 procurement headache.

Slow SRAM

The year 1989 will mark the introduction of 1Mb slow SRAM and the increased availability of 256K devices. The easing of the 256K slow SRAM shortage should occur after the easing of 1Mb DRAM shortage—toward the middle of the year.

EPROM

During 1989, Japanese producers are expected to ramp production of 1Mb EPROM quickly; however, North American suppliers will increase output at a slower rate. North American and European users of 1Mb EPROM will be supplied from North American-based suppliers because Japanese products should flow in large part to Japanese customers.

Modules

An emerging trend is the increased availability and use of high-density memory modules. For example, Dataquest expects almost half of 1989 Japanese megabit DRAM production to be in the form of the SOJ package with nearly two-thirds of the the SOJs aimed at modules.

MICROCOMPONENTS

Reduced-Instruction-Set Computing (RISC)

RISC continues to overcome initial skepticism and is developing into a generic industry-standard architecture. A major 1989 trend focuses on the growing number of second-source agreements and other technology alliances.

32-Bit MPUs

Intel will increase the supply of 80386 devices. The firm faces a manufacturing challenge, however, regarding high-speed 386 parts (25 MHz and above). The 80386X offers 386-type performance in terms of internal calculations at a price discount as compared with the 80386 device.

Dataquest anticipates 32-bit microprocessor product introductions during the second half of 1989 from Motorola (68040) and Intel (80486). Few specifications are available on either; however, Dataquest expects the 486 to be basically a superfast version of the 386. Users can also look to Japanese suppliers like Toshiba and Fujitsu for 32-bit devices developed under The Real-Time Operating Nucleus (TRON) project.

PC Chip Sets

There are now two chip set architectures. The AT bus is supported by a host of suppliers, while the Micro Channel bus is supported by Chips & Technologies, Faraday/Western Digital, G2, and Intel.

For PC manufacturers, chip sets reduce part counts and system size (or "footprint"), thus lowering total system cost. A new third architecture derived from the AT bus—namely, the Extended Industry Standard Architecture (ESIA)—is expected to receive chip set vendor support next year.

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Digital Signal Microprocessor Units (DSMPUs)

In the DSMPU arena, 1989 should mark low-volume production of floating-point processors. Translating this newly emerging product technology into practical applications is a challenging process. The three main issues are applications support of users by vendors; the availability of development tools like compilers, assemblers; and simulators; and user training.

OTHER SIGNIFICANT 1989 TECHNOLOGY TRENDS

ISDN ICs

Dataquest believes that 1989 will be a year of users' design-in activity. Suppliers will introduce a greater number of ISDN ICs next year in terms of both samples and production volumes. Although the applications that use these chips are not expected to grow until the 1990s, supply-base managers and strategic planners should be looking at these ICs and their suppliers.

Standard Logic/ASIC Displacements

Displacement #1

Older standard logic families like 74C/4000 and ECL 10K will be displaced relentlessly in systems applications by new families like 74AC/ACT (and Fact) and ECL 10KH/100K, respectively, or gate arrays.

Displacement #2

During 1989, low-density gate arrays (2,000 gates or fewer) face displacement by programmable logic devices (PLDs) for use in systems to be produced in low-unit volumes. This is because when 2,000 or fewer systems (an approximate number) are to be produced, the avoidance of nonrecurring engineering (NRE) costs through use of PLDs instead of gate arrays typically translates into lower total system cost.

DATAQUEST RECOMMENDATIONS

Dataquest recommends that supply-base teams—buyers, design engineers, component engineers, and strategic planners—plan now for the slew of newer, faster, and higher-density products that will be available next year as a result of advances in semiconductor technology.

Dataquest specifically recommends that users give careful consideration to the use of BICMOS products—fast SRAM, gate arrays, and intelligent power—for use in the high-performance systems of the late 1980s and the 1990s. Dataquest also recommends that supply-base managers examine the use of newer product technologies like ISDN ICs, RISC-based processors, and digital signal processors in their systems.

DATAQUEST CONCLUSIONS

As shown by the advance of the BICMOS technology, the R&D effort of semiconductor vendors during 1987 and 1988 should mark 1989 as a banner year in terms of new high-performance devices. For users, this product technology reality translates into both a 1989 supply-base challenge and an opportunity.

Ron Bohn

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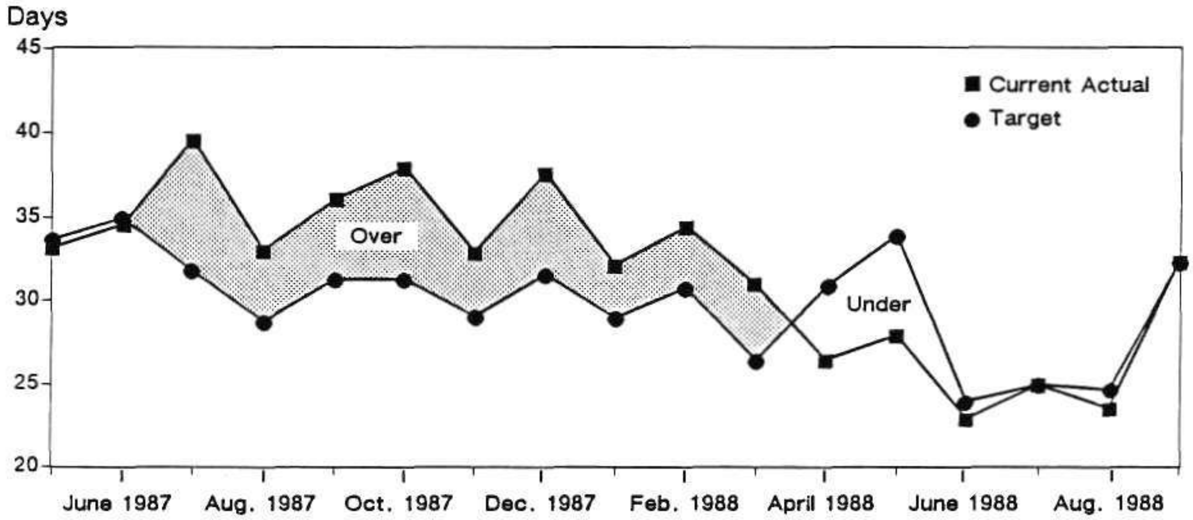
SEPTEMBER PROCUREMENT SURVEY: INVENTORY CONTROL TAKES PRIORITY AS SALES SLOW DOWN

The main concern of the respondents to our current procurement survey is controlling semiconductor inventories within targeted levels as overall sales growth begins to plateau. While sales are expected to continue growing, they are not expected to grow at previous levels. In their efforts to control inventories, both overall and computer OEM respondents have raised their inventory targets to 32.5 days from August's 28-day average target. Memories continue to be a concern, but now SRAMs have become the primary headache producer, with DRAMs taking a close second position. Figure 1 illustrates how actual and targeted inventories continue to remain balanced, albeit at a higher level.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



Source: Dataquest September 1988

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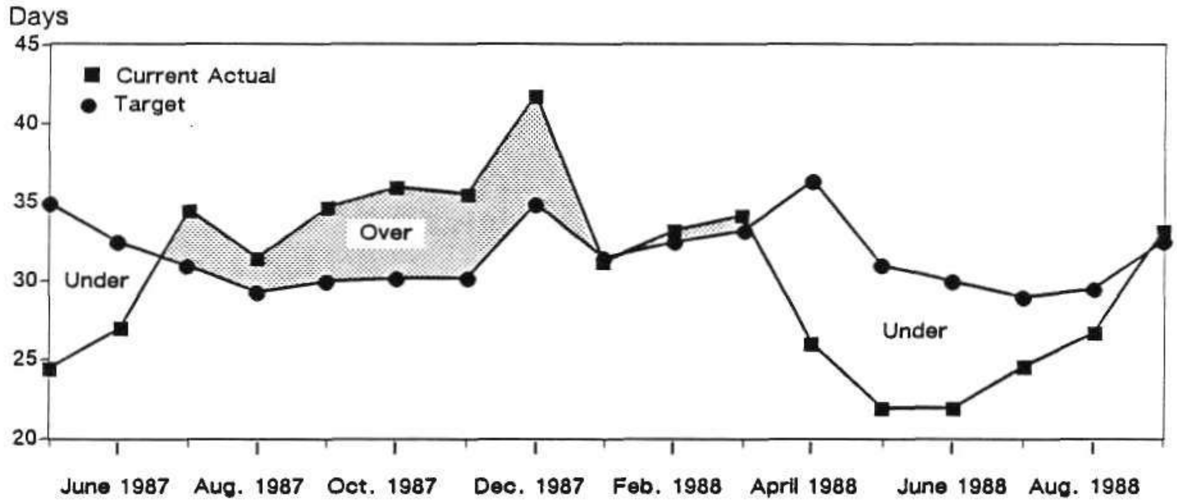
Computer OEM actual inventories again have exceeded targeted levels (33.4 days actual versus 32.6 days targeted) for the first time in nine months, as shown in Figure 2. Tighter quality controls (in ppm) continued as inventories rose.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



Source: Dataquest September 1988

Prices have remained relatively stable, but lead times have decreased, on the average, by two weeks, as semiconductor supplies continue to increase. Orders to distributors have edged slightly upward by 1 to 2 percent as a result of efforts to cut inventory costs. While the majority of computer OEMs use surface-mount packages, availability of these parts no longer appears to be an immediate problem, except for some high-speed memory products.

DATAQUEST ANALYSIS

The acid test of the "user-supplier alliance" philosophy is now beginning as system end use shows signs of leveling off and accurate component forecasting becomes mandatory in controlling inventory levels. Vendors of semiconductors will benefit by accurate forecasts (up or down) from their customers by knowing how to allocate capital and human resources, which, in turn, will provide a steadier supply base of components.

Mark Giudici

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Research Newsletter

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SEMICONDUCTOR PRICE SURVEY: SUPPLIES AND PRICES TIGHT, BUT RELIEF IS ON THE WAY

SUMMARY

Semiconductor pricing in the second quarter of 1988 remained relatively stable compared with the first-quarter price hikes for memory devices. Besides memory prices calming down, the standard-logic and microprocessor prices have continued their supply-demand balanced trends in the face of steady system growth. Availability of DRAMs and some SRAMs is still a concern for procurement managers, but the increased supplies of 1Mb DRAMs and their ripple influences on ancillary devices will improve overall pricing starting in the latter part of the fourth quarter of this year. This newsletter will cover highlights of Dataquest's latest price survey and forecast.

STANDARD LOGIC TRENDS

A balanced market typifies the standard-logic arena, as prices have remained very stable over the last three months (see Figure 1). Prices will firm over the next six months because demand is expected to increase as DRAM availability improves, freeing up latent orders dependent on memory. Lead times have risen slightly by 1 to 2 weeks and now range between 8 to 12 weeks, reflecting this balanced market.

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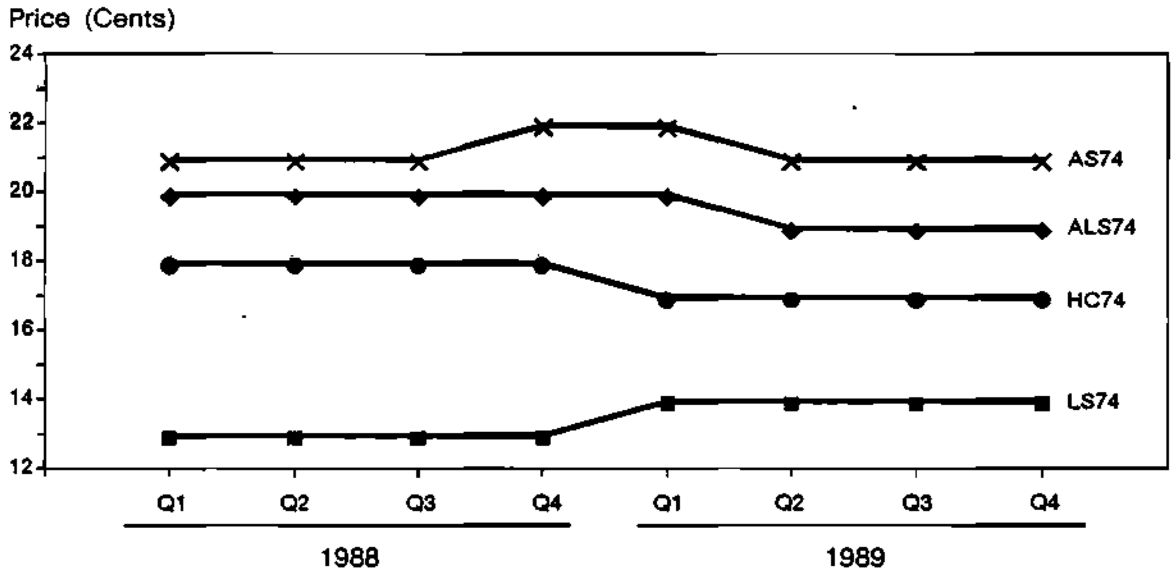
Figure 1

Standard Logic Price Trends



Source: Dataquest
August 1988

MICROPROCESSOR TRENDS

Microprocessor prices have also evened out as supply for both high- and low-end processors has stabilized against demand. Demand for high-speed (12+ MHz) 16-bit and 32-bit processors remains strong, keeping prices firm and flat on through the end of the year. New 32-bit microprocessor offerings from Intel (80386SX) and Motorola (68030) are expected to follow gradual declining price curves in the current sole-source, 32-bit environment.

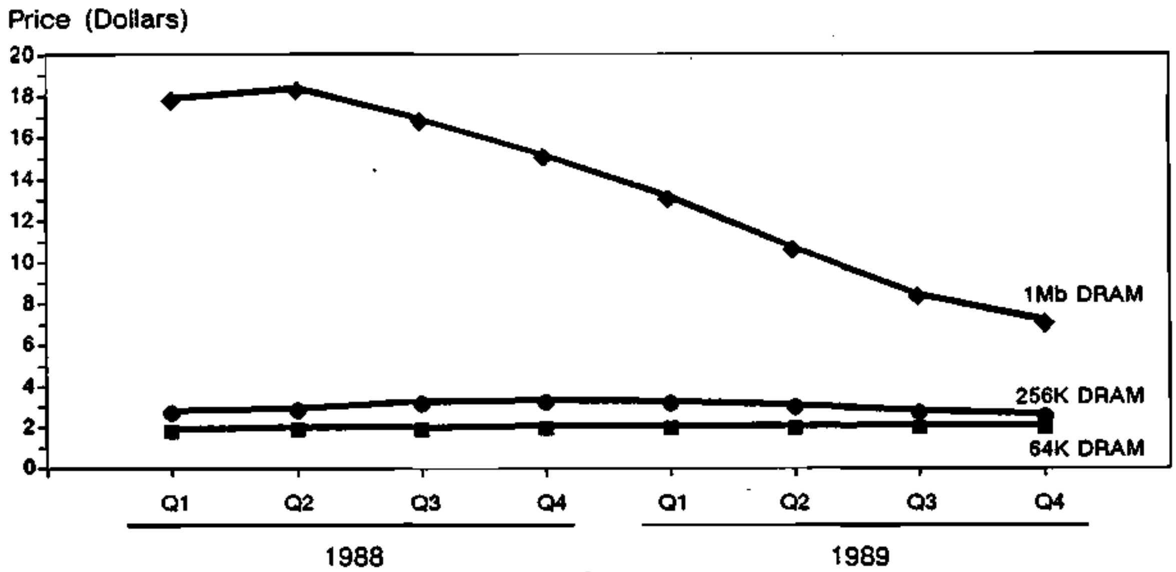
MEMORY TRENDS

Memory availability continues to be in the news, and the beginning of increased supplies of 1Mb DRAMs now slowly coming to the market will have many ramifications on dependent devices. The 1Mb DRAM prices are expected to gradually decline as production ramps up, while 256K DRAM prices will continue to increase and stabilize through the fourth quarter 1988 to the first quarter 1989 time frame, as supplies are cut back 5 percent per quarter through 1989. The expected softening in the electronics market beginning in the second quarter of 1989 will occur just as the majority of the 1Mb vendors reach peak production. The combination of aggressive market share pricing, based on cost reductions with a moderation of demand, will accelerate price declines for the 1Mb part, as shown in Figure 2. For those IC vendors still supplying the rather stable 256K device prices, a shift in capacity to take advantage of decent profit margins will be short-lived until supply meets up with demand and causes 256K pricing to decline also.

SRAM pricing will follow the DRAM trend by about three to six months as this product line again becomes an attractive margin producer. However, in the face of slack demand, prices for these parts will decline also. EPROM pricing has been rather stable and will continue to be so (especially in the lower densities) on through the end of this year as demand for systems remains steady.

Figure 2

DRAM Price Trends



Source: Dataquest
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ASIC TRENDS

Standard cell prices have declined since our last survey, largely due to competition from high-density gate arrays. NRE charges remain higher for these parts due to the inherent higher costs involved with full mask sets and CAD time. Gate array prices stabilized, with vendors now focusing on throughput and customer service, as seen in Figure 3. ECL gate array pricing is becoming a two-tier structure with small-geometry, ultrahigh performance technologies competing with larger (3.0-micron) geometry, very-high-performance parts. The more expensive small-geometry devices currently take a 50+ percent price premium over current price trends. We expect to see continued price competition in the standard-cell and ECL gate array markets as channelless gate arrays continue to fight for the same sockets as standard cells and more vendors enter the ECL gate array arena.

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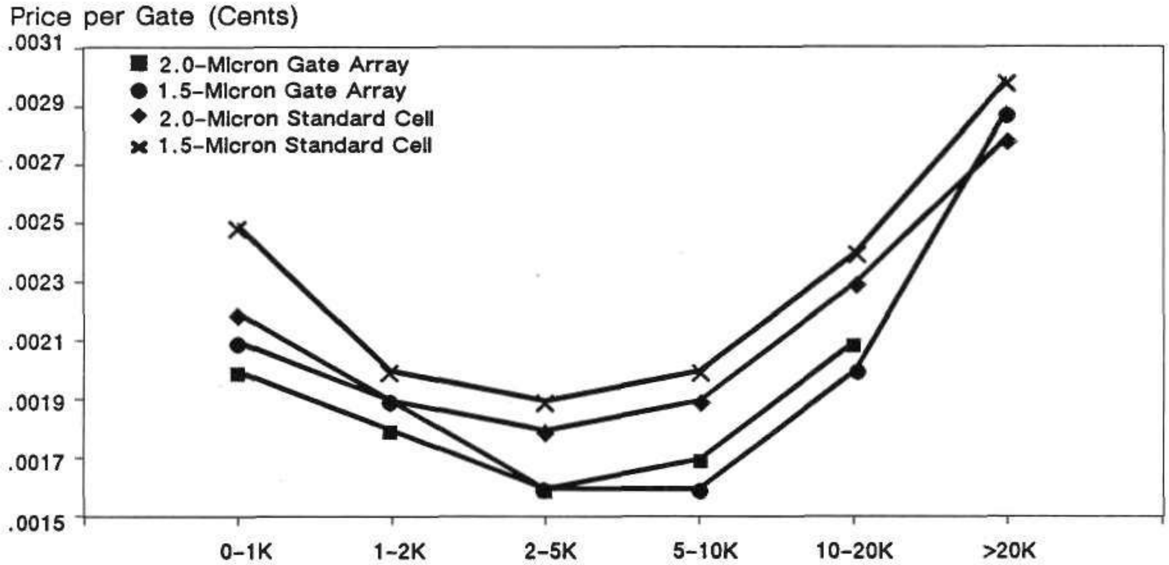
Figure 3

1988 ASIC Price Trends



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DATAQUEST RECOMMENDATIONS

The correction of the past unbalanced supply-demand equation in DRAMs will spill over into other IC areas. In the face of current steady demand, the increased supply of memory will reduce the price of these parts and cause a firming of prices for other devices where there is a market balance (some standard logic and microprocessor parts). When electronics system demand moderates in the second quarter of 1989, overall semiconductor pricing will gradually decline. Close communication between semiconductor buyers and vendors will prevent over-inventory and/or over-capacity situations while allowing both parties to flow with the economic tide rather than fight it.

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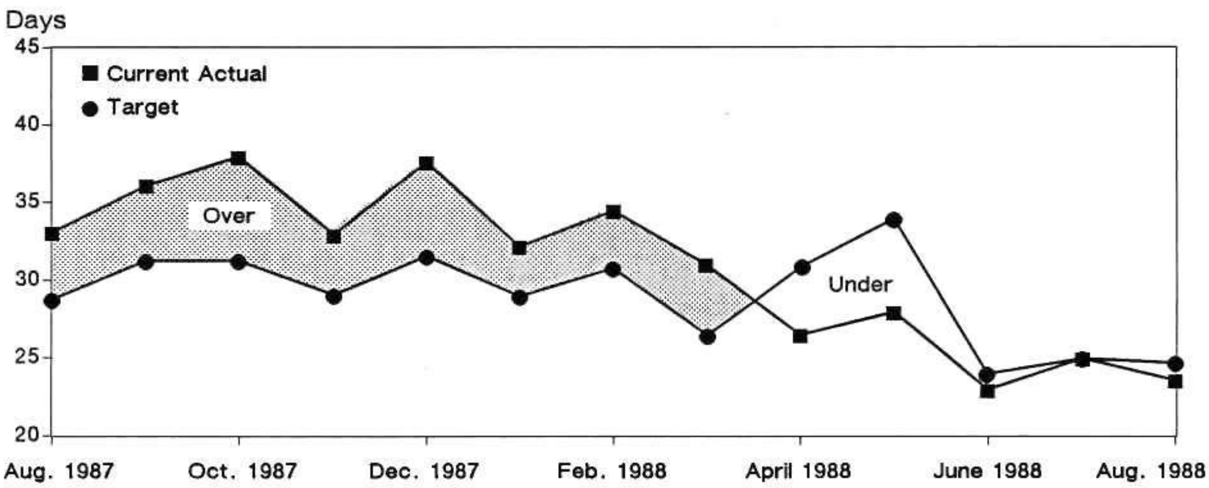
AUGUST PROCUREMENT SURVEY: ORDER RATES FLAT, INVENTORIES MIXED

Respondents to our procurement survey expect August semiconductor orders to remain static, compared with the levels set for July. Sales of electronic systems are forecast to be higher or remain the same during this time frame. The lower overall targeted and actual inventory levels seen in June have continued into July, as shown in Figure 1. The current levels of 24 days targeted inventory and 23 days actual inventory reflect the continued strain that DRAM availability has had on the availability of other semiconductors. While the memory shortage still exists, it appears to have peaked for the majority of users, as procurement practices and inventory levels have adjusted to the situation.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



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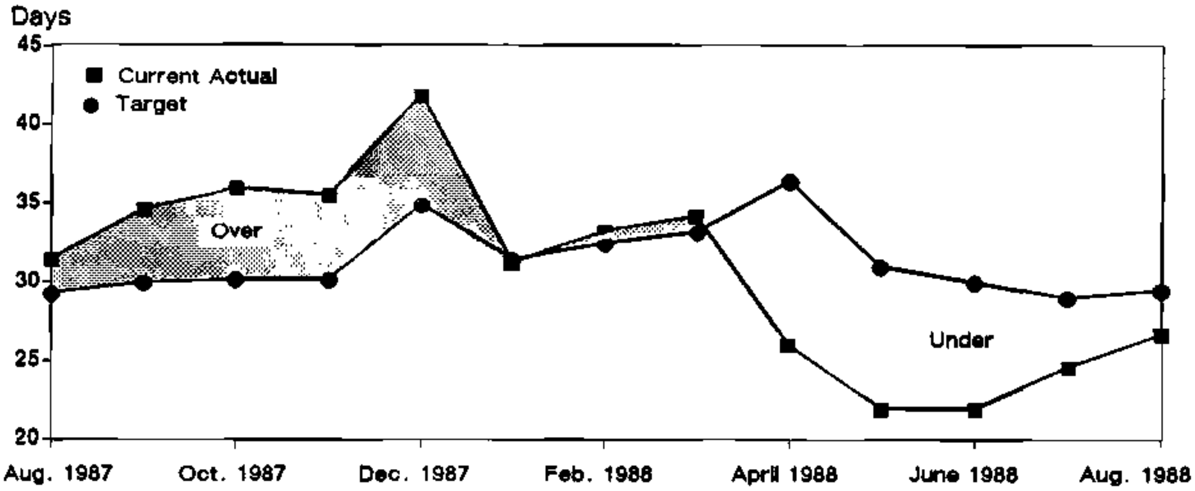
Computer OEM actual inventory levels of semiconductors have risen to slightly more than 26 days, while target levels have remained unchanged at 29 days (see Figure 2). As inventories have increased, more stringent incoming quality assurance levels (in ppm) have been imposed upon vendors.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



Source: Dataquest
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Prices and lead times have continued to remain stable, while there is some indication that lead times will decline as product bottlenecks ease. Distribution orders also remain unchanged since our last report, which also reflects the relative easing of product availability. Surface-mount parts continue to be difficult to obtain, especially in the high-speed memory area. Besides DRAM and slow SRAM shortages, some discrete devices are also hard to obtain. The current difficulty in obtaining discretes may become exacerbated once memory supplies improve.

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QUARTERLY ELECTRONICS INDUSTRY UPDATE: FROM END-USE EQUIPMENT TO SEMICONDUCTOR CAPITAL SPENDING

SUMMARY

Probably one of the most frequent questions we are asked at Dataquest is "What is driving the semiconductor recovery, and how long will it last?" We have published several newsletters and other material that address various aspects of this question, which our clients have received. The purpose of this newsletter is to compile information that has already been published and present, in one newsletter, a very concise summary of the electronics industry as we see it for the next five years. Our intent is to provide a reference document to be used for high-level forecasts.

The newsletter presents top-level forecasts of the electronic equipment industry, the semiconductor production required to meet the electronic equipment demand, and the capital spending required by the semiconductor manufacturers to meet semiconductor demand.

ELECTRONIC EQUIPMENT

The electronics industry has gained clout as a major driving force behind the worldwide economy. Few are aware that in 1988 $770 billion worth of electronic equipment will be produced, creating direct demand for a $49 billion semiconductor market.

The electronics industry, made up of six major markets, will grow more than 12 percent this year. Figure 1 reflects the major factors behind that growth—the data processing and consumer markets. In the United States, Japan, and the Far Eastern countries, these two markets comprise the bulk of electronic equipment production. Major growth areas within these markets are personal computers, workstations, terminals, televisions, VCRs, and compact disk players. All of these areas have two points in common: high pervasiveness, meaning high semiconductor content, and high volume. All of the previously mentioned products are tied to individual use; that makes for a very large total available market.

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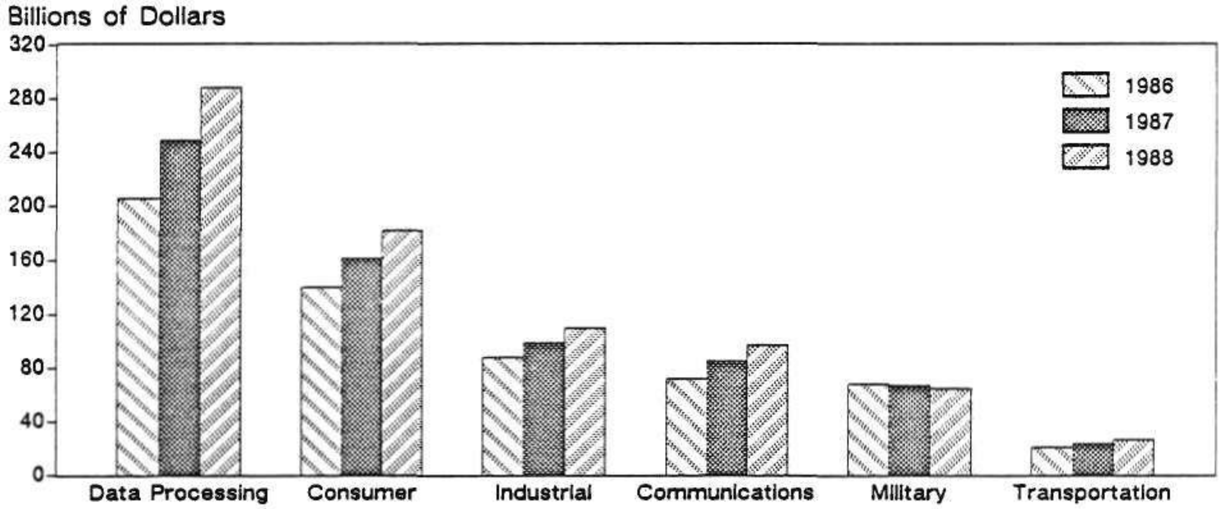
Figure 1

Worldwide Electronic Equipment Market by Electronics Segment



Source: Dataquest
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Table 1 shows Dataquest's estimates for worldwide electronic equipment market. Solid state technology now affects all of us; our appliances, entertainment, transportation, telephones, and productivity tools rely on semiconductors. The commoditization of electronics and the semiconductor industry may ultimately create a more stable marketplace. Market demand is broad based, and marketing and manufacturing strategies are assessed across an international marketplace. Closer ties between users and vendors create implications for more stable growth. We believe that there will be less dramatic swings in the semiconductor industry, which will be largely due to a changing worldwide electronics industry.

Table 1

Worldwide Electronic Equipment Semiconductor Production and Capital Spending (Billions of Dollars)

	1986	1987	1988	1989	1990	1991	1992	CAGR 1986-1992
Electronic Equipment Market	$595.0	$685.0	$769.0	$819.0	$843.0	$968.0	$997.0	9.0%
Semiconductor Production	32.8	39.9	49.1	54.1	54.2	62.8	75.9	15.0%
Capital Spending	5.3	6.0	8.3	9.0	9.1	11.8	15.4	19.5%

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August 1988

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SEMICONDUCTOR PRODUCTION

Electronic equipment demand drives semiconductor production. Figure 2 shows the semiconductor consumption by electronic equipment segment. Here we see that the data processing and consumer electronics markets alone will consume almost $30 billion worth of chips in 1988; this represents more than 60 percent of all the chips produced in 1988. Table 1 shows Dataquest's latest estimates of worldwide semiconductor production by all producers, including captive and merchant.

Semiconductor production in 1988 will increase by 23 percent over 1987 levels, which were up 22 percent over 1986 levels. The bookings momentum and the shortages in leading-edge semiconductor products suggest that strength in shipments should continue through the first half of 1989. Growth in 1989 should be 10 percent, followed by a flat 1990.

In spite of memory chip shortages, the short-term outlook is very strong because of the increasing demand for high-end microprocessors and ASIC devices that are consumed in the production of data processing equipment. Overall capacity utilization is estimated to be 82 percent by the end of 1988, up from 78 percent in 1987. Capacity is tight for the leading-edge products, with capacity utilization in excess of 90 percent for the finer-line geometries in the 1.5-micron range.

As new plants are brought on stream, capacity utilization for high-integration devices should ease a bit later this year. High-end microprocessors should soon cease to be supply limited, but microprocessor demand in 1988 is constrained by memory shortages. Although we expect DRAM demand to exceed supply in 1988, we expect supply to catch up in 1989 as a result of increased capacity and improved yields for 1Mb DRAMs, putting downward pressure on prices.

Figure 2

Worldwide Semiconductor Consumption by Electronics Segment

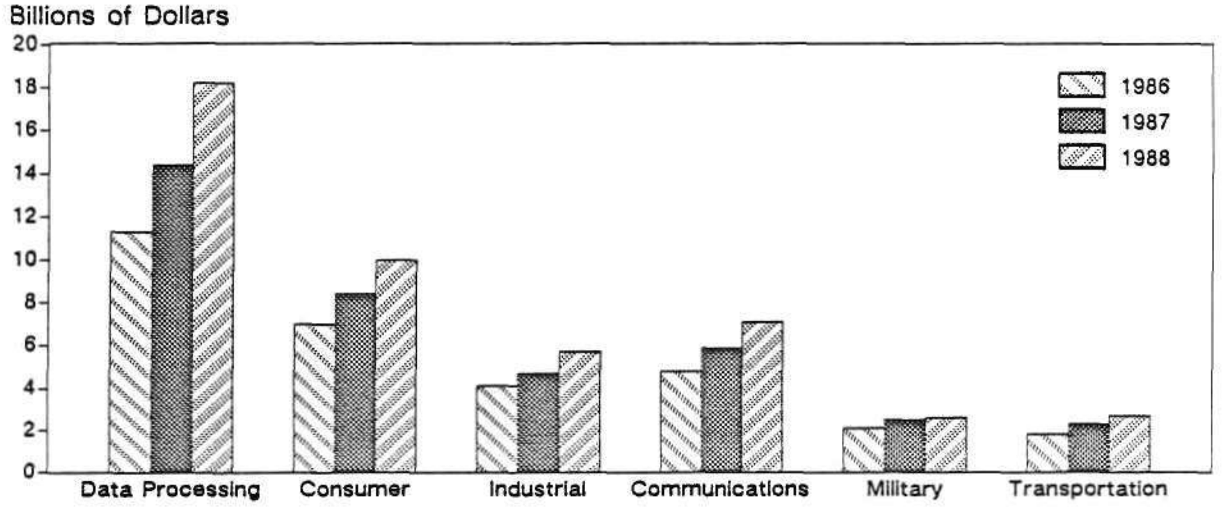

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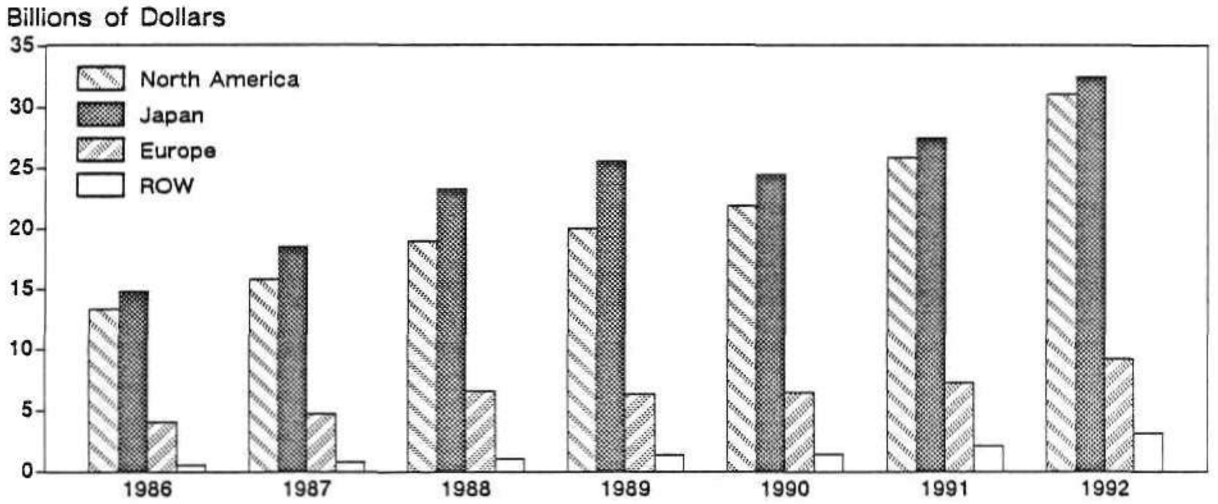
Figure 3 shows the regional production of semiconductors, which includes production by all companies in the region, regardless of country location of headquarters. Table 2 shows the shift in regional production from 1984 through 1992. Here we see that for North America, in spite of the increase of Japanese and European fabs in the United States, its share of worldwide semiconductor production will only be about 41 percent by 1992.

Figure 3

Worldwide Semiconductor Production by Region



Source: Dataquest
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Table 2

Worldwide Semiconductor Production by Region

	1984	1992
North America	49.8%	40.9%
Japan	38.3	42.8
Europe/ROW	11.9	16.3
Total	100.0%	100.0%

Source: Dataquest
August 1988

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CAPITAL SPENDING

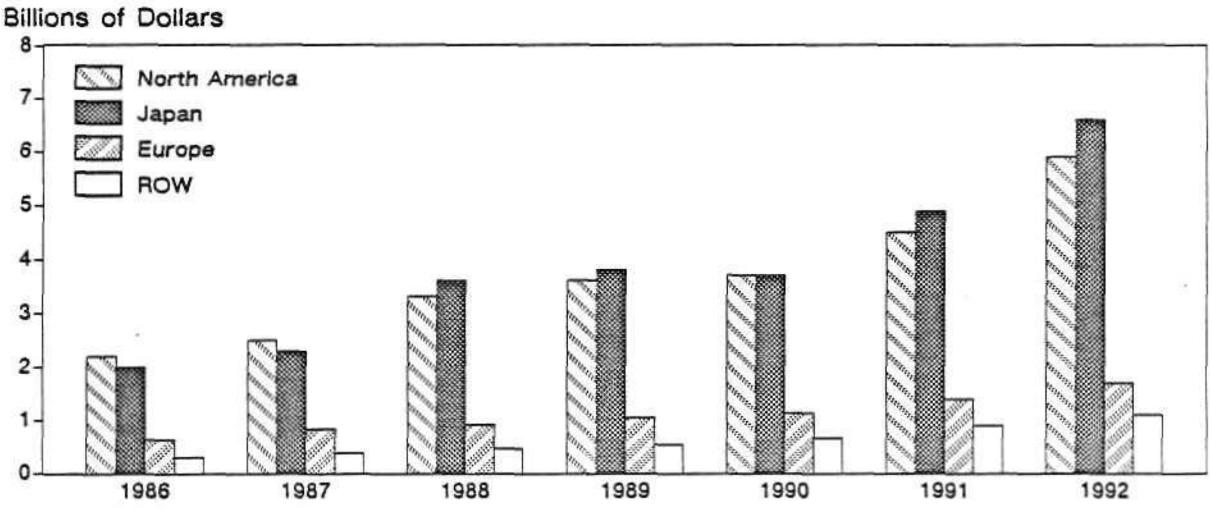
Table 1 also shows the capital spending that must be made by the world's semiconductor producers in order to meet the projected semiconductor demand. Capital spending will be driven by the need for increased capacity and upgrades, especially for leading-edge devices. Capital spending will also be fueled by competitive pressures as many manufacturers locate front-end facilities offshore to be close to their markets and to protect themselves from the double nemesis of trade friction and currency fluctuations.

Capital spending, like the electronics end markets that it eventually serves, will grow at a much more steady rate than in the past. Semiconductor manufacturers, although spending for more capacity, will remain cautious; they prefer to increase equipment availability and to increase yields before adding capacity. Consequently, although Dataquest does not anticipate the skyrocketing growth that occurred in 1984, we also do not anticipate the devastating descents that occurred in the 1985 to 1986 time frame. The peaks may not be as high, but the ride will be smoother and more sustainable.

Figure 4 shows the capital outlays by region that must be made to support the semiconductor output of those regions. Again, these projections represent spending by all companies in the region, regardless of the company nationality. We expect spending by all companies in Japan (including U.S. merchants and IBM) to increase at a CAGR of 24 percent. The reason for this high growth in Japan is the fairly low starting base, especially in terms of yen. Spending in yen by Japanese companies, U.S. companies, and IBM in Japan actually fell 65 percent from 1984 to 1987—from ¥924 billion in 1984 to ¥325 billion in 1987.

Figure 4

Worldwide Capital Spending by Region



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We also expect spending by all companies in the Asia-Pacific region to grow at a CAGR of 24 percent. This growth rate will be driven by Asia-Pacific companies' commitment to become world-class manufacturers and by new fab construction by European and North American companies.

Spending in North America will grow at a healthy 19 percent CAGR, and will be almost $6 billion in 1992. This spending will be fueled by new fabs and upgrades for leading-edge devices, especially DRAMs and microprocessors. Dataquest also anticipates a strong surge of spending by Japanese companies in the United States, as several Japanese companies either have already initiated new fab construction or are soon planning to begin.

Europe will experience the slowest growth rate—only 15 percent. The relatively slow rate in Europe is due to the recent completion of major expansions by Philips and Siemens and to the rationalization of existing facilities by SGS-Thomson. Captives will play a major role in Europe: AT&T will complete its new fab in Spain in 1989, and IBM will begin production on the largest 200mm fab in the world at Singlefingen, West Germany, also in 1989.

Capital spending, like the electronics industry it serves, will be more stable than it has been in the past. It will also be more international—and more competitive. Equipment vendors will have to serve markets that are culturally different from their home offices and compete with new competitors on their home turf. Capital spending may grow at a more stable rate than in the past, but competition will be as fierce as ever.

DATAQUEST CONCLUSIONS

The forecast presented here for the electronics industry—from end-use markets through capital spending—shows a consistent picture of healthy and sustainable growth rates. Furthermore, worldwide markets, increased dialog, just-in-time inventory control, and more realistic capacity planning are beginning to pay off for the electronics industry. The good growth rates, combined with a more mature business point of view, signify that the electronics industry is emerging from the vertigo of youth and should rationally grow to a $1 trillion level by 1992. That is, indeed, good news.

Anthea Stratigos
Joseph Borgia
George Burns
Joe Grenier

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AGGRESSIVE START–UPS SPAWN NEW COMPANIES

Many believe that start–up companies serve only one purpose––to be acquired. However, some of the recently formed start–ups are actively making acquisitions and spawning new start–ups. This newsletter describes the acquisitions and equity investments by these aggressive new companies. The information is based on research contained in a new Dataquest directory entitled A Decade of Semiconductor Companies— 1988 Edition.

Significantly, start–up companies have spawned six enterprises, five of them semi–conductor companies. They are Aspen Semiconductor Corporation, G–2 Incorporated, Inter–Act Corporation, Multichip Technology Incorporated, Nihon Semiconductor Corporation, and Chartered Semiconductor Corporation. Cypress Semiconductor provided first–round financing for two of the new companies—Aspen Semiconductor and Multichip Technology. Aspen Semiconductor will develop and market ultrahigh–speed ECL ICs, and Multichip Technology will manufacture high–density memory modules using surface–mount packaging technology. Inter–Act, in which LSI Logic has a 66 percent interest, will develop and market an integrated software and hardware development system for the MIL–STD–1750 embedded system marketplace. The complete list of equity investments is shown in Table 1.

Table 1

New Company Formations/Equity Investments by Start–Up Companies

Investor Company	Invested Company	Year of Investment
Cypress Semiconductor	Aspen Semiconductor (100%)	1987
Cypress Semiconductor	Multichip Technology (100%)	1988
LSI Logic	G-2 Incorporated (100%)	1987
LSI Logic	STC (semi. div.) (>50%)	1984
LSI Logic	Nihon LSI Logic K.K. (100%)	1984
LSI Logic	Nihon Semiconductor (55%)	1985
LSI Logic	LSI Logic (Canada)	1987
LSI Logic	Video Seven (20%)	1987
LSI Logic	Master Images (20%)	1986
LSI Logic	Inter-Act Corporation (66%)	1987
Micron Technology	Barvon Research (16%)	1985
Micron Technology	Standard Microsystems	1988
Sierra Semiconductor	Chartered Semiconductor (17%)	1987

Source: Dataquest
July 1988

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Start-ups also have acquired 12 companies, as shown in Table 2. California Micro Devices (CMD) has been most active, acquiring Micro Innovators in 1983, merging Custom MOS Arrays in 1986, and acquiring the GTE Microcircuits Division in 1987. The acquisition of GTE Microcircuits adds new microcomponent and telecom IC products to CMD's existing thin film and ASIC capability.

In contrast, 13 start-ups have been acquired as listed in Table 3.

Table 2

Acquisitions by Start-Ups

Start-Up Company	Acquired Company	Year Acquired
Acrian	Communication Transistor	1982
Austek	Silicon Macrosystems	1986
Brooktree	Manx Engineering	1987
California Micro Devices	Micro Innovators	1983
California Micro Devices	Custom MOS Arrays	1986
California Micro Devices	GTE Microcircuits	1987
Calmos Systems	Siltronics (bipolar IC line)	1988
European Silicon Structures	Lattice Logic	1987
European Silicon Structures	Best	1987
MemTech	Materials Progress (crystal div.)	1987
Microwave Technology	Monolithic Microsystems	1987
VLSI Technology	Visic	1986

Table 3

Start-Ups that Have Been Acquired/Merged

Start-Up Company (Date Formed)	Acquired By	Year Acquired
Array Technology (1982)	Imperial Chemical Industries	1986
Custom MOS Arrays (1982)	California Micro Devices	1986
Inmos (1987)	Thorn EMI	1984
Spectrum Microchip (Insouth)	Fairchild Communications	1983
Integ. Power Semiconductor (1984)	Seagate Technology	1987
Panatech Semiconductor (1981)	Ricoh	1987
Signal Processor (1981)	Analog Devices	1983
Silicon Macrosystems (1984)	Austek Microsystems	1986
Vatic (1983)	Thomson-Mostek	1986
Visic (1983)	VLSI Technology	1986
VTC (1984)	Control Data Corporation	1987
ZyMOS (1978)	Daewoo Corporation	1986

Source: Dataquest
July 1988

DATAQUEST CONCLUSIONS

Start-ups are not the easy pickings for long-established companies that some believe. The acquisitions and equity investments by these aggressive young companies serve a variety of purposes, including expansion of product and marketing horizons. These are a few of the ways start-ups are adding the muscle needed to compete in worldwide markets. More and more, start-ups are becoming companies to watch out for!

Penny Sur

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Research *Bulletin*

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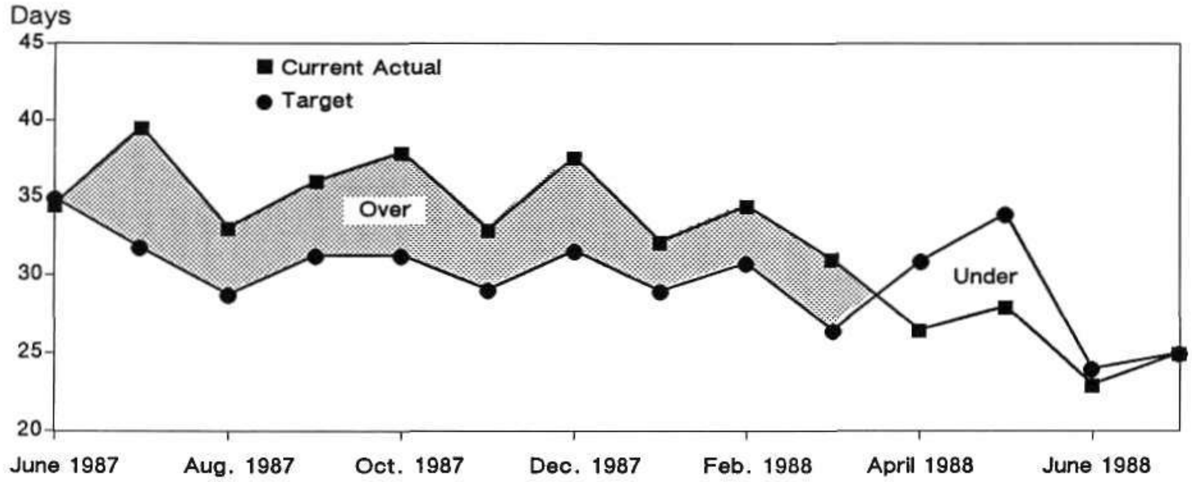
JULY PROCUREMENT SURVEY: ORDER RATES AND INVENTORIES LEVEL OFF

Respondents to this month's survey expect to see both semiconductor billings and orders remain at, or below, last month's levels. This leveling of semiconductor orders is in response to the mixed levels of electronic system sales---some of our respondents expect higher sales while others expect lower sales this month. Both targeted and actual semiconductor inventory levels have leveled out at around 10 turns per year, as seen in Figure 1. Many of our respondents noted that although memory supplies (DRAM and SRAM in particular) are still in tight supply, some parts are more easily available than in the recent past. Long-term contracts continue to provide adequate supplies of key components.

Figure 1

Current Actual versus Target Inventory Levels (All OEMs)



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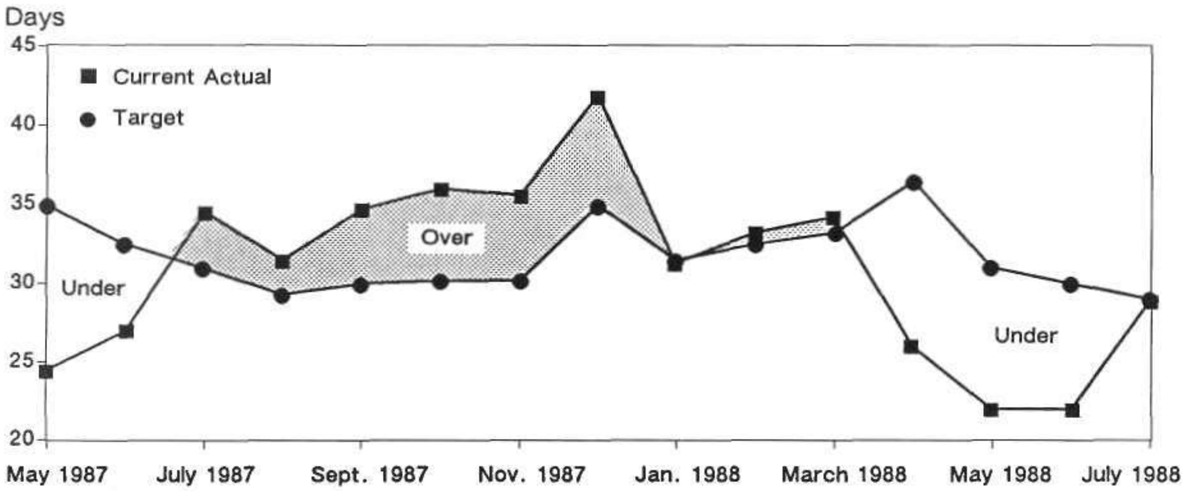
Computer OEM actual semiconductor inventory levels have remained steady at 29 days while the actual level has risen up to meet it. The DRAM/SRAM shortage is now a given in procurement plans, and purchases of DRAM-dependent ICs have been adjusted downward to accommodate this situation.

Figure 2

Current Actual versus Target Inventory Levels (Computer OEMs)



Source: Dataquest July 1988

Pricing has remained the same and in some cases has risen, while overall lead times have remained steady or declined from June's survey. Distribution orders have declined slightly, primarily in response to the perceived easing of supply for some IC parts. For over half of the respondents who use surface-mount parts, availability of surface-mount ICs is a serious problem, especially in the memory area. We expect this situation to continue until the DRAM shortage begins to ease in the fourth quarter of 1988 through first quarter of 1989 timeframe.

Mark Giudici

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Research Newsletter

SUIS Code: 1988–1989 Newsletters: July–September
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DRAM AVAILABILITY IMPACT ON DEPENDENT ICs AND SYSTEMS

SUMMARY

This newsletter reviews the current DRAM shortage, the direct and indirect impact on IC purchases dependent on DRAMs, and the long-term implications for end-use system competitiveness. We will also review the future supply lines of these critical components and note possible alternatives available to prevent such shortages in the future.

CURRENT STATUS

For at least six months now, DRAM availability (or lack thereof) has been bemoaned to the extent that many buyers with contracts have been forced to go to the spot market in order to secure adequate supplies. The cause of the current problem dates back to the measures MITI reluctantly took during the first quarter of 1987. These measures were so successful that by the end of 1987 the reduced supply of key DRAMs had the AEA and the DOC demanding that MITI "advise" increased production. Production advisories were raised in December of last year that would allow market demand to determine production rates.

The opening of production to demand forces did not result in immediate supply increases. Despite shifts in existing capacity to the 1Mb part and lower than anticipated overall yields for this part, the net supply of both 256K and 1Mb DRAMs increased only slightly during the first quarter of 1988, as shown in Figure 1. This supply shortfall in the face of steady demand drove prices rapidly upward during this time period, as seen in Figure 2. Current DRAM prices remain at this elevated level and are not expected to come down until the late third quarter, when the combination of increased wafer starts and higher device yields will begin to make a dent in the pent-up demand for 1Mb parts. The 256K DRAM supply is not expected to increase, as most vendors focus on the newer, more profitable 1Mb part. The amount of demand shifted to the 1Mb part relieving pressure on 256K supplies is expected to be balanced by decreases in 256K capacity.

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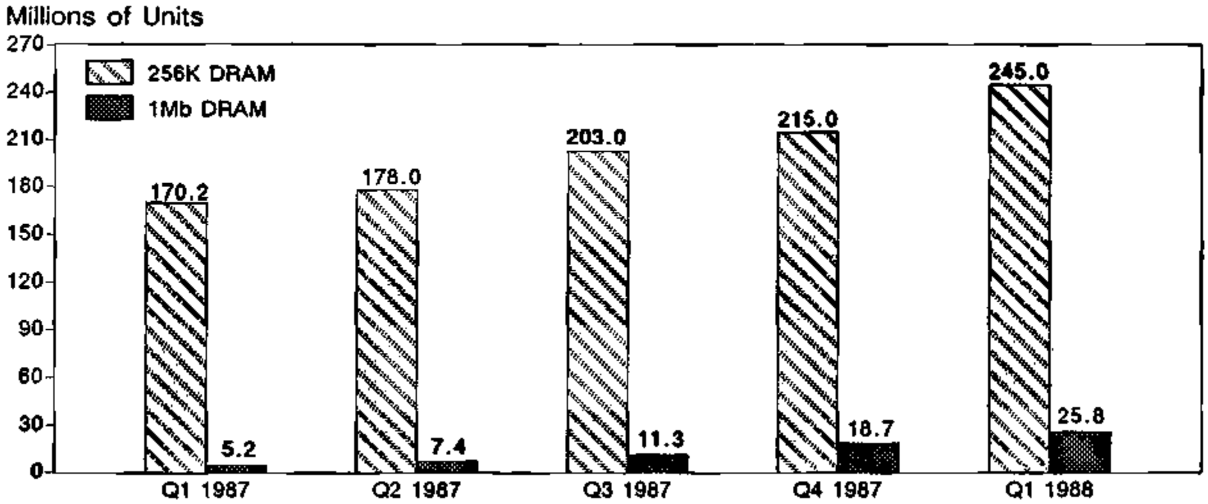
Figure 1

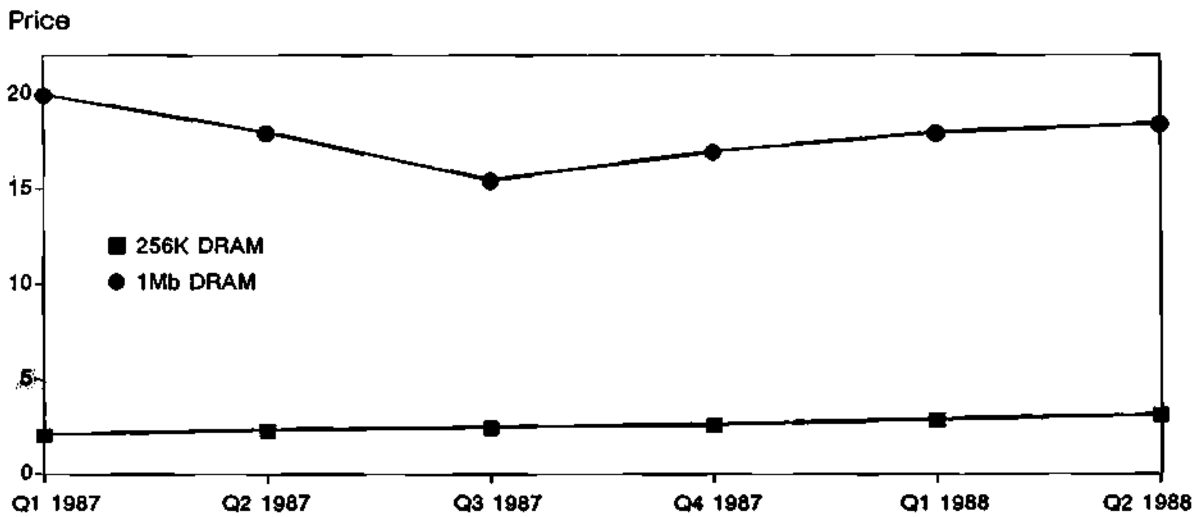
Worldwide DRAM Shipments—256K and 1Mb (Millions of Units)



Source: Dataquest
July 1988

Figure 2

U.S. DRAM Contract Pricing—$256K and 1Mb (Millions of Units)



Source: Dataquest
July 1988

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DRAM SHORTAGE FALLOUT

Semiconductors

Besides the direct shortage of DRAMs crimping end-user supply lines, SRAMs and Video RAMs have also been directly affected. This situation is due to the similar processes utilized by the three devices and the current higher profits derived from DRAM shipments. The result of decreased SRAM and Video RAM supplies have raised prices for these parts, thus raising their respective profits. As supplies of DRAMs increase, thereby reducing their respective prices and profits, manufacturing is expected to migrate back to SRAM and Video RAM production, increasing supplies and tempering prices. This migration is expected to occur during the mid to late 1989 time frame.

Two semiconductor product groups that have been indirectly affected by this situation are the slow-speed (6 to 8 MHz) microprocessors and some standard logic families (i.e., LS, HC, ALS). These parts have had relatively less demand compared with overall semiconductor sales growth. This situation implies that once DRAM supplies improve, these product prices will also begin to firm up as a result of higher demand.

Systems

Although the DRAM crisis has affected all users of these parts, not all users have been equally affected. Generally, large users that have good communications with their vendors have weathered the storm better than smaller users or those that have been opportunistic in their past procurement practices. The current shortage has caused much turmoil for small companies that depend on state-of-the-art, high-speed memory parts for their systems to successfully compete in the marketplace.

Another subtle effect of the DRAM shortage is the shortage of exported surface-mount packages for these parts. Taken in aggregate, the overall lack of SMT devices has forced many system manufacturers to delay new product introductions, retrofit their new board designs, or stay with older board designs. Either way, an otherwise competitive edge is foregone because of a lack of supply. SOJ package capacity increases are expected to alleviate this situation as the volume of 1Mb DRAMs increases, starting later this year.

FUTURE DRAM SUPPLIES

The majority of DRAM supplies in the future will continue to be primarily Japanese owned. However, the actual sourcing/manufacturing of these parts will be spread more evenly on a regional basis in response to demand and the currently strong yen, making Japanese capital investment affordable. This increase in regional supply will help to alleviate regional supply bottlenecks and potential political market share problems. Table 1 shows the current regional 1Mb DRAM merchant market fab location and ownership percentages and their estimated regional percentages in 1990.

Tabel 1

Regional 1Mb DRAM Merchant Market Fabrication Capacity

Region	1988	Percent Japanese Owned	1990	Percent Japanese Owned
U.S.	3%	0	9%	0
Japan	92	93%	67	94%
Europe	3	40%	9	33%
ROW	2	0	15	0
Worldwide Total	100%		100%	

Source: Dataquest
July 1988

Another trend that may have unanticipated side effects is the increased interest by large system manufacturers in adding captive fabrication capacity. For companies with means, the option to internally source key semiconductor components has always been a double-edged decision. In high-demand periods, internal capacity often requires merchant market supplementation at higher than captive transfer cost-based prices, whereas in slow periods, external purchases are reduced and market prices may be lower than captive transfer prices. Over the long term, internal sourcing has provided a technological edge and steady supply of key components for companies that have chosen this option. The requirement of a steady supply of high-quality components from internal sources is being countered with the increasing cost of making state of the art semiconductors (i.e., fab equipment, clean rooms, etc.), now reaching the $100 million range.

DATAQUEST ANALYSIS

The current shortage of key memory components can be seen as a blessing in disguise. To the extent that the prolonged delivery of key components has extended and perhaps mollified the traditional boom/bust electronics cycle, long-term procurement strategies have become more prevalent to the benefit of the electronics industry. The regional DRAM supply-demand imbalance is being addressed by the major suppliers at the demand of users. It remains to be seen if the merchant market suppliers can forge long-term arrangements with their key accounts to provide a stable supply of high-quality next-generation products that will forestall captive semiconductor manufacturing. By stressing the need for regional vendor support, users become less dependent on the regional "sole-sourcing" type of phenomena that often precedes competitive disadvantage.

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Some users share costs for capital equipment that is predominantly utilized by a user's specific parts (i.e., special surface-mount handling machines, high-speed testers, etc.). This, in effect, guarantees capacity for users and lowers capital expenditures for vendors. In this way, users know that they have a viable supply of parts because they helped pay for the capacity, and vendors can enter new areas of business with reduced risk because of lower equipment costs.

The DRAM shortage will correct itself within the next six to nine months. The challenge for users of these strategic components is to plan procurement strategies that ensure adequate future supplies at a reasonable price. Although it is currently a sellers' market, users that have put into place a rational method of forecasting and have gained credibility with vendors will ride out future economic cycles better than competitors that do not.

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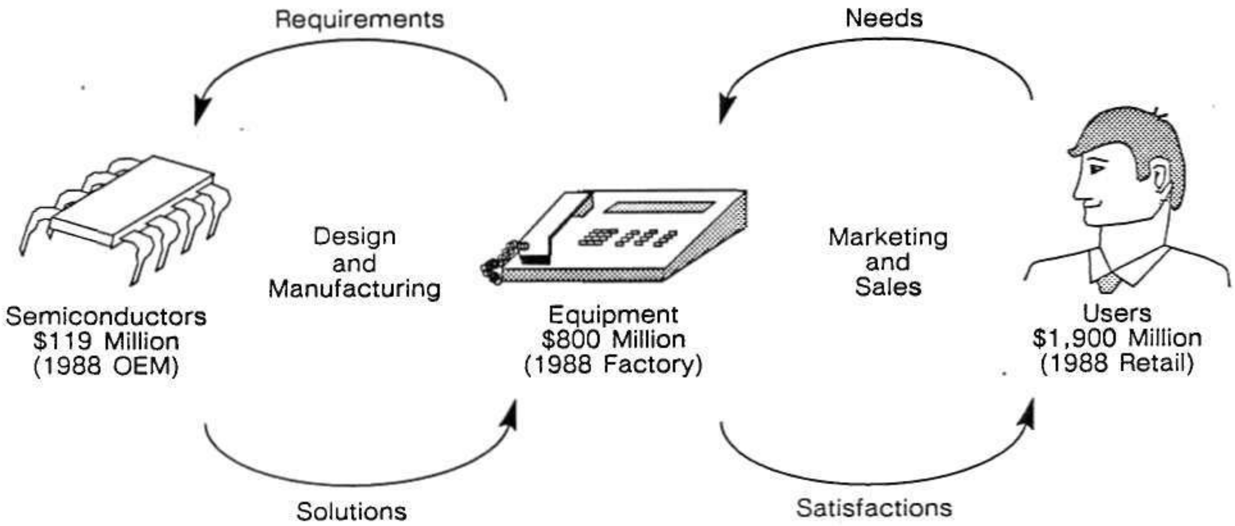
FAX MACHINES: IMPROVED SEMICONDUCTORS LEAD TO INCREASED SALES

SUMMARY

A revolution in personal communications is occurring today because consumer demands and technology capabilities are now impacting each other. Figure 1 illustrates the favorable environment needed to create the type of progress that is currently happening. Equipment designers and semiconductor suppliers are presented with challenging opportunities whenever consumer needs or component technologies change or advance. This newsletter focuses on the specifics for fax machines from the standpoint of these concurrent and interrelated market and product evolutions.

Figure 1

Linking Market and Product Evolution



0002096-1

Source: Dataquest
December 1988

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Dataquest believes that continuing evolutionary advancements in semiconductors will make a revolution in fax machines possible. End-user needs drive equipment designs, and equipment requirements drive semiconductor components. However, advances in semiconductors make better equipment designs possible, and the end users receive more value for the purchase price of the equipment. We conclude that the result will be the widespread acceptance of fax by the business community within the next few years, and that fax then will be as essential to running a business as the telephone is today.

Dataquest estimates that in the United States, fax machine prices will continue to decline at a compound annual percentage rate (CAGR) of negative 10 percent; unit shipments will continue to increase at a CAGR in the 20 to 40 percent range; penetration of the business market, which is approximately 20 percent in 1988, will increase to about 70 percent in 1992; and a home market for fax will emerge in the early 1990s. We also predict that over the next decade, the capability for remote hard copy replication will become a standard feature on the deluxe models of some computer and communications equipment, such as laptop computers, laserbeam printers, cellular telephones, and personal computers.

THE MARKETING SIDE OF FAX MACHINES

Dataquest's estimate of fax machine sales in the United States is presented in Table 1. Between 1983 and 1987, Dataquest estimates that unit sales increased at a CAGR of 41 percent, while the average retail price declined at a CAGR of negative 11 percent. For 1988 through 1992, Dataquest estimates that unit sales will increase at a CAGR of 21 percent, while the average retail price will continue to decline at a similar CAGR of negative 12 percent. Semiconductor content is calculated using an average input/output ratio of 6.2 percent of retail sales.

Table 1

Estimated Sales of Fax Machines in the United States

Year	Unit Shipment (Thousands)	Average Price	Retail Sales (Millions)	Semiconductor Consumption (Millions)
1981	56	$4,747	$ 267	$ 17
1982	64	$4,429	$ 283	$ 18
1983	75	$4,195	$ 316	$ 20
1984	89	$3,827	$ 341	$ 21
1985	157	$3,170	$ 497	$ 31
1986	188	$2,682	$ 504	$ 31
1987	425	$2,352	$ 999	$ 62
1988	864	$2,227	$1,924	$119
1989	1,288	$1,921	$2,474	$153
1990	1,740	$1,627	$2,832	$176
1991	2,092	$1,327	$2,839	$176
1992	2,282	$1,146	$2,615	$162

Source: Dataquest
December 1988

User Base Expansion Is Under Way

Dataquest predicts that as the retail price of fax machines continues to decline, they will begin to be located at the department level in larger companies. (We believe that most fax machines today are located in centralized fax rooms.) We also predict that in the United States, the installed base of fax machines will increase from 1.5 million units in 1988 (or 19 percent of the 7.7 million business establishments) to 5.7 million units in 1992.

As additional evidence of the growing popularity of fax machines, Dataquest notes that there have been recent developments in the channels used to market fax machines to smaller businesses and also in the communications networks used to transmit fax. For example, in 1988, the Tandy Corporation announced that it would sell its $1,299 TandyFax 1000 fax machine through its 7,000 Tandy and Radio Shack retail outlets. Also in 1988, MCI Communications Corporation announced a new service called MCI FAX for the transmission of domestic and international facsimile messages.

THE MANUFACTURING SIDE OF FAX MACHINES

Dataquest's estimate of the semiconductor content of economy and midrange fax machines is presented in Table 2. Virtually all fax machines today are made in Japan and meet the Group III standard of the CCITT, which means they use digital transmission techniques based on modems and require approximately 20 to 30 seconds to transmit a page of information. Fax machines based on the Group IV standard currently being defined will use the ISDN network and will require about 2 to 5 seconds to transmit a page of information.

Fax machines based on the Group I or Group II standards are being retired from the installed base, and Dataquest estimates that they will no longer be in use after 1990. Group I and Group II machines use analog transmission techniques and require 120 to 360 seconds (2 to 6 minutes) to transmit a page of information.

Table 2

Estimated Semiconductor Content of Group III Fax Machines

Semiconductor Components	Economy Machines	Midrange Machines
Integrated Circuits		
Memory		
SRAM	1 (64K)	1 (256K)
EPROM	1 (256K)	1 (512K)
Microcomponents		
Microprocessor	1	1
Microcontroller	0	2
Microperipheral	1 (modem)	2 (modem, watch)
Logic		
Standard Logic	10	20
Gate Array	2	2
Linear	10	10
Discrete	51	57
Optoelectronic		
CCD	1	1
LED Array	1	1
Total Semiconductors	¥15,550 $124	¥18,850 $151
Facsimile Equipment	¥87,000	¥143,300
Factory Cost	$696	$1,146
Retail Price	$1,670	$2,750
Input/Output Ratio (factory)	17.9%	13.2%
(retail)	7.4%	5.5%

Note: ¥125 = $1.00

Source: Dataquest
December 1988

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Component Prices Continue to Decline

The negative 11 percent CAGR reduction in fax machine prices is made possible in part by the reduction in numbers and prices of the components used to make the fax machine. For example, the fax modem component was a complete card in 1983, with an estimated OEM-volume price of approximately $300, and it was supplied only by Rockwell. In 1988, Dataquest estimates that this same circuit function is implemented as either one or two semiconductor components with an OEM-volume price in the $80 to $100 range, and that more than six component manufacturers have entered the market. (The fax modem suppliers include Hitachi, Hycom/Sharp, Matsushita, Oki, Rockwell, Toshiba, and Yamaha. Dataquest believes that SGS-Thomson also will be offering a fax modem component soon.) In 1989, Dataquest estimates that the OEM-volume price of the fax modem component will be reduced to the $40 to $50 range, as these component manufacturers attempt to grow their sales by competing for design-ins and bookings.

Component Functionality Continues to Increase

Another trend in fax machines is the use of components that can be programmed with software to perform a number of different operations. For example, the NeXT Computer system will use a digital signal processor (DSP) component made by Motorola that can be configured with software to be either a fax modem, a high-speed data modem, a speech synthesizer, or a CD-quality sound generator. Dataquest believes that OEM-volume pricing for such a component will be less than $40 in 1989, and if a user needs all of these features in an item of equipment that already has a microprocessor, the equivalent cost of the fax modem would be just a fraction of the cost of the DSP component itself.

There also may be fax component opportunities for suppliers of application-specific integrated circuits (ASICs). Dataquest believes that additional standard logic, linear, and discrete components might be integrated into ASICs to reduce the manufacturing cost and product size. Even though most fax machines sold today anywhere in the world are made in Japan, Dataquest notes that the Japanese manufacturers have been accelerating overseas production since 1986 to compensate for the high yen and the fear of trade barriers, such as tariffs and import restrictions. Local content regulations also have been proposed in some market areas, and if enacted, these rules would encourage the use of components supplied by companies located within the same market areas.

Component Technology Continues to Advance

As users are becoming experienced with fax, new feature-related needs are emerging that will affect the components required inside a machine. Dataquest believes that there are potential markets for fax machines with capabilities for color, store-and-forward, plain paper, error correction, multiple copies, shades-of-gray, and broadcast distribution. These deluxe model features will become more practical and more common as technology advancements continue to reduce their implementation costs to the point where users can afford them.

For example, the reliability and resolution of the scanning operation could be improved by changing from charged-coupled device (CCD) to contact image sensor (CIS) technology. However, Dataquest believes that the cost of the CIS technology will have to be reduced before it becomes a widely accepted substitute for the CCD technology currently used in most machines. Also, the current typical transmission time of 20 seconds per page for Group III machines using the Modified Huffman coding technique could be reduced by 55 percent to about 9 seconds per page using the Modified Modified Read (MMR) coding technique. Memory and microprocessor components are needed to run the software programs used to implement these coding techniques, and Dataquest estimates that the prices on these components will continue to decline in general at CAGRs in the negative 5 to negative 15 percent range over the next four years.

DATAQUEST CONCLUSIONS

The market for fax machines is growing rapidly, the number of suppliers of fax-related components is increasing, and the base of users of fax machines is segmenting. These trends in the fax industry indicate opportunities for entrepreneurs to find new groups of users for new kinds of fax-related equipment.

Fax Machine Sales Expected to Continue

Dataquest estimates that the maximum potential installed base for fax machines at companies in the United States is 7.5 million units. Although there are an estimated 7.7 million business establishments in the United States in 1988, 77 percent of these are the 5.9 million companies that have fewer than 10 employees. While a Fortune 500 company may own several hundred fax machines, some of the smaller companies may decide that the services of a neighborhood fax center are sufficient to meet their needs.

Dataquest also believes that there will be a home market for fax machines and the fax-related equipment that will emerge in the early 1990s. Our estimate for the potential installed base for fax equipment in the home is 7.5 million units. Some of these home users would be telecommuters who work at home several days each month, and a fax machine would supplement the office-compatible personal computer systems they already use at home for their work. Other home users would be people who moonlight in home businesses. Dataquest notes that statistics on moonlighters and home businesses are difficult to obtain, because participants in these activities are often reluctant to reveal their involvement. However, there are approximately 68 million white-collar workers and 91 million households in the United States in 1988, and we believe that the 7.5 million potential installed base of fax machines in the home to be a conservative projection.

Additional Opportunities in Niche Markets

Dataquest believes that the application markets for fax components are beginning to diversify. Today, most fax components are used in standalone fax machines, and Dataquest expects that this application will be the major market for fax components over the next five years. There are, however, other application markets currently in the niche stage that could expand as additional users discover the potential benefits of these fax-related products.

For example, fax cards for personal computers are available on the market now at prices ranging from $400 to $1,200, depending on the features included. Dataquest estimates that the 1987 PC fax card sales of 11,000 units in the United States will increase to 349,000 units in 1992, for a CAGR of 101 percent. Dataquest also believes that fax modem ports will be offered as features on deluxe models of laptop and portable computers, cellular telephones, and laserbeam printers. Coin-operated fax machines also are beginning to appear at some locations frequented by business people (such as airports), and Dataquest believes that this trend will continue as fax becomes an essential part of everyday business.

Long-Term Implications of Present-Day Developments

As communications networks continue to evolve throughout the 1990s, Dataquest expects that more image storage and transmission will take place electronically. Companies directly or indirectly involved in the telecommunications market must become aware of the impact of the present fax phenomenon upon their business. Fax machine manufacturers' purchasing managers for example, will want to have good relationships established with marketing managers at fax component manufacturers to ensure a dependable supply of parts.

Dataquest believes that separate pieces of equipment, such as personal computers, copiers, and fax machines, will begin to merge during the 1990s into an all-electronic communications network. Peripherals such as scanners and printers will be attached to this network as the link to the world of hard copy. The likelihood of this happening sooner rather than later depends on how fast the business community adopts fax as a necessity. That acceptance depends, to a large extent, on technology continuing to find ways to reduce the manufacturing cost of a fax machine today.

(Some of the data in this research newsletter were supplied by Dataquest's Japanese Semiconductor Application Markets service and Telecommunications Industry Service.)

Roger Steciak

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Research *Bulletin*

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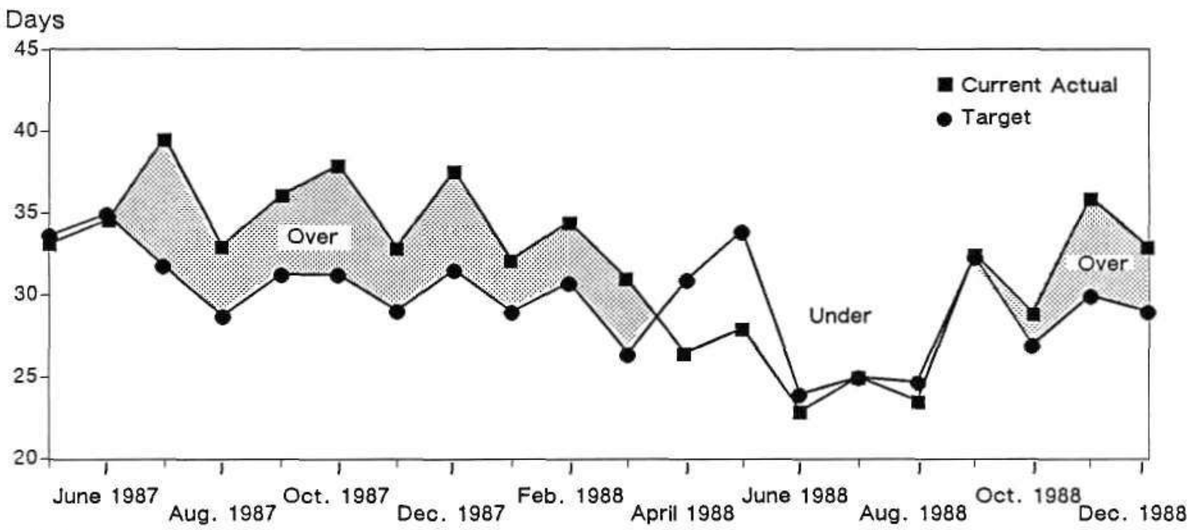
DECEMBER PROCUREMENT SURVEY: INVENTORY CONTROL REFLECTS ORDER RATE STABILITY

This month's survey respondents' actual inventory levels have edged back downward closer to targeted levels. Order rates for semiconductors remain mixed but also are edging downward, reflecting the need to keep actual and targeted inventories in line. System sales continue to fluctuate; the aggregate trend shows short-term high growth with slower growth rates expected next year. Overall, semiconductor billings are expected to be lower, mostly due to holiday downtime. As seen in Figure 1, the overall targeted inventory level has declined by 1.3 days down to 29 days, while the actual level has dropped a substantial 3.3 days down to 32.9 days. Improvements in memory availability and the effects upon other parts are being incorporated into procurement plans, keeping inventory levels in check.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0002166-1

Source: Dataquest
December 1988

Inventory levels for computer OEMs still remain over target but have significantly dropped since last month's survey. This month's difference between targeted and actual levels (4.2 days) is half that of last month, with targeted inventories lowered to 30 days and actual levels down to 34.2 days. The larger adjustment in computer company

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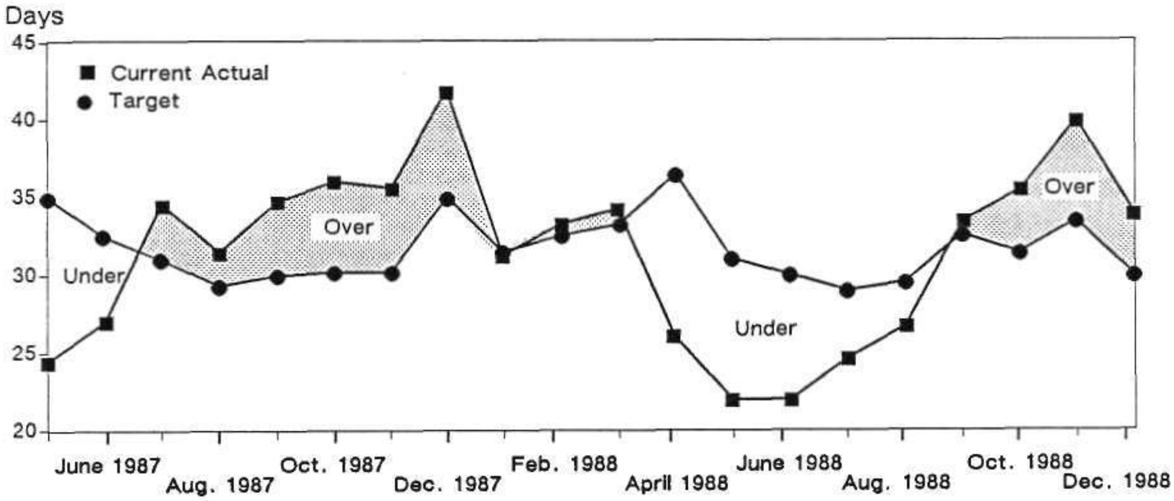
inventories is due to two factors: their relatively higher use of memory that has begun to be more available and the close communications this segment of the industry has exhibited with its semiconductor vendor base.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



0002166-2

Source: Dataquest December 1988

Semiconductor pricing has stabilized compared with last month's softening. SRAM pricing remains firm and, in some configurations, is rising due to the continued lack of supply. DRAM pricing is softening in the 1Mb density, while remaining steady for the 256K parts. Overall lead times have declined by less than a week and still remain at 11 weeks. Surface-mount package availability continues to be a problem for some users, and the perennial problem of memory availability has not yet disappeared. Memory x4 configurations and sub-100ns speed availability are now of prime concern to many DRAM users.

DATAQUEST ANALYSIS

The inventory pendulum has begun to swing back toward targeted levels in response to lowered booking levels and related softening prices and lead times. The anticipated correction in inventory levels is on course. Dataquest expects this trend to continue through the end of this year, and actual levels should be very near or possibly below target by the end of January 1989. As 1Mb DRAMs continue to become increasingly available in the upcoming months, the momentum that is now beginning to decrease inventory levels will ensure that targets are hit or lowered. The current low inventory levels infer the following:

- Users are loathe to replay the 1984–1985 scenario.
- Good forecast communications are now in place that should smooth out some of the cyclicality of this volatile market.

We expect these trends to be the lasting legacy of the 1984–1985 fiasco and remain with the industry through this and upcoming cycles.

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Research Newsletter

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TI: VERTICAL INTEGRATION U.S.-STYLE

SUMMARY

As the furor over chip dumping subsides, the United States is beginning to realize that the vertical integration of Japanese electronics companies is as much responsible for their worldwide success as their forward pricing strategies. Furthermore, there is a growing realization that in an era of application-driven design, vertical integration between systems and components yields benefits as substantial as the fostering of economies-of-scale manufacturing.

With the exception of a few companies, including Texas Instruments (TI), the U.S. semiconductor industry, at least in the merchant arena, is not marked by vertical integration. This newsletter analyzes TI and provides an update on the company's current semiconductor strategies from the standpoint of vertical integration, which Dataquest characterizes as follows:

- Synergy between systems and components
- Forward-looking R&D investments to support the systems and components
- Successful commercialization of technology
- Manufacturing excellence
- International marketing presence

TI FINANCIAL UPDATE

Recovery in 1987

TI experienced a strengthening in its main businesses—semiconductors and defense systems—in 1987. The company also invested in knowledge-based systems, industrial automation, and computer-aided software engineering to increase productivity. TI took a major realignment step by selling its majority interest in Geophysical Service, Inc. (GSI). This consolidation was undertaken to drive TI's total business mix toward a higher

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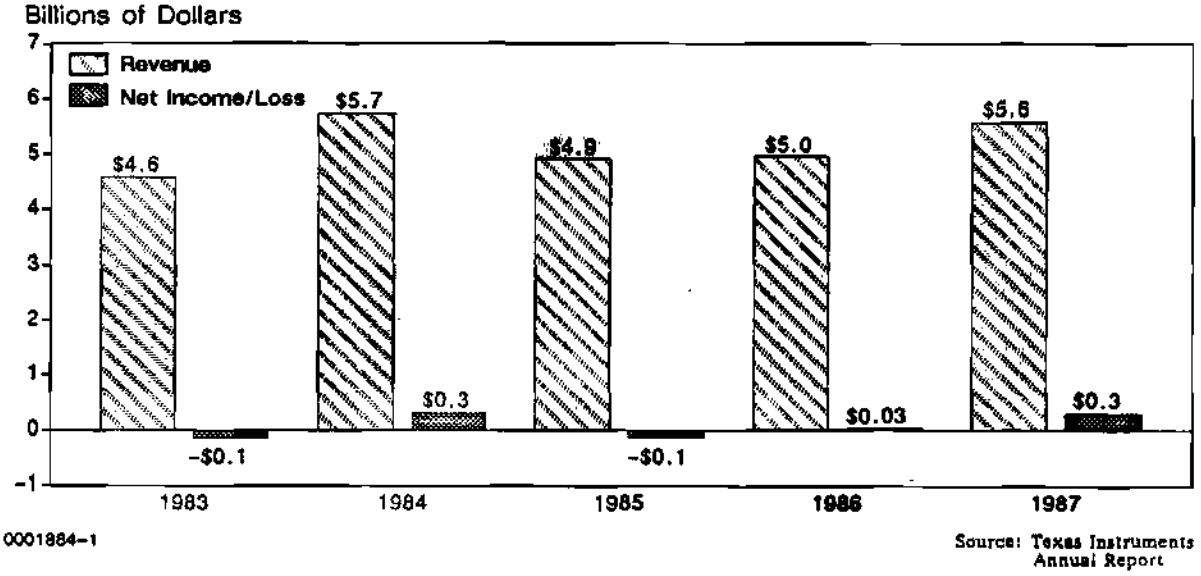
content of proprietary systems and software. Improvement continued in the company's financial performance in 1987, as shown in Figure 1. Revenue totaled $5.6 billion, an increase of 12 percent over 1986. Net income was $309 million, up substantially from $29 million in the prior year. TI continues to defend its investment in intellectual property vigorously, as is apparent from the DRAM litigation, which resulted in adding $191 million of royalty income to the company's net income figure.

Figure 1

TI Revenue/Income
1983–1987



Positive Outlook for 1988

TI's total order backlog reached record levels in the first quarter of 1988, amounting to $5 billion. First quarter 1988 revenue was approximately $1.5 billion, up 15 percent from the corresponding period in 1987, but down from the prior quarter. Reasons contributing to this decline from the fourth quarter were TI's sale of GSI, the timing of defense electronic shipments, and the seasonal decline in consumer electronics. Semiconductor demand continued to strengthen, however. Other income for the first quarter included $52 million of royalty income from the settlement of the DRAM patent litigation, including royalties from another company not listed in that litigation. Royalty income will be less significant in the second quarter.

The company's overall outlook for 1988 is positive. TI has reaped financial benefits from the DRAM shortage situation. Semiconductor bookings are being driven by PCs and electronic workstations (EWs). TI expects worldwide semiconductor growth of 25 percent and U.S. growth of 20 percent in 1988, basically consistent with Dataquest forecasts.

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Capital Spending and R&D Increases

Total company capital expenditure is forecast to increase more than 30 percent in 1988, as shown in Table 1, and will primarily support the company's semiconductor operations and defense business. In the semiconductor area, capital expenditure will be largely for equipment to outfit new front-end operations. Capital expenditure on equipment for 1Mb DRAM capacity has been approved for both TI's Miho, Japan, and Dallas, Texas, fabs. Currently, TI is in volume production of 256K DRAMs at its DMOS IV facility in Dallas and is producing 1Mb DRAMs at its Miho fab. In the latter half of 1988, 256K DRAM production at Dallas is expected to transition over to 1Mb devices. TI's R&D spending in 1988 is expected to grow 5 percent, again reflecting large investments in semiconductor products, particularly systems-level products.

Table 1

Texas Instruments
Estimated Semiconductor Capital and R&D Expenditure
(Millions of Dollars)

Texas Instruments	1983	1984	1985	1986	1987	1988	Change 1987-1988
S/C Revenue	$1,638	$2,484	$1,742	$1,781	$2,127	N/A	
Capital Expenditures	$ 478	$ 722	$ 515	$ 447	$ 459	$600	30.7%
S/C Capital Expenditures	$ 232	$ 472	$ 281	$ 213	$ 231	$360	55.8%
Capital as a % of S/C Revenue	14.2%	19.0%	16.1%	12.0%	10.9%	N/A	
R&D	$ 301	$ 367	$ 402	$ 406	$ 428	$450	5.1%
S/C R&D	$ 163	$ 195	$ 214	$ 256	$ 270	$295	9.3%
R&D as a % of S/C Revenue	10.0%	7.9%	12.3%	14.4%	12.7%	N/A	

N/A = Not Available

Source: Texas Instruments, Inc.
Dataquest
November 1988

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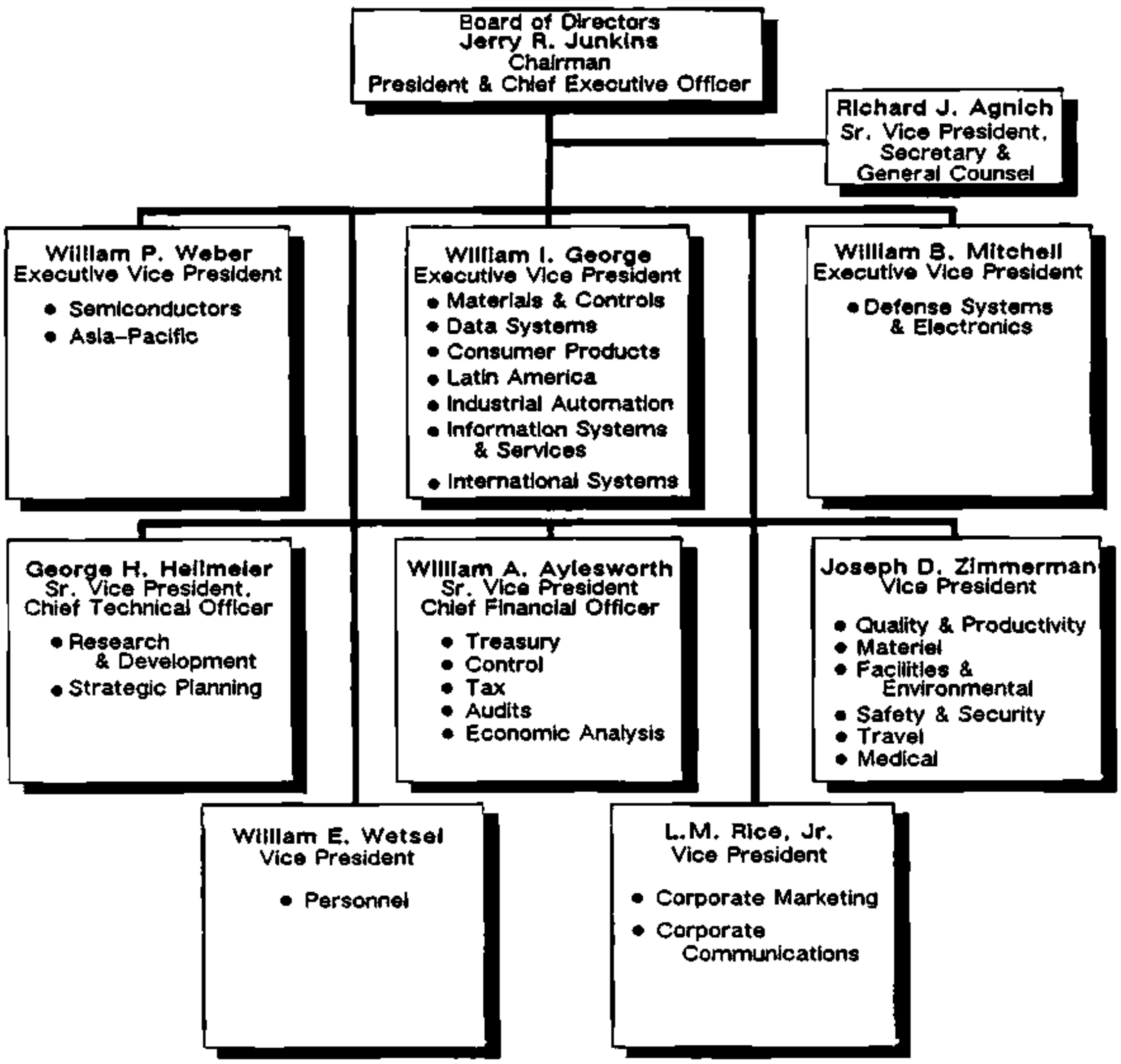
MANAGEMENT

It was announced at TI's Annual Shareholder's meeting that Mark Sheppard Jr. would be stepping down as Chairman of the Board after 40 years at the helm of Texas Instruments. His announced successor, Jerry Junkins, has been operating as the company's president since the departure of Fred Bucy in 1985. This restructuring of management is reflected in the organization chart shown in Figure 2. Prior to the changeover of presidents in 1985, TI had suffered from an industry perception of being overly introspective. This attitude, however, appears to be changing under the new management. Nowhere is this change more evident than in the company's newly developed interest in strategic alliances, which is in sharp contrast to its former custom of going it alone. This greater openness of management philosophy is viewed as a positive development.

Figure 2

Texas Instruments, Inc.
Organization Chart



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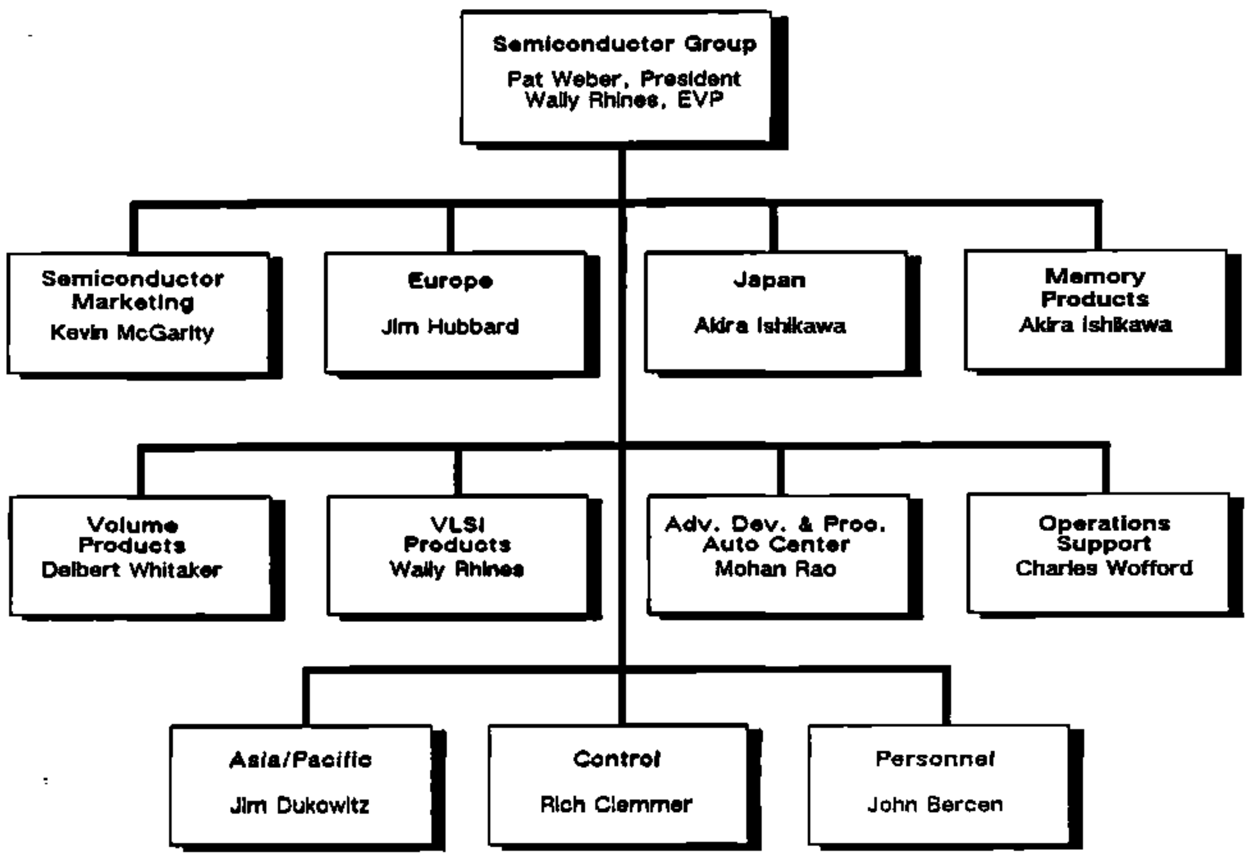
Source: Texas Instruments Inc.

Semiconductor Group Organization

TI changes in management over the past few years were made with a view to honing its structure to better compete in a more global marketplace. Effective January 1987, William "Pat" Weber, formerly in charge of corporate development, became president of the Semiconductor Group, replacing William Sick, Jr. A newly established position of creating alliances and cooperative agreements and raising TI's visibility in the Asia-Pacific region was filled by William Sick until his departure from TI. Mr. Sick handled the formative period of this program during a turbulent time while the search for a home for Sematech was under way and there was ongoing litigation between TI and some Far East companies. Since Mr. Sick's departure from TI, this area of responsibility resides within the office of the president, which is occupied by Pat Weber and Wally Rhines, as shown in Figure 3. In June 1986, the company's memory operations were reorganized under Akira Ishikawa; he is responsible for operations in Japan as well as worldwide memory operations, reporting to Pat Weber.

Figure 3

Texas Instruments, Inc.
Semiconductor Group Organization Chart



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Source: Texas Instruments Inc.

Two key indicators can be used to measure the effectiveness of management: long-term planning and leadership. The challenge that TI management has defined for itself is to compete with well-financed vertically integrated Far East manufacturers in an increasingly global market.

VERTICAL INTEGRATION

Synergy between Systems and Components

TI believes that AI and industrial automation can support much more business and thus strengthen systems capability throughout the company. TI views itself as a pioneer in AI/speech/factory automation/CAD technology. It contends that there is an emergence of the concept of "hypermedia," where text, speech, images, and graphics converge. TI intends to be a leading supplier of productivity solutions through investment in three key areas:

- Knowledge-based systems (AI)
- Industrial automation
- Computer-aided software engineering

TI traditionally has been strong in AI hardware and development tools, and recently has augmented its position through an agreement with Apple Computer that is aimed at delivering AI capability to desktop computers.

By acquiring Rexnord's control and industrial systems division and the company's own product development, TI is becoming a full-range supplier of factory automation systems (Rexnord is a wholly owned subsidiary of Banner Industries, a supplier of aviation replacement parts as well as a diverse line of pumps and other mechanical and electronic parts and systems for the industrial market.) The following two Rexnord product lines were of particular interest to TI:

- The D/3 system is a distributed process control system that offers advanced, integrated batch capabilities aimed at medium-size to large businesses and complements TI's own TRISTAR system, which is aimed at small to medium-size businesses.
- The other product line, the S/3 system, is a supervisory control and data acquisition product for geographically distributed business operations.

TI is pursuing a market opportunity in software development that will reduce development time and cost. The company will be marketing a new product—Information Engineering Facility—that will allow system developers to analyze problems and design software using simple graphical diagrams to generate computer programs.

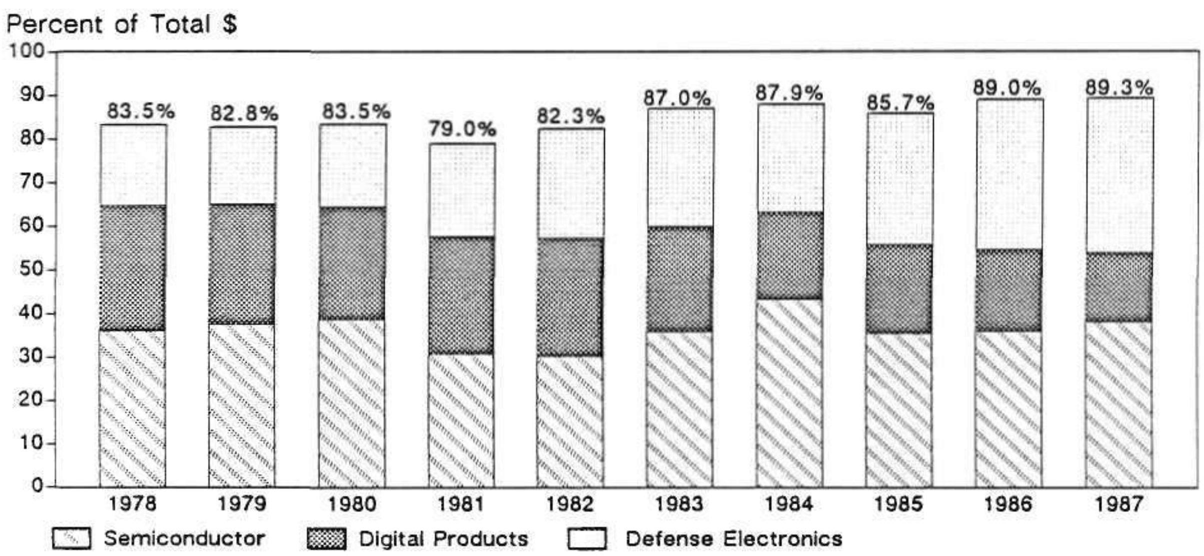
For the merging of silicon and systems to be successful, integration of the two is key. TI has recognized this and has established a business objective that builds on the synergy between its semiconductor and defense electronics business. Figure 4 shows how semiconductor and defense business revenue has been gaining as a percent of TI's total revenue for many years now. R&D expenditure will focus on a higher level of systems capability, primarily in VLSI, defense electronics, artificial intelligence (AI), and industrial automation technology.

TI believes that AI and industrial automation will strengthen systems capability throughout the company. The company's strategies to address this challenge include the following:

- Increasing design automation to shorten time to market and achieve lower costs
- Maintaining manufacturing process leadership through focused R&D investment and aggressive moves into new technologies
- Developing closer customer relationships
- Penetrating the components market in the product areas where TI can provide system-level solutions, as follows:
  - ASICs (application-specific integrated circuits)
  - Application processors
  - Advanced linear devices
  - Military semiconductors
  - VLSI logic

Figure 4

Semiconductors, Digital Products, and Defense Revenue (Percent of Total Business)



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Source: Texas Instruments Annual Report

The System is the Chip

The rapidly evolving pace of technology and accelerating product life cycles are forcing companies to speed up their decision-making process, respond to new markets more quickly, and introduce products much faster. If ASICs—or CSICs (customer-specific ICs) in this case—become the new technology driver, value-added design will move closer to the user and the need for closer customer-vendor relationships will become more critical. In this environment, a company can introduce higher value-added products through the application of better technology. New products and short runs will drive the manufacturer's speed, flexibility, and assembly. Companies will only be considered "global" when they can manufacture, market, and design products anywhere in the world. Although TI has made its money in the standard logic business, a "sunset" product segment, its manufacturing capabilities, customer service emphasis/sales support, and standard product dominance in the logic area put the company in a very strong position in the applications-specific era. It is this focus on applications that reflects TI's forward-looking approach.

Application Processors

TI is the leading supplier of single-chip digital signal processors (DSPs). According to Dataquest estimates, 1987 revenue in this market amounted to $98 million, with TI by far the dominant supplier at approximately 45 percent market share. Originally, DSP devices were conceived to support complex speech and telecommunication applications, but they are finding their way into markets such as active suspension systems for automobiles, which is potentially a very significant market opportunity. A key feature of TI's success in this market was its commitment of the resources to provide an extensive infrastructure to support the needs of its customers.

TI has employed a heavily modular design approach in its recently announced configurable MCU family, the TMS370, so that this high-performance 8-bit MCU is reconfigurable to include such on-chip options as EEPROM and A/D converters. Because of features such as more on-chip functions, speed (the device has a 20-MHz clock), fabrication in 1.6-micron CMOS for low power consumption, and a host of development support tools, this product family has the potential to raise TI's standing in the MCU world, where its TMS1000 was once the industry leader.

In the graphics arena, TI's 34010 32-bit MPU, which focuses on graphics applications, has been well received. TI claims 750 design wins for the product. According to Dataquest estimates, approximately 100,000 units were shipped in 1987.

TI's IC design methodology is to use a standard process and design rules, which are stored electronically in TI's library. Not only can this decrease design cycle time by 75 percent, it also allows customers to access designs. In ASICs, TI's standard cell library offers 1-micron feature sizes in CMOS technology. Its LinASIC library contains 30 analog cells and 300 digital cells in CMOS and allows a combination of analog and digital circuits on one chip.

TECHNOLOGY

TI emphasizes enabling technologies. In this respect its military focus is important in advancing technology, and TI participates in GaAs and the government-funded MIMIC (monolithic millimeter wave/microwave IC) Program and VHSIC (very-high-speed IC) Program. In order to contend with what TI terms the 1-micron barrier, the company moved to a CMOS process technology and opted to employ a trench capacitor approach for production of the 1-Mbit DRAM. TI's 1Mb CMOS DRAM process is called EPIC 1. Because trench capacitors have a large surface area as opposed to the planar approach, TI decided to move to a 3-D approach at the 1Mb level. So far only one other company has taken this approach. The company adopted a phased approach to production of the 4Mb DRAM, so in addition to the trench capacitor, both 4Mb and 16Mb DRAMs will have trench transistors. By using a proprietary self-contained unit photolithographic work cell, TI achieves operation at Class 1 levels with robotic handling of the wafers as well as shortened process time.

The company's bipolar focus is its ExCL bipolar transistor, which offers high performance and self alignment. Another process, EPIC-B, combines TI's ExCL bipolar process with its EPIC CMOS process to create a BICMOS process. This process allows CMOS design library compatibility in order to combine CMOS and bipolar. Because of the importance of BICMOS as an emerging technology, TI is trying to leverage multilevel metal from bipolar into CMOS.

Future Technology Trends

TI's approach to VLSI divides into four main areas: advanced materials and device structures; interface technology; data/knowledge technology; and mass storage. The company participates in the first three elements of this four-prong plan through the following approaches:

- Technology
  - VLSI for scaling
  - Double- and triple-level metal
  - CMOS processes for SRAMs, gate arrays, MPUs, and logic
  - GaAs for niche markets
  - Multimaterial chips for performance
  - Focal plane array technology
- Manufacturing and assembly
  - Excimer laser lithography to operate at 0.6 microns
  - Laser direct-slice write systems
  - Flexible manufacturing and assembly

- 3-D packaging
- Ability to add incremental capacity

- Design
  - Object-oriented design to combine 500K to 1M transistor design in 3 to 6 months

MANUFACTURING: A CORNERSTONE

Although other U.S. manufacturers chose to abandon the DRAM market, TI deemed its participation in this market strategic. As well as being high-performance devices, DRAMs constitute both a technology and manufacturing driver for the company's semiconductor products. From a market standpoint, DRAMs drive volume, price, quality, and reliability. In terms of manufacturing expertise, DRAMs are clearly a primary driver for the following areas:

- Technology
- Manufacturing
- Particle reduction
- Equipment
- Diagnostic tools

The key elements of TI's manufacturing are as follows:

- Leading-edge process technology (see the Technology section of this newsletter)
- High yields and reliability
- Automation and accountability

High Yields and Reliability

TI's reputation ranks it as one of the preeminent manufacturers in the United States. The company offers high-quality, high-volume, and high-yield manufacturing capability. Compared with the other major U.S. suppliers, our data show that TI has the highest revenue per square inch of silicon. Furthermore, in terms of revenue per square inch of silicon, the U.S. semiconductor manufacturers, overall, are ahead of the Japanese. (This may, however, indicate that the Japanese companies use more test wafers to qualify their manufacturing process than U.S. companies.)

When the disquieting news began to emerge in the early 1980s that the quality and reliability of Japanese-manufactured devices exceeded that of their U.S. competitors, the U.S. manufacturers began to focus on Japanese manufacturing procedures as the means by which to learn how to improve their own standards. Because of the importance accorded by Japanese semiconductor manufacturers to manufacturing, TI measures itself against the Japanese. Memory processes, TI's acknowledged manufacturing driver, are generally brought up first at Miho, Japan, and then transferred to Dallas, its U.S. counterpart. According to TI, the yields and costs at the two plants are now comparable.

Automation and Accountability

TI has an innovative approach to equipment assembly. The company's PAC group (Process Automation Control) builds much of TI's equipment needs, such as etchers and E-beams. TI is very interested in automation and its implementation has forced the company to study how a facility actually runs. Automation is a priority investment for TI and requires a management with vision to commit the sizable upfront investment to put such resources in place.

TI's WIP (work in process) tracking system is unique and demonstrates almost unparalleled customer service. This extensive computer system, which was internally developed and operates on TI hardware, is used to track devices through the assembly cycle offshore. The system tracks all device locations through the assembly cycle and provides TI with current status, yield information, and detailed records for product accountability. Even though a process currently may be within specifications, an elementary expert network and statistical quality control system can be used to determine if a process is trending out of specifications.

Customers are even able to place orders directly with the FAM (Flexible Assembly Module) computer system. With vendor consolidation occurring among its customers, TI wished to ensure that it would be chosen as the primary supplier. FAM was developed to guarantee 100 percent on-time delivery. FAM was started in late 1983/early 1984 to develop cost-competitive onshore assembly versus low-labor-cost offshore assembly. Should a yield problem from an offshore assembly location indicate the possibility that an on-time delivery might not be met, the information would be transmitted to the FAM system, which would flag the appropriate wafers from inventory in Sherman, Texas, to enter the assembly cycle. By this means, products can generally be assembled in about a week or two. Communication between the companies' customers and suppliers can be effected electronically, and the WIP can be accessed by customers to get updated information on their orders.

ALLIANCES

Nowhere is TI's change in philosophy more in evidence than in the area of alliances. The company has come to the realization that its "loner" mentality is no longer appropriate. Consequently, it has entered into an increasing number of agreements with other semiconductor suppliers and customers in the past few years.

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The adversarial, contractual relationships of merchant semiconductor companies has tended to promote fragmentation and instability in the industry. Cooperation between buyers and sellers of products all along the chain of supply has become essential and the concept of "virtual vertical integration" has come into vogue. Its advocates urge that product development alliances be extended into joint-manufacturing agreements, long-term purchase contracts, and other relationships that help justify capacity expansions. As an example, TI is helping Hyundai of Korea bring up DRAM manufacturing capability and will use the company as a source of foundry production. The appeal of such a strategy is that it provides a means for U.S. companies to preserve their innovative and competitive nature while working toward greater long-term planning and cooperation.

MARKETING: AN INTERNATIONAL PRESENCE

TI first applied to MITI for permission to establish a wholly owned subsidiary in Japan in January 1964; permission was finally granted in May 1968. TI managed to use to its advantage the fact that the Japanese needed a license from TI for access to Jack Kilby's IC patent in exchange for TI eventually owning a manufacturing facility in Japan. Initially, TI started up in Japan as an equally financed joint venture with Sony. As agreed, after three years Sony withdrew from the arrangement and the corporation became wholly owned by TI. Although it was several years before TI was granted permission to set up a facility in Japan, it was worth the effort and TI claims to be doing well there. Table 2 shows the results of TI and Motorola having invested very early (in the 1960s and early 1970s) in markets outside of the United States. Of the three companies in Table 2, TI has been the most successful because it was the first to establish factories in regional markets. In fact, the company has done so well that more than half of this business is non-United States. For about 10 years, TI was the only U.S. semiconductor company with a manufacturing facility in Japan. Where it has achieved excellent penetration, especially in the memory and standard cell markets. TI has been able to capitalize on its experience in the Japanese market in order to maintain its presence in the memory market. TI moved from being the sixth largest DRAM supplier worldwide in 1986 to being ranked fourth worldwide in 1987, as shown in Figure 5.

Since manufacturing where the market is located is a key feature of TI's strategy, it is not surprising that the company is an international semiconductor manufacturer in terms of fab locations. Outside of the United States, TI's production capability is in the United Kingdom, West Germany, and Japan—a total of seven fabs. TI has just received approval from the Korean government for a wholly owned operation in that country. Motorola, TI's largest U.S. competitor, also has seven overseas fabs. NEC operates just two non-Japan-based manufacturing facilities—one in Scotland and one in the United States.

Table 2

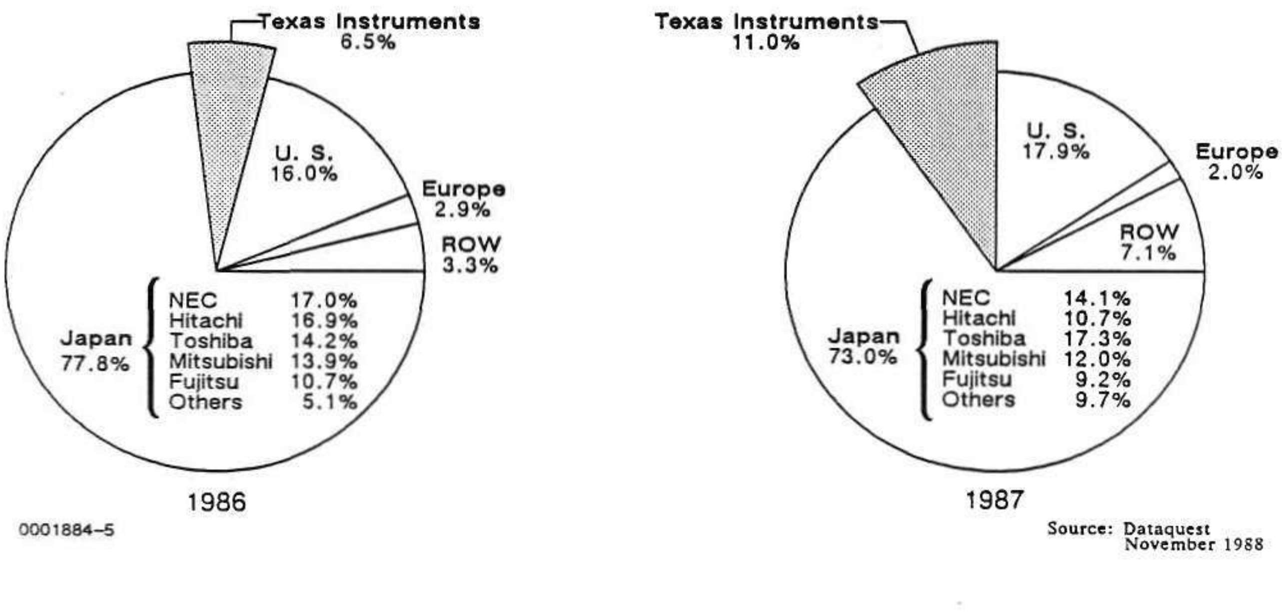
Total Semiconductor Business
Estimated 1987 Regional Share

	NEC		Motorola		Texas Instruments	
	Revenue	Regional Share	Revenue	Regional Share	Revenue	Regional Share
United States	$ 335	10.1%	$1,542	62.9%	$1,036	48.7%
Japan	2,449	73.7	170	6.9	403	18.9%
Europe	255	7.7	478	19.5	492	23.1%
ROW	286	8.6	260	10.6	196	9.2%
Total	$3,325	100.0%	$2,450	100.0%	$2,127	100.0%

Source: Texas Instruments, Inc.
Dataquest
November 1988

Figure 5

Top Six Worldwide DRAM Suppliers
1986 and 1987
(Dollarized Unit Shares)



Source: Dataquest
November 1988

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DATAQUEST ANALYSIS

The semiconductor industry is undergoing massive restructuring. The nature of global competition is changing, not just for U.S. semiconductor suppliers, but also for the Japanese suppliers and the "Four Tigers" (South Korea, Taiwan, Hong Kong, and Singapore). Being a world-class electronics company that can think, communicate, and act globally, implies more than just an operational perspective. It requires a long-range outlook and in-depth knowledge of customers and markets.

Our research leads us to conclude that TI differs from its major Far Eastern competitors. Two main points of contrast are that TI is driven by its components business rather than by its systems business, and it has been more selective about the type of business it targets. The company's thrust is to be a leading supplier of semiconductors and a leading supplier to the military market. For many of its Far Eastern competitors, semiconductor components are a much less prominent piece of their overall business. By contrast, TI's semiconductor operations are based not on its internal requirements, which it nonetheless supports, but on its fundamental objective to become the leading component supplier to the U.S. market, as well as a major global player. So, although TI is not vertically integrated in the same fashion or to the same degree as many of these competitors, it represents a good example of vertical integration U.S.-style, and its semiconductor business represents a firm foundation on which to build or support other business activities.

TI is committed to making investments of strategic importance from a corporate view, thus enhancing its ability to maximize the synergy generated by the many constituents of its business. TI's choice of investment contends that, contrary to popular belief, we are now in the information age. We are, in fact, data rich but information poor. Dataquest believes that TI exhibits the strengths necessary to compete with other vertically integrated competitors worldwide, and that in response to the changing nature of global competition, the company has planned well and invested wisely for the shape of things to come.

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Mark Giudici
Patricia A. Galligan

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AT&T: SEMICONDUCTORS, SYSTEMS, AND SERVICES (PART 2)

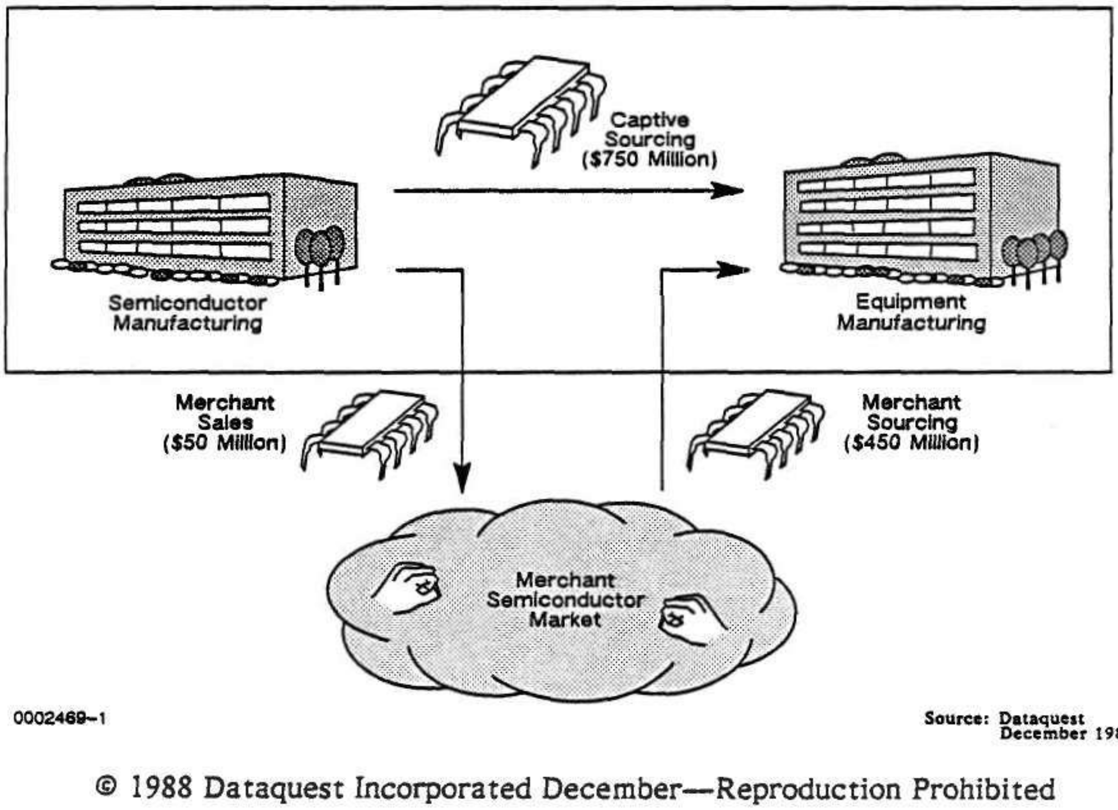
INTRODUCTION

AT&T is a vertically integrated company in transition from a regulated utility to a market–driven supplier of goods and services. This newsletter focuses on AT&T's $1,200 million consumption and $800 million production of semiconductors as it relates to its transition strategy.

AT&T is a manufacturer, seller, and purchaser of semiconductors as shown in Figure 1. We believe that the company will continue to expose its captive semiconductor operations to greater merchant competition as part of its overall strategy to survive in nonregulated businesses. In this newsletter, Dataquest examines AT&T's use of semiconductors along with the role of AT&T's captive semiconductor operation.

Figure 1

Semiconductor Consumption and Production at AT&T



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Source: Dataquest
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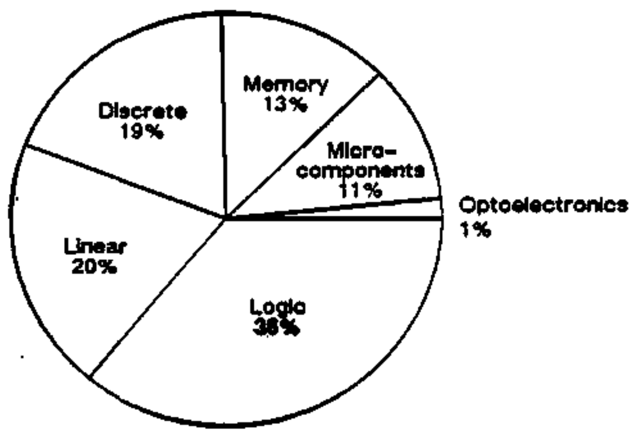
SEMICONDUCTOR USE

Dataquest's estimate of AT&T's 1987 semiconductor consumption by device type is presented in Figure 2. Communications-specific semiconductors such as codecs and combos are classified as linear devices. Logic devices include both application-specific integrated circuits (ASICs) and standard logic. AT&T has developed advanced ASIC CAD tools and uses its extensive knowledge of both networks and equipment to design customized devices for its communications products.

Figure 2

AT&T's Estimated 1987 Semiconductor Consumption by Device Type



Semiconductor Consumption = $1,224 Million

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Source: Dataquest December 1988

Dataquest's estimate of AT&T's 1987 semiconductor consumption by end equipment (with our estimate of AT&T's U.S. market share for this equipment) is presented in Table 1. The company has its strongest presence in the public network equipment market. In the customer premises equipment market, Dataquest estimates that AT&T's consumption of semiconductors for use in telephone equipment and facsimile machines, for example, is very small because AT&T purchases most of its consumer telephones and facsimile machines from manufacturers in the Far East.

Dataquest's estimates of AT&T's semiconductor consumption and production by captive versus merchant sources are presented in Table 2. The percentage of semiconductors supplied to the company by its own component operations began to decline when AT&T dropped out of the DRAM manufacturing business. This trend reflects the company's process of adapting to a nonregulated business environment by dealing more with the outside merchant market. (AT&T's estimated captive versus merchant semiconductor sales will be discussed later in this newsletter.)

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Table 1

AT&T's Estimated 1987 Semiconductor Consumption by End Equipment (Millions of Dollars)

Equipment Type	Equipment Revenue	U.S. Market Share	Semiconductor Content
Public Network	$3,759	50%	$688
Central Office Switches	1,395	49%	251
Trunk Carrier	494	45%	74
Multiplexers	350	37%	53
Subscriber Carrier	312	57%	47
Microwave Radios	104	22%	16
Satellite Earth Stations	15	5%	2
Others	1,089	N/A	245
Customer Premises	$2,580	25%	$450
Private Branch Exchanges	705	21%	120
Key Telephone Systems	637	28%	96
Telephones	320	15%	5
Modems	210	22%	32
Local Area Networks	45	2%	7
Data Service Units	30	48%	5
Facsimile Machines	27	3%	0
Automatic Call Distributors	16	13%	2
Voice Messaging Systems	15	5%	2
Modem-Based Network Control	13	20%	2
Integrated Voice/Data Workstations	5	8%	1
Video Teleconferencing	2	2%	0
Others	555	N/A	178
Data Processing	$ 575	3%	$ 63
Personal Computers	460	3%	46
Minicomputers	115	2%	17
Military	$ 560	N/A	$ 23

N/A = Not Applicable

Table 2

AT&T's Estimated Semiconductor Consumption and Production by Captive and Merchant Operations

Semiconductors	1985 $M	1985 %	1986 $M	1986 %	1987 $M	1987 %	CAGR 1985-1987
Total Consumption	$1,405		$1,188		$1,224		(7%)
Captive Source	1,095	78%	968	81%	757	62%	(17%)
Merchant Source	310	22%	220	19%	467	38%	23%
Total Production	$1,100		$ 983		$ 802		(15%)
Captive Use	1,095	99%	968	98%	757	94%	(17%)
Merchant Sales	5	1%	15	2%	45	6%	200%

Source: Dataquest
December 1988

All merchant-sourced semiconductors needed for manufacturing are purchased through AT&T's Integrated Circuit Procurement Center (ICPC) in Allentown, Pennsylvania. This centralized purchasing facility acts as a liaison between the company's several factory locations in the United States and the several semiconductor suppliers serving AT&T. The company and its suppliers enter into a partnership arrangement. The AT&T selection committee is composed of the following four members:

- Integrated Circuits Procurement Center
- Engineering for Purchased Integrated Circuits (EPIC)
- AT&T Bell Labs IC Reliability and Qualification Group
- Quality Management Services Organization (Springfield, New Jersey)

Selection criteria used by AT&T for establishing partnerships with a supplier include the candidate's pricing, product quality and reliability, manufacturing capacity, responsiveness on requests for quotations, and commitment of the management and staff to serving AT&T. Major trends at AT&T include the shift to surface-mount packaging, the growing use of ASICs, a narrowing of its supplier base, and the goal of implementing a just-in-time manufacturing system.

AT&T is also a major proponent of Integrated Services Digital Network (ISDN) and will be needing components for its ISDN equipment. The company's components group is planning to manufacture ISDN semiconductors both for AT&T's own internal use and for other customers. For this reason, Dataquest believes that a merchant supplier of ISDN semiconductors will face stiff competiton when trying to obtain design-ins at AT&T.

COMPONENT OPERATIONS

Dataquest's estimate of AT&T's 1987 semiconductor production by device type is presented in Figure 3. AT&T's estimated $802 million semiconductor output makes the company one of the 15 largest semiconductor manufacturers in the world. AT&T has focused its design efforts on ASICs, DSP, linear, communications, and high-voltage semiconductors. In the early 1980s, AT&T was one of the first semiconductor manufacturers to introduce a 256K DRAM product to the merchant market; it also introduced the 1Mb DRAM in the mid-1980s. In 1986, AT&T dropped its DRAM product line when these items could be purchased from the merchant market at a lower cost than they could be manufactured internally. AT&T is still a leader in SRAM technology and will supply its 64K specifications and tooling data to Sematech. All of AT&T's SRAM production, however, is consumed by its own equipment manufacturing.

Dataquest's estimate of AT&T's semiconductor production by captive versus merchant sales was presented in Table 2. Virtually all of the company's semiconductor production was consumed internally in 1987. Merchant sales have been growing at a CAGR of 200 percent, however, and AT&T has a goal by 1993 of deriving 50 percent of its semiconductor revenue from the merchant market. (Dataquest predicts that the company's 1988 merchant semiconductor sales will be in the $100 million range.)

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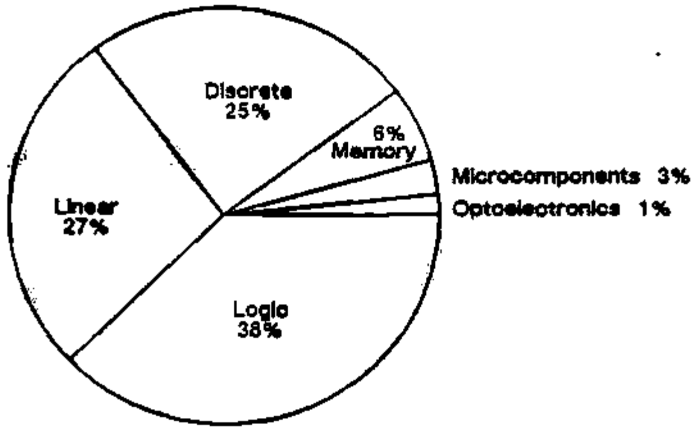
Figure 3

AT&T's Estimated 1987 Semiconductor Production by Device Type



Semiconductor Production = $802 Million

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Source: Dataquest December 1988

Western Digital and AT&T have entered into a strategic alliance that includes extensive technology transfer; design support; and fab, assembly, and test of semiconductors. We estimate that Western will purchase approximately $55 million of custom CMOS ICs from AT&T in 1988 using AT&T's standard cell technology, and we believe that this business will expand to the $80 million range in 1989. We also believe that AT&T has a goal of establishing partnership arrangements with a total of 25 to 50 OEM companies as the preferred way of doing business in the merchant market.

AT&T recently reorganized its $2 billion component operation into five decentralized strategic business units. These units include MOS, lightwave, high performance (e.g., linear and digital bipolar, high voltage, and GaAs), power (e.g., transformers, power supplies, batteries, and magnetics), and interconnects. Dataquest believes that this organization change signals AT&T's commitment to being successful in the merchant market because the organization structure parallels the decentralized P&L approach already used by many component suppliers in this market.

Dataquest's estimate of AT&T's semiconductor fabrication capabilities is presented in Table 3. The company's broad mix of technologies and capabilities includes analog and digital, bipolar and MOS, commercial and military, and silicon and gallium arsenide. Both integrated circuits and photonics (i.e., fiber optics) are the semiconductor-related strategic research areas at AT&T Bell Labs. (Superconductivity is also a strategic research area at AT&T Bell Labs. However, just how superconductivity technology might apply to semiconductor components is not yet clear. As it did with the transfer-resistor—now shortened to the word "transistor"—in the 1940s, the company has a tradition of funding basic research with the hope that it might have a practical use.) Dataquest believes that AT&T will be installing submicron digital CMOS fab equipment in its factories before the end of 1988. Besides its own internally developed component technology, the company is willing to obtain technology from the outside as it is now doing with Sun Microsystems on the SPARC 32-bit microprocessor.

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Table 3

AT&T's Semiconductor Fabrication Capabilities

Process	Location	Wafer Size	Capacity (Starts/Month)	Products
MOS	Allentown, PA	5-in.	16,000	Microperipherals, ASIC, DSP, communications (Mil. Std.)
	Allentown, PA	4-in.	10,000	ASICs, logic, communications,
	Orlando, FL	5-in.	28,000	SRAMs, cell-based ICs, microperipherals
	Spain	6-in.	Start-up	ASICs
Bipolar	Allentown, PA	4-in.	10,000	Logic
	Kansas City, MO	4-in.	10,000	Diodes, small-signal transistor
	Reading, PA	4-in.	2,000	Interface, telecom
	Reading, PA	5-in.	2,000	Op amps, converters
GaAs	Reading, PA	3-in.	1,000	Logic, memory, linear (Mil. Std.)

Source: Dataquest
December 1988

DATAQUEST CONCLUSIONS

Dataquest believes that, as part of its strategy to survive in nonregulated business areas, AT&T is encouraging its equipment manufacturing groups to obtain their components from the best available source. By doing so, AT&T will make its equipment more competitive in the marketplace. Its competitors, for example, will always strive for lower costs, higher performance, more features, and better quality as a way to differentiate their products from AT&T's products and from those of one another. Because these equipment-level characteristics are strongly influenced by the components used, we believe that AT&T's policy is a good one.

For the merchant manufacturers supplying (or wanting to supply) semiconductors to AT&T, this policy represents a business opportunity. Although the captive semiconductor operation may have been in a better position to supply components to AT&T's equipment factories prior to 1984, we believe that all semiconductor suppliers—both captive and merchant—now will be judged on their competitive merits when doing business with AT&T.

For the captive semiconductor operation at AT&T, however, this policy represents a business challenge. No longer is there a guaranteed market inside the company for its semiconductors. In addition, AT&T has begun to offer its semiconductor products to the merchant market. Hence, the company's semiconductor group now feels competition from both inside and outside AT&T.

Dataquest believes that AT&T must still learn how to compete in a nonregulated market. Just a few years ago, for example, the company was a leading supplier of 256K and 1Mb DRAMs to the merchant market. It had made an investment in the technology and had earned its leadership position. Yet AT&T quickly surrendered the market to the merchant suppliers just as soon as they could deliver higher volumes at lower cost. The company has demonstrated that it knows how to make breakthrough discoveries. We believe that AT&T must now learn how to do "street fighting" in a competitive market.

Dataquest has observed several recent developments at AT&T suggesting that the company is headed in the right direction, and we believe that it will expedite the formation of a culture driven by customer needs within AT&T. The company also has shown a willingness to make modifications and adjustments to a previously made decision when necessary. Dataquest sees AT&T's willingness to learn and to make midcourse corrections when necessary as major strengths.

Although AT&T has not yet made any major inroads into the merchant semiconductor market, we believe that the company will do so within the next five years. The company's ASIC design tools are state of the art, and its strategy of forming partnerships with several major OEMs will reduce some of the risk it sees in the semiconductor market. In the short term, these partnering arrangements may provide the company with enough of a breathing spell to get its objectives, strategies, and tactics in alignment. The merchant semiconductor market is not a static one, however. AT&T will likely find the merchant market of five years from now to be much different from the market of today because its merchant competitors also will be adapting their objectives, strategies, and tactics to the changing marketplace over the next five years.

Although most merchant semiconductor manufacturers do not consider AT&T a serious threat today, they might want to watch AT&T closely over the next five years to avoid being lulled into a false sense of security. With AT&T Bell Labs continuing to provide leading-edge technologies and the willingness of AT&T management to learn step by step how to succeed in a nonregulated rough-and-tumble marketplace, Dataquest believes that AT&T will emerge in the 1990s as a formidable semiconductor competitor.

Roger Steciak

Dataquest
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Research Newsletter

SUIS Code: 1988–1989 Newsletters: October–December
1988–44
0001948

SEMICONDUCTOR PRICE SURVEY: COMMODITY PRICES EASE WHILE KEY MEMORIES REMAIN FIRM

SUMMARY

Prices of commodity semiconductors (standard logic, mature microprocessor, and nonvolatile memories) began to decline as capacity increases of the past year finally caught up with demand levels. Supplies of 1Mb DRAMs continue to increase, and we are beginning to see slow decreases in prices as pent-up demand begins to be met. Other key memory products (256K DRAMs and slow SRAMs) remain in short supply and will continue to have firm, if not rising prices through the first quarter of next year. This newsletter will cover highlights of Dataquest's latest price survey and forecast.

STANDARD LOGIC TRENDS

The supply–demand balance that was in evidence in our last survey has now become one of imbalance as production levels have outpaced overall demand. The traditional summer bookings slowdown experienced this year did not result in a corresponding correction in capacity. Standard logic prices (especially in the more mature families) have declined since summer and are expected to continue declining through the first quarter of next year, even though demand will remain steady due to the increased availability of the DRAM product (see Figure 1). Lead times have been cut in half and are now four to six weeks.

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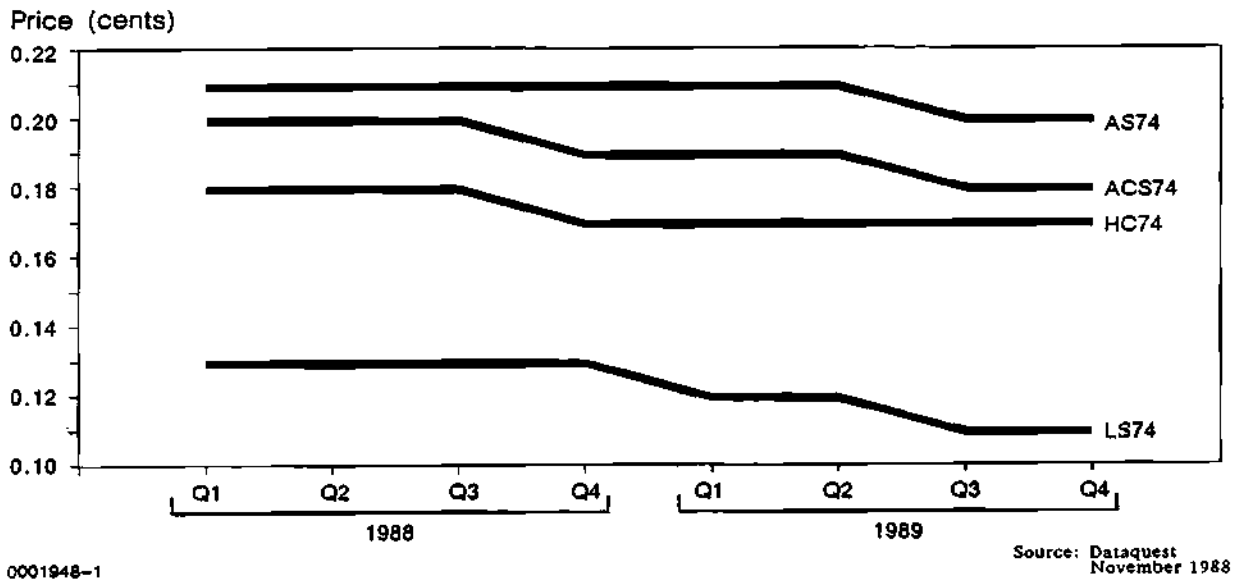
Figure 1

Standard Logic Price Trends



MICROPROCESSOR TRENDS

Microprocessor price trends show a softening in the slower 8- and 16-bit devices as the personal computer markets begin to show signs of a leveling of growth. The demand for high-end, 32-bit devices is becoming moderate, but prices remain firm and in line with the projected 5-percent-per-quarter price declines. The acceptance of the Intel 80386SX, Motorola 68020, and 80286-16 have caused some price erosion in the 10- and 12-MHz 80286 market, as these new products vie for market share. Lead times now range from 6 to 8 weeks.

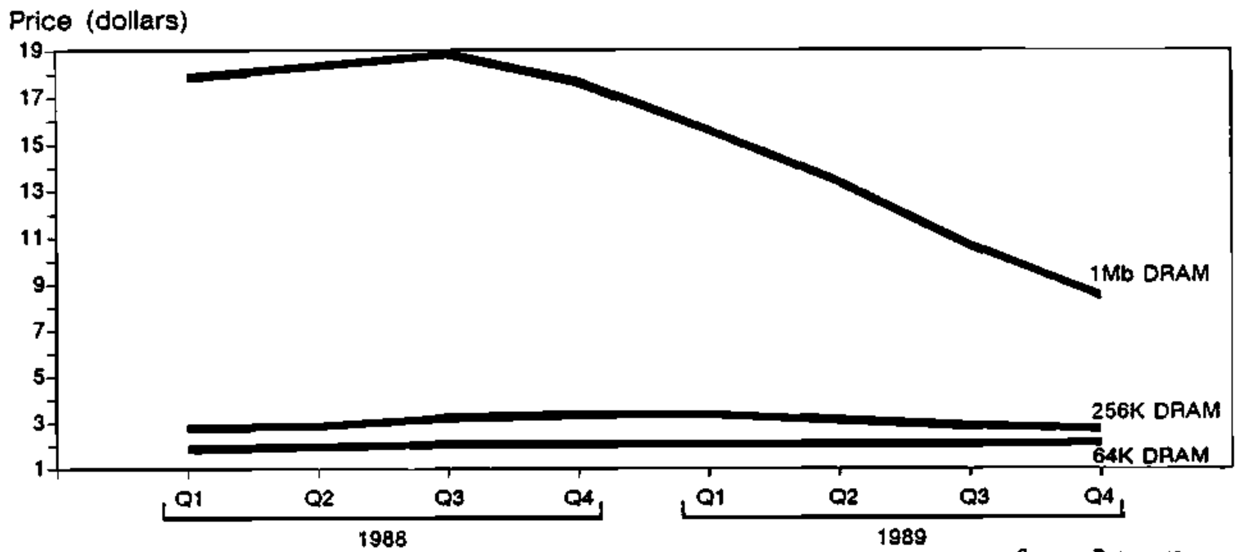
MEMORY TRENDS

Memory price trends fall into the following two camps: nonvolatile (EPROM, EEPROM, PROM et al.) and volatile (DRAM and SRAM). Nonvolatile memory prices have remained consistent, as a balance between supply and demand for these prices continues. Lead times for EPROMs and EEPROMs vary from between six and eight weeks and are expected to remain there.

The volatile memory market remains constrained because DRAMs have shown no easing in price for the 256K density (see Figure 2). The only decline seen has been in the 1Mb area; prices are beginning their long-anticipated decline due to production ramp-ups. We expect the 1Mb DRAM price erosion to continue and begin to accelerate in the second quarter of 1989, once supply catches up with pent-up demand. Prices for the 256K devices are expected to plateau by the end of the first quarter of next year and then will gradually ease as the overall electronics market demand softens. SRAM pricing is expected to follow the DRAM price trend by about three to six months. Slow, low-density (16K and 64K) SRAM vendors continue to make rumblings of an exodus from this market even though prices continue to climb. Until Korean and second-tier Japanese SRAM suppliers begin to fill this supply vacuum, prices will continue to rise. Lead times for the volatile memories range from 16 to 26 weeks (allocation).

Figure 2

DRAM Price Trends



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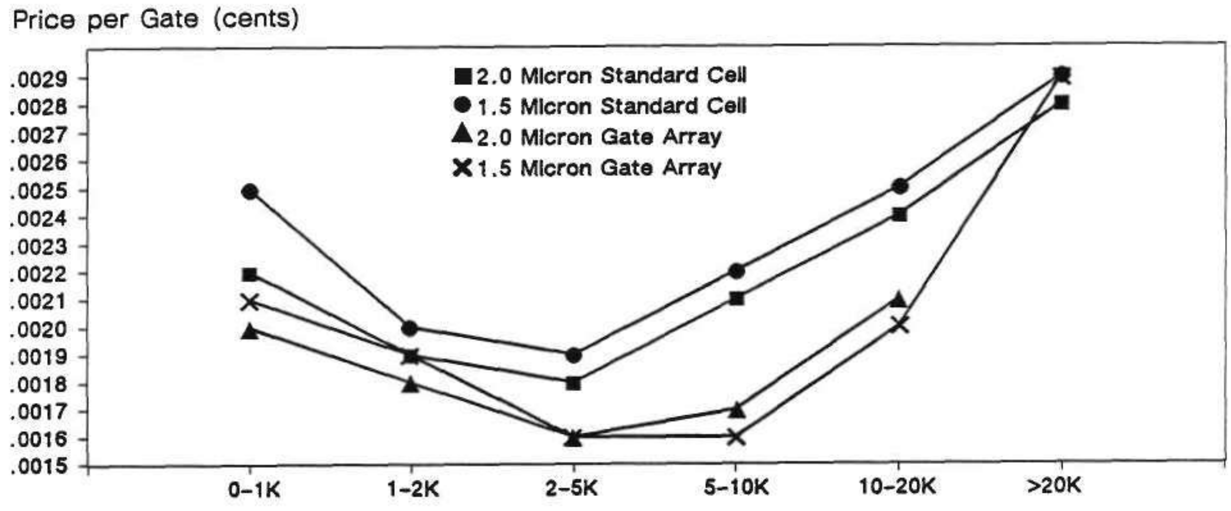
Source: Dataquest November 1988

ASIC TRENDS

Prices for both gate arrays and standard cells, as seen in Figure 3, have remained relatively unchanged since our last review. The differential between gate prices in the 1.5- and 2-micron range have narrowed, with the 1.5-micron technology now being at parity with the middensity (2K to 10K gates) range. Standard cell pricing still has the 2-micron process edging the 1.5-micron cells, while nonrecurring engineering (NRE) charges are almost the same. ECL gate array prices continue to exhibit high and low ranges reflecting the high- and ultrahigh-performance technologies now in the market. The more expensive small-geometry parts continue to take a 50-plus percent price premium over current price trends. We expect to see continued price competition in both gate array price per gate and NRE, as geometries are reduced and more Japanese vendors enter the market.

Figure 3

1988 ASIC Price Trends



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Source: Dataquest
November 1988

DATAQUEST RECOMMENDATIONS

The increase in 1Mb DRAM supplies now beginning to be seen in the market will have a direct impact on prices for these and similar process memories. Pricing for the other IC families will also be tempered, as pent-up system demand eases. Contracts involving 1Mb DRAMs should, where possible, include clauses allowing for quarterly price reviews (+ and -). Prices for 256K DRAMs should be locked in at current levels for at least six months until the 1Mb supply balance and the electronics market slowdown begin to siphon off demand. System and component forecast accuracy, which is always important, is especially crucial during changes in the business cycle and when supply dynamics are in flux. In order for semiconductor users to retain the gains made through closer vendor communications, accurate forecasts are more important now than ever.

Mark Giudici

Dataquest
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Research *Newsletter*

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DATAQUEST LOOKS INSIDE IBM'S MODEL 30–286

SUMMARY

On September 13, 1988, IBM introduced a new addition to its PS/2 family—the Model 30–286. After analyzing the Model 30–286, Dataquest has made the following observations:

- The Model 30–286 will allow IBM to regain some of the market share lost to AT–compatible manufacturers in the business market.
- The Model 30–286 will extend the life of the PC AT architecture and delay the acceptance of microchannel.
- A Model 25–286 will be introduced in the near future.
- IBM's use of a PC chip set in the Model 30–286 will accelerate the use of PC chip sets by other PC manufacturers.

This newsletter discusses the positioning and the IC content of the Model 30–286 in further detail.

PS/2 MODEL 30–286

Product Specifications and Positioning

Has IBM reincarnated the original IBM PC AT? The Model 30 is not the original AT reincarnated but an enhanced version. Table 1 compares the specifications of the Model 30–286 and the IBM PC AT. The most notable changes are the 3.5–inch floppy disk drive, the inclusion of graphics capabilities on the motherboard, a 10–MHz processor instead of an 8–MHz processor, three expansion slots instead of seven, and a price of $2,595 instead of $4,595.

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Table 1

IBM PS/2 Model 30-286 versus the Original IBM PC AT (Feature Comparison)

Feature	Model 30-286	IBM PC AT (Model 339)
Processor	80286 (10 MHz)	80286 (8 MHz)
Bus Architecture	16-bit AT	16-bit AT
Memory	512KB	640KB
Graphics	VGA	N/A
Floppy Disk Drive	3.5-inch	5.25-inch
Hard Disk Drive	20MB	30MB
Expansion Slots	3	7
Price	$2,595	$4,595

N/A = Not Applicable

Source: Dataquest
November 1988

The question often asked is: Does the introduction of an 80286-based AT-architecture PC by IBM mean that IBM is moving away from the new microchannel bus? IBM's introduction of an AT certainly does not mean that the company will not continue to support the microchannel architecture in the future. However, the introduction of a new AT bus machine does create some confusion in the marketplace and probably will push the acceptance of microchannel-based machines even further into the future.

The 30-286 fills a hole in IBM's product line that the 8086-based Model 30 did not fill well—the low-end mainstream business PC user segment. Because IBM's 8086-based Model 30 is not competitive on a price/performance basis with the clone products, this market is being satisfied by the AT clone manufacturers. The new Model 30 is similar to current AT compatibles in that it has the AT bus, an Intel 80286 microprocessor, a 20MB hard disk drive, and VGA graphics capabilities. The new Model 30 differs from the standard AT compatible today in that it has only 512KB of main memory versus 640KB (expandable to 4MB), and a 3.5-inch floppy disk drive versus a 5.25-inch floppy disk drive. These differences should not hinder the acceptance of the Model 30-286 in the current marketplace. When the memory shortage has passed, IBM may increase the base memory configuration, and many vendors are offering customers the option of a 3.5-inch floppy disk drive.

The model 30-286 is much more price-competitive than the original Model 30. It costs just $300 more than the original Model 30 and has higher-resolution graphics and a higher-performance processor (80286 versus 8086). Dataquest believes that this price/performance improvement will allow IBM to gain back some of the market share lost to the AT clone manufacturers.

IC Content Analysis

The motherboard of the Model 30-286 is all surface-mount technology and highly integrated. The surprise was to see IBM using VLSI Technologies' PC chip set instead of the IBM proprietary gate array design that was used in earlier PS/2 family models. A number of reasons may have prompted IBM to move from a proprietary solution to the off-the-shelf VLSI Technologies chip set:

- VLSI's solution may be less expensive.
- The design time using the VLSI chip set may be faster than a proprietary solution.
- IBM may not have wanted to commit more fab capacity for the manufacturing of proprietary chips.

Whatever the reasoning for using chip sets, IBM's decision to do so has turned VLSI Technologies into a major participant in the PC chip set market. Dataquest believes that IBM's decision to use a standard chip set solution will lower the barrier to entry for chip sets to be designed into other PC manufacturers' products. Table 2 presents Dataquest's IC content analysis for the Model 30-286.

Table 2

IBM PS/2 Model 30-286 IC Analysis

Description	Quantity	Cost	Major Suppliers
SSI/MSI Standard Logic	25	$ 5.43	National, Signetics, TI
Memory Devices			
256K DRAMs	18		TI
64K DRAMs	8		NEC
256K EPROM	2		Intel
SRAM	1		Inmos
Total Memory	29	$129.80	
ASICs			
Proprietary Custom VLSI	2	$ 21.00	IBM/SMOS
Microdevices			
80286 (10 MHz)	1		Intel
PC Chip Set	5		VLSI Technology
Floppy Controller	1		NEC
Clock/Calendar	1		Dallas Semiconductor
Peripheral Interface (8742)	1		Intel
Total Microdevice	9	$106.65	
Total IC	65	$262.88	

Source: Dataquest
November 1988

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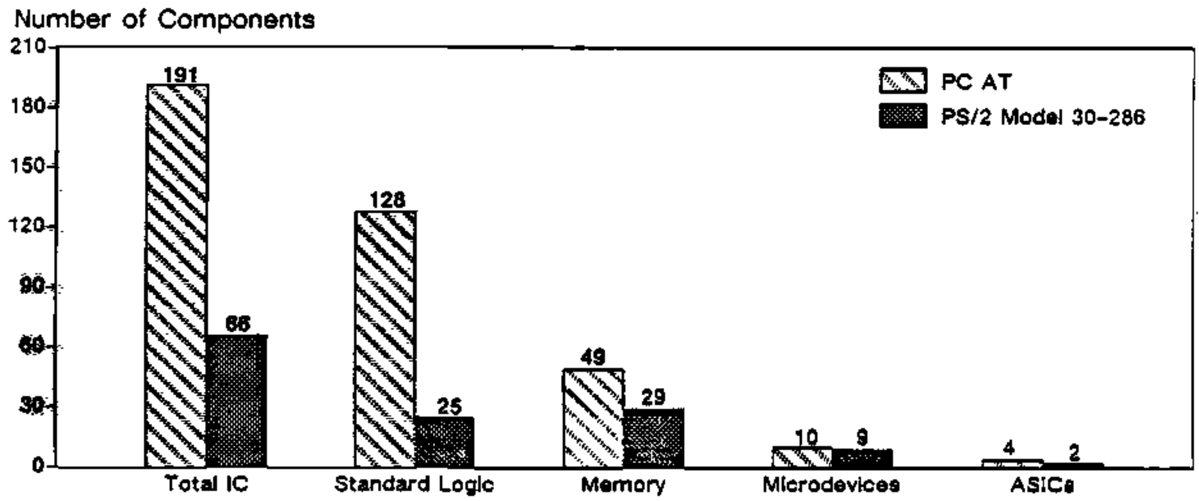
Figure 1 shows a comparison of the IC content of the original IBM PC AT with that of the Model 30-286. The IBM PC AT used a total of 191 components at a cost of $304.54 for the motherboard and separate display board. The PS/2 Model 30-286 uses 66 ICs at a total cost of $262.88. That is a 65 percent reduction in IC count and a 14 percent reduction in IC cost. The performance gain of the Model 30-286 in clock speed is 25 percent. The Model 30-286 also provides more than a 4X improvement in display resolution. The point is that advances in semiconductor technology have allowed IBM to manufacture their low-end PC with fewer components and higher performance at a lower cost than their high-end PC of less than three years ago.

Figure 1

IBM PS/2 Model 30-286 versus IBM PC AT
(IC Content Comparison)



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Source: Dataquest
November 1988

DATAQUEST ANALYSIS

Earlier this year, IBM stated that all of its PCs would be based on the Intel 80386, 80386SX, or higher-performance processors by the end of 1989. The move to upgrade the Model 30 from an 8086 to a 80286 processor appears to be in line with this strategy of moving the PS/2 family to higher-performance processors. Dataquest believes that the introduction of the Model 30-286 at its current price point rings the death knell for the 8086-based Model 30. This introduction also foreshadows a similar upgrade for the Model 25. In fact, when looking at the Model 30-286, we noticed that the board layout is very similar to the current Model 25 motherboard. IBM may use the same motherboard for both systems.

The Model 30-286 moves the Model 30 from a machine based on dated technology to a segment of the market that Dataquest expects to grow over the next four years. We forecast 80286-based machines to grow at a 12 percent compound annual growth rate (CAGR) over the next four years, while 8086-based machines are expected to decline at a 22 percent rate for the same time period.

Dataquest believes that the use of an off-the-shelf chip set in the Model 30-286 is a fantastic coup for VLSI Technologies. It is also a good sign for other chip set vendors, indicating that chip sets will continue to replace proprietary ASIC and "discrete" standard logic solutions, especially in low-end systems.

Dave Norman

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THIRD QUARTER ELECTRONIC EQUIPMENT UPDATE

SUMMARY

Dataquest forecasts that North American electronic equipment production will grow 8.5 percent in 1988, up slightly from 8.3 percent growth in 1987. We expect growth in 1989 to slow to 7.6 percent, as U.S. economic growth decelerates and saturation continues in end-use equipment markets.

This newsletter presents an overview of business activity and trends in the six semiconductor application markets. It also discusses implications for semiconductor consumption. Forecast application market activity is summarized as follows:

- Data processing equipment production is expected to grow 13.4 percent in 1988, driven by personal computer production, and 11.3 percent in 1989. Computer chip consumption is expected to continue to drive the North American market.

- Consolidation and long-term plant and equipment investment in the communications industry should translate into moderate but relatively steady growth through 1992.

- Investment in manufacturing automation systems is expected to pace industrial electronic equipment production, resulting in 11.2 percent growth in 1988. We expect this growth to slow to 5.6 percent in 1989, reflecting deceleration in economy-wide capital spending.

- Consumer electronics growth will remain lackluster, despite a resurgence in personal electronics.

- Increasing electronic and semiconductor content in military systems will counter slower defense spending, resulting in real growth of military electronic equipment production.

- Rising pervasiveness of automotive electronic systems should result in transportation electronic equipment production outpacing automobile production.

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OUTLOOK FOR APPLICATION MARKETS

Table 1 and Figure 1 show Dataquest's most recent North American electronic equipment forecast. We expect the electronic equipment industry to grow 8.5 percent in 1988, to $271.3 billion. This compares favorably with 1987, when the industry grew 5.6 percent. Data processing applications, fueled by PC production, are expected to lead the pace with 13.4 percent growth in 1988. We expect data processing applications to have a compound annual growth rate (CAGR) of 10.2 percent through 1992.

Table 1

North American Electronic Equipment Forecast (Millions of Dollars)

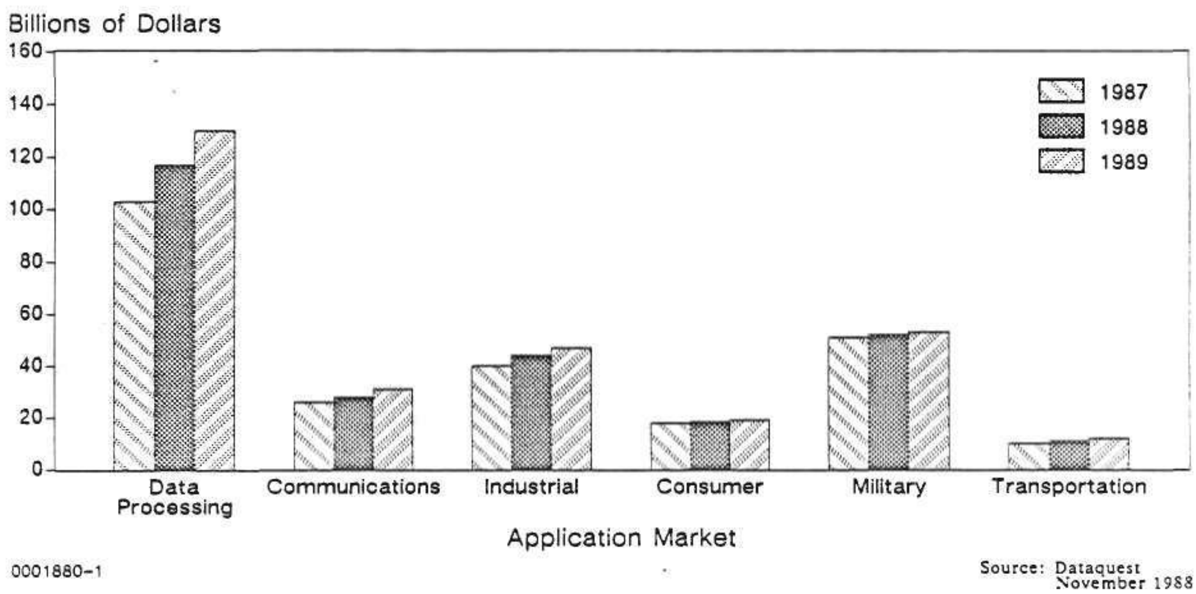
	1987	1988	1989	1990	1991	1992	% Change 1987-1988	CAGR 1987-1992
Data Processing	$103,552	$117,434	$130,662	$143,519	$157,180	$168,372	13.4%	10.2%
Communications	26,367	28,380	30,504	32,430	34,517	36,449	7.6%	6.7%
Industrial	40,384	43,866	46,990	49,759	53,974	58,074	8.6%	7.5%
Consumer	18,063	18,294	18,863	19,560	20,650	21,710	1.3%	3.7%
Military	51,549	52,345	52,968	55,348	57,842	60,454	0.4%	3.2%
Transportation	10,199	10,964	12,042	13,281	14,809	16,314	7.5%	9.9%
Total	$250,113	$271,282	$292,029	$313,897	$338,971	$361,372	8.5%	7.6%

Note: Columns may not add to totals shown because of rounding.

Source: Dataquest November 1988

Figure 1

North American Electronic Equipment Forecast



Source: Dataquest November 1988

As shown in Table 2 and Figure 2, we believe that the data processing sector will continue to be the largest and fastest growing consumer of semiconductors. Personal computers, expected to account for 11.1 percent of total North American semiconductor consumption in 1988, remain the driving force and the volatile factor underlying the forecast.

Table 2

North American Semiconductor Consumption by Application Market (Millions of Dollars)

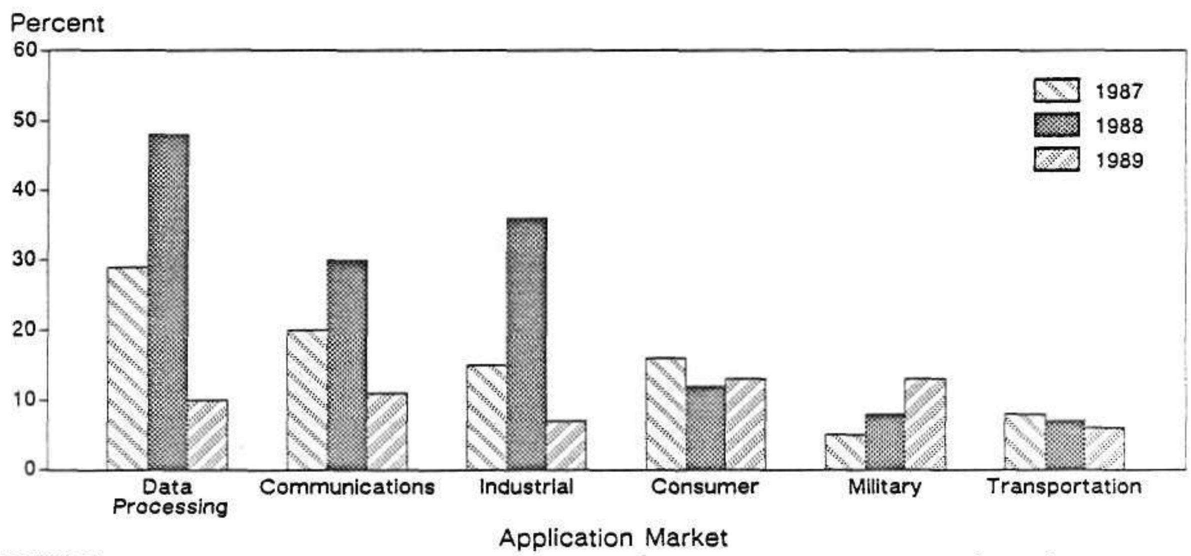
	1987	1988	1989	1990	1991	1992	% Change 1987-1988	CAGR 1987-1992
Data Processing	$ 4,913	$ 7,295	$ 7,997	$ 8,000	$ 9,550	$12,006	48.5%	19.6%
Communications	1,716	2,214	2,463	2,452	2,813	3,338	29.0%	14.2%
Industrial	1,847	2,512	2,685	2,671	3,189	3,954	36.2%	16.4%
Consumer	844	941	1,057	1,029	1,166	1,367	11.5%	10.1%
Military	1,631	1,751	1,970	2,106	2,280	2,456	1.4%	8.5%
Transportation	918	987	1,052	1,195	1,372	1,664	0.6%	11.1%
Total	$11,869	$15,700	$17,224	$17,452	$20,370	$24,785	32.3%	15.9%

Note: Columns may not add to totals shown because of rounding.

Source: Dataquest
November 1988

Figure 2

North American Semiconductor Consumption by Application Market



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Source: Dataquest
November 1988

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Data Processing

Dataquest expects the North American data processing industry to grow 13.4 percent this year, up from 12.4 percent in 1987 and slowing only slightly to an 11.3 percent pace in 1989. Business' purchases of PC systems, in addition to new product introductions such as IBM's AS/400 Silverlake business system, have contributed significantly to this year's growth and should provide a foundation for next year's expected performance.

The importance of PC production in driving the current semiconductor expansion is easily seen when one considers the following: According to the Semiconductor Industry Association, July year-to-date total U.S. semiconductor shipments are up 28 percent over year-earlier levels. However, total U.S. shipments less memory shipments are up 13 percent; and total U.S. shipments less memory and microdevice shipments are up only 4 percent. Given that single-user PCs ($1,000 to $10,000) account for 11.1 percent of North American semiconductor consumption, a major growth change in this market would probably send a chilling correction throughout the industry.

One factor mitigating against an industry correction to the extent that occurred in 1985 is the fact the computer manufacturers are capable of producing more mips (i.e., computing power) than users can absorb. Major opportunities that meet user needs while absorbing mips include the following:

- Imaging and Graphics—Today's graphics, voice, and imaging applications require higher levels of mips to satisfy users' performance needs.
- Desktop Standards—Two likely operating systems in the battle for supremacy include OS/2 and UNIX.
  - Once standards are established, users will work in an environment of common user interfaces, common communications interfaces, and enhanced applications software interfaces.
  - Established standards should lead to increased penetration into the work environment.
- Knowledge-based Systems—The adoption of knowledge-based systems is bound to make new tasks feasible, enabling real-time collection and analysis of data.

Meeting these goals will require more computing power, accomplished by greater semiconductor power. Thus, the continued rise in semiconductor pervasiveness should help stave off an abrupt industry contraction.

Communications

Would that the typical workplace could get its desktop computers and peripherals to "talk" to one another. Conceptually, this is a simple yet elusive notion, but progress is being made. Dataquest expects the North American local area network (LAN) industry to grow 58.3 percent in 1988, to $2.6 billion, and 40.3 percent in 1989, to $3.6 billion. We believe that the LANs of choice will be Xerox's Ethernet and IBM's Token-Ring.

Industry consolidations and product competition have placed pressure on prices, constraining industry growth. But data communications equipment is providing some industry relief, while growth in public telecommunications systems (e.g., central office switching equipment) remains sluggish. Overall, Dataquest estimates that North American communications systems shipments will be up 7.6 percent in 1988 and up 7.5 percent in 1989.

Industrial

We forecast the industrial electronic equipment industry to grow 8.6 percent in 1988, slowing to 7.1 percent in 1989. Electronic manufacturing systems sales are setting the pace.

Performance in the industrial application market is tied more closely to overall capital equipment spending in the economy than performance in the other application markets. We believe that this year's capital spending boom will lead to 8.6 percent growth in industrial electronic equipment in 1988, with manufacturing systems setting the pace at 12.5 percent expected growth. As the capital spending boom begins to subside next year, shipments of industrial systems will likely follow suit.

Consumer

North America started to lose the consumer electronics battle years ago. Since then, most production has shifted to Japan and Asia. But certain niche markets, such as electronic games, remain a North American stronghold. Overall, however, the consumer electronic equipment market is forecast to grow a lackluster 1.3 percent in 1988, going up only 3.1 percent in 1989. Growth is being constrained by a mild rate of new product introductions and the high saturation rate of appliances per household.

On September 1, the Federal Communications Commission (FCC) issued high-definition television (HDTV) guidelines. The guidelines stipulate that, although only HDTV sets will display the sharper image, conventional TV sets must be able to receive high-definition signal transmissions.

We believe that the FCC action will discourage the implementation of any of the proposed incompatible foreign HDTV standards. Furthermore, the FCC action should encourage the U.S. consumer electronics industry's participation in the domestic TV set and TV broadcasting equipment markets, which are now dominated by foreign companies.

The implications for the semiconductor industry are far reaching. Richard Elkus, Chairman and CEO of Prometrix Corporation, observed at the recent Semiconductor Industry Association/Dataquest conference that, in the same way that Japan's domination of the worldwide VCR market has led to domination of interrelated systems and semiconductor industries, the nation (or nations) that dominates the HDTV market will reap similar but enormously larger rewards as the world's stock of video equipment is revamped. Not only will HDTV systems open up a new market for semiconductor manufacturers, but spinoff products will likely find uses in data processing, communications, medicine, and military applications.

Dataquest believes that an unusual opportunity exists for U.S. manufacturers to reclaim some of the consumer electronics market over the next 5 to 10 years.

Military

For defense contractors, the bad news is that worldwide military spending has slowed as growth in the U.S. defense budget, which accounts for about 50 percent of the free world's defense spending, slows. (Assuming that the U.S. inflation rate remains in the 4 percent neighborhood, which is likely, this implies declining real defense spending growth.) The good news is that the electronic and semiconductor content of new military systems, as well as upgrade programs, is growing and should continue to increase well into the next century.

For the period 1987 through 1992, military electronic production is expected to grow at a 3.2 percent CAGR. Military semiconductor consumption is expected to grow at an 8.5 percent CAGR.

Transportation

Detroit's Big 3 automobile manufacturers have recently raised their fourth quarter U.S. production forecast, according to Automotive News, boosting the industry's estimate of unit production of cars and trucks by 8.7 percent over the fourth quarter of 1987. U.S. automakers expect that a healthy economy—coupled with an unexpected recent surge in car sales—will continue. In the third quarter, U.S. automakers increased production by 12.6 percent from year-earlier levels. Nonetheless, unit sales are expected to decline 0.1 percent, from 7.094 million units in 1987 to 7.086 million units in 1988.

We believe that continued automotive electronics systems pervasiveness will translate into automotive electronic systems growth, even in view of expected sluggish U.S. automobile production.

DATAQUEST CONCLUSIONS

For years, the semiconductor industry has been subject to a pronounced boom/bust cycle. The cycle's wide swings may finally be damping, however. For example, as North American semiconductor consumption heads toward what we believe will be the next cyclical trough in 1990, we further expect that positive, albeit very slow, growth will be maintained. Should this occur, it would be a far cry from the collapses that the industry experienced in 1975 and 1985.

Dataquest believes that better inventory control and closer supplier/user relationships are helping mitigate wide industry swings. If inroads continue to be made in these two areas, the industry may be headed for even smoother times in the years to come.

Terrance A. Birkholz

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Research *Bulletin*

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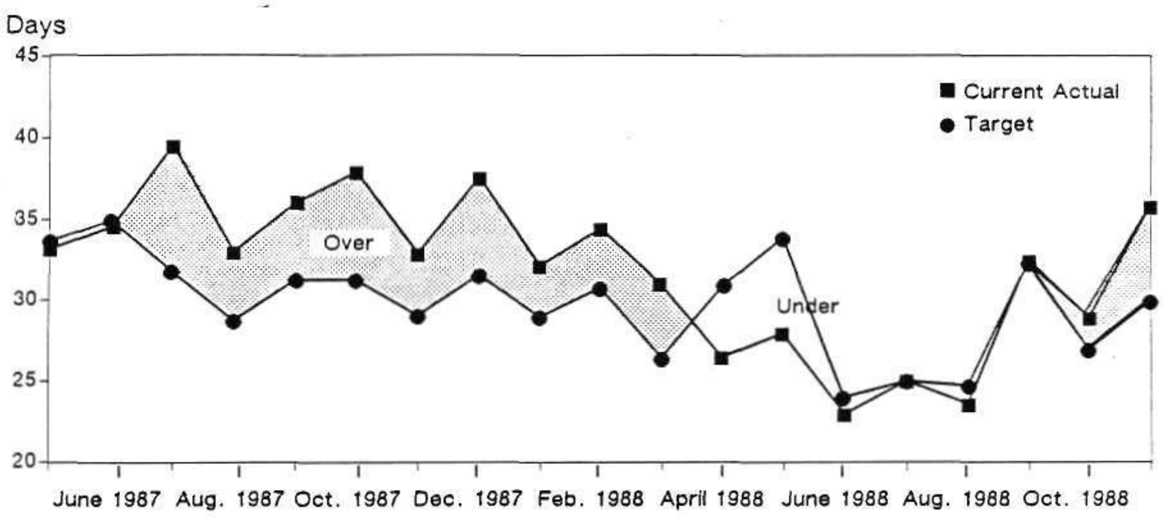
NOVEMBER PROCUREMENT SURVEY: INVENTORY TARGETS REMAIN ELUSIVE WHILE ORDER RATES STABILIZE

For the respondents to this month's survey, actual inventory levels continue to rise above targeted levels. Buyers have kept semiconductor orders at the same or slightly lower levels than last month in efforts to control these inventory costs. System sales have been mixed, with an even mix of respondents seeing slight increases and declines in their billings. As seen in Figure 1, the overall targeted inventory level has risen to 30 days, but the actual level of 36 days still remains above the new average target. This higher inventory target reflects how the momentum of past component shortages and recent availability improvements have combined to cause an overcorrection in actual inventory levels.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



0001882-1

Source: Dataquest November 1988

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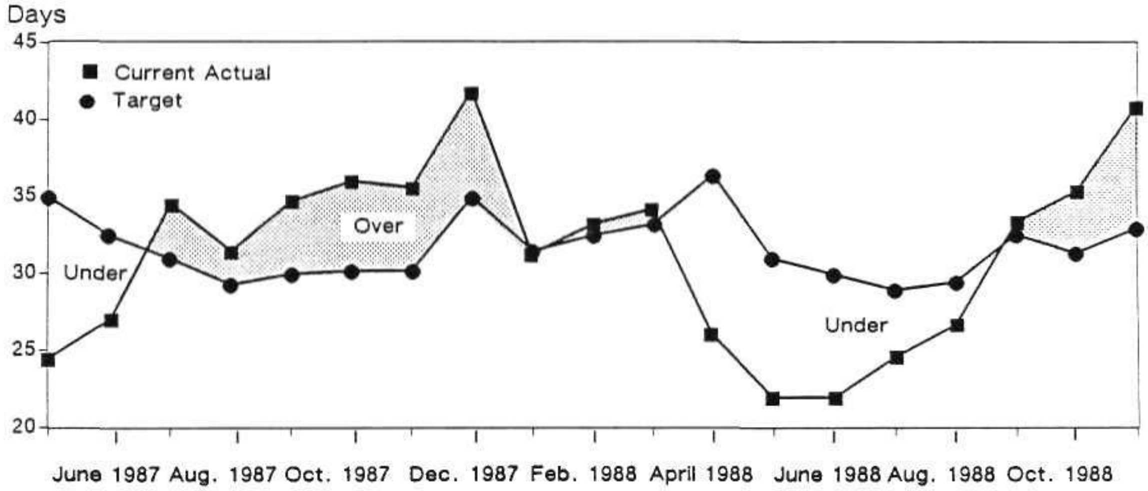
Inventories of computer OEMs remain over targeted levels, as seen in Figure 2, but the overage has stabilized with targets now set at 33 days and actual levels averaging 41 days. The adjustment period in inventories is expected to continue through the end of this year as a result of the aforementioned momentum of pent-up component demand.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



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Source: Dataquest November 1988

Pricing of semiconductors has softened in commodity standard logic and in some microprocessor devices. DRAM and SRAM prices remain high, but there is continued easing in 1Mb DRAM availability and prices. Overall lead times have remained the same at 11 weeks. Some renewed problems have occurred with surface-mount package availability, especially in the high-pin-count ASIC packages. Memory availability continues to be a problem; however, some ASIC supplies and deliveries now have become a procurement issue also because of shortages of high-pin-count ceramic surface-mount packages. This package situation should ease as more users shift to low-cost plastic alternatives.

DATAQUEST ANALYSIS

The continuation of inventory control measures now being exercised is initially reflected in the softening of commodity semiconductor prices and lead times and a resulting lowering of the semiconductor book-to-bill ratio experienced over the past two months. As 1Mb DRAMs continue to increase in supply, other related products (SRAMs, Video RAMs) will improve in availability also. Accurate forecasts of these key components will ensure that inventory levels of both semiconductor manufacturers and users do not drastically remain out of balance. As mentioned in our last bulletin, we expect this inventory correction to continue on through the end of this year.

Mark Giudici

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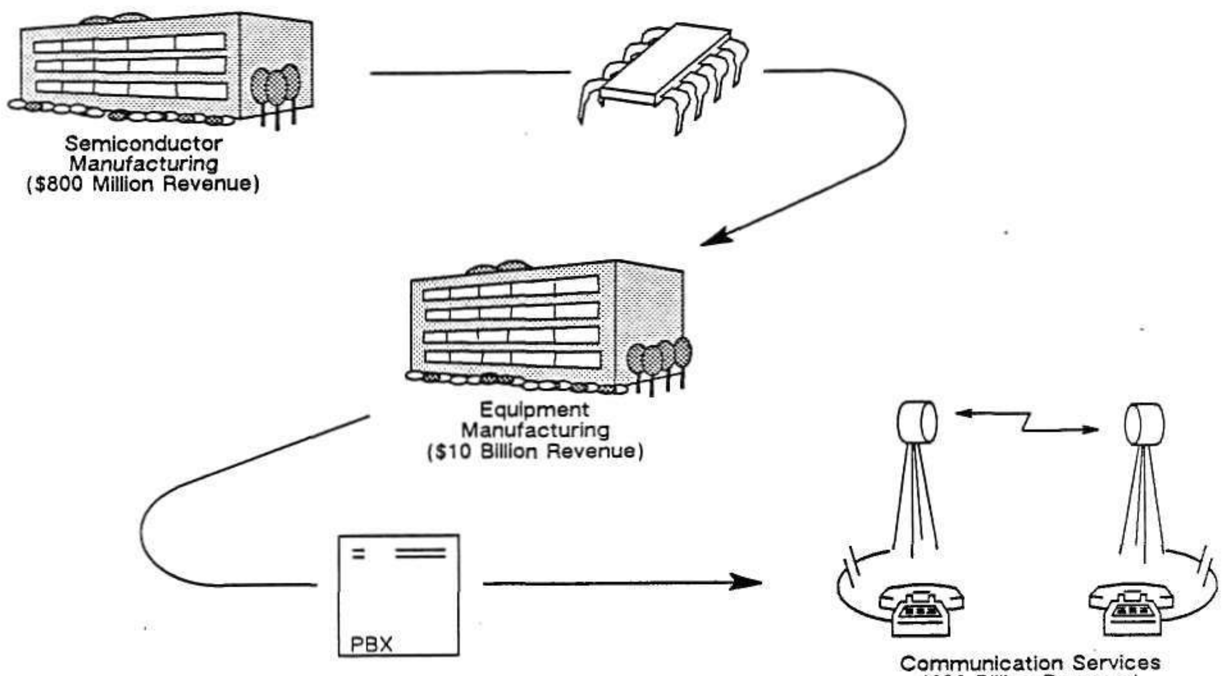
AT&T: SEMICONDUCTORS, SYSTEMS, AND SERVICES (PART 1)

SUMMARY

AT&T is a $34 billion vertically integrated "sand-to-service" company, as shown in Figure 1. AT&T is also a company in transition from a regulated utility to a market-driven supplier of goods and services, and both its equipment and component operations are being affected by this changeover.

Figure 1

Vertical Integration at AT&T



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The company lost 54 percent of its revenue and 76 percent of its assets overnight in 1984, when it had to divest itself of its local telephone business as part of an out-of-court settlement to an antitrust lawsuit. This 1984 settlement also replaced a 1956 out-of-court settlement to an earlier antitrust lawsuit that had prohibited AT&T from competing in the merchant markets for equipment and components. Since 1984, AT&T has been restructuring its organization and making whatever other adjustments are necessary to be able to compete in nonregulated business areas.

The downsized and unshackled AT&T remains on the "Fortune 10" list, but its manufacturing operations alone would have always qualified for the "Fortune 30" list. Dataquest has examined AT&T as a vertically integrated manufacturer of both semiconductors and systems to determine where the company is headed now that it has this new freedom to compete. We conclude that, although the company still has some adjustments to make, it is learning quickly and is destined to become a "lean-and-mean giant" in the 1990s, capable of competing in any areas it chooses.

Part 1 of this newsletter focuses on AT&T's $10 billion equipment manufacturing business as it relates to its transition strategy. Part 2, to be published at a later date, will focus on AT&T's $1,200 million consumption and $800 million production of semiconductor components as they relate to its transition strategy.

MANUFACTURING OPERATIONS

AT&T derives $10 billion per year from the sale of products, representing 30 percent of the company's revenue. AT&T's product lines consist of equipment for the communications, data processing, and military markets. In addition, AT&T has its own components group to supply communications-related materials and devices to its equipment manufacturing operations and to the merchant market. AT&T also has the Bell Labs organization to conduct basic and applied research into technology areas that are strategic for the company. Of the company's $2.4 billion research budget, 90 percent is applied toward the development of revenue-generating products and services; the remaining 10 percent of the budget is applied toward fundamental research in fields that show promise for revenue-generating applications in the future, ranging from basic physics to software. It is these capabilities for research, design, and manufacturing that AT&T is adjusting in order to survive and prosper in nonregulated businesses.

AT&T's performance results for the years 1985 through 1987 are presented in Table 1. Overall, revenue has remained relatively flat at $34 billion and head count has been reduced slightly to a level of 300,000 employees. However, income has increased during this time period as a result of the company's ongoing efforts to adjust. In 1986, for example, the company recognized the need to establish a reserve of $2.5 billion (pretax dollars) to cover the cost of restructuring over the next several years. To date, four equipment manufacturing plants have been closed, two more facilities are scheduled for closing, and Dataquest believes that other production lines will be consolidated in the future to lower the company's manufacturing costs.

Table 1

AT&T's Performance Results

	1985	1986	1987	1985-1987 CAGR
Revenue ($M)	$34,417	$34,087	$33,598	(1.2%)
Income ($M)	$ 1,557	$ 139	$ 2,044	13.5%
Employees	338,000	317,000	303,000	(5.3%)
Merchant Product Sales ($M)	$11,235	$10,178	$10,206	(4.7%)
Merchant Products/Revenue	33%	30%	30%	

Source: AT&T Annual Report
Dataquest
November 1988

AT&T has traditionally been a company based almost entirely in the United States. One aspect of its new strategy is to establish a stronger international presence, and AT&T now is engaged in joint ventures with companies in Europe, Japan, and Southeast Asia to smooth its entry into these markets. The company also has begun to locate some of its production activities offshore using either company-owned facilities or contract assemblers to lower its manufacturing costs.

EQUIPMENT SALES

The relative sizes of AT&T's manufacturing businesses (including captive sales) are shown in Figure 2. The majority of electronics-based revenue is derived from the sale of public network equipment. Dataquest estimates that AT&T has 50 percent of the U.S. market; the customer base for this equipment includes AT&T Communications, the seven regional Bell operating companies (i.e., the local telephone service companies spun off from AT&T in 1984), and the approximately 1,400 independent telephone companies operating in the United States.

Dataquest also estimates that the company's sales of customer premises equipment represent 25 percent of the U.S. market and that the company's sales of personal and minicomputers represent 3 and 2 percent of the U.S. market, respectively. (The 1956 ban on AT&T supplying computers to the merchant market was lifted in 1984 as part of the antitrust settlement.) The United States Air Force awarded AT&T a $1 billion contract in 1988 for the delivery of computer equipment and software for both military and civilian installations worldwide. Besides the potential for up to $5 billion of revenue to the company over the next five years, we believe that this contract award will have spillover effects by helping to improve AT&T's reputation and position in the merchant computer market. In addition, AT&T's military business makes it one of the 20 largest defense contractors to the U.S. government.

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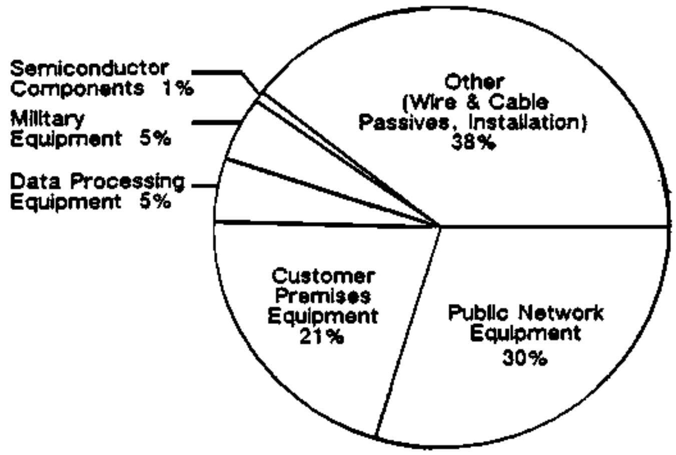
Figure 2

AT&T's Manufacturing Businesses (Including Captive Equipment Sales)



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Source: Dataquest November 1988

Dataquest believes that AT&T manufactures $2 billion of components each year. Approximately $800 million of this production is semiconductors, and the remainder is other products such as wire and cable, passive components, batteries, electronic power supplies, and transformers. About $300 million of this $2 billion production is sold to the merchant market, and the remainder is consumed internally. We further believe that AT&T's $45 million of semiconductor component sales in the merchant market in 1987 provided it with less than 1 percent of its manufacturing-derived revenue.

AT&T's 1987 overseas manufacturing activities are listed in Table 2. The company desires to increase the amount of revenue it derives from sources outside the United States from the present 9 percent to an eventual 25 percent. Besides manufacturing, AT&T has joint marketing arrangements in other countries. In Japan, for example, AT&T Ricoh markets key business telephone systems, Toshiba distributes AT&T's private branch exchange equipment, and Japan ENS Corp. (which is 50 percent owned by AT&T) provides value-added network services. Most of these ventures were started within the past five years. We believe that AT&T has found the competition in these overseas markets to be stiffer than expected and will continue to make adjustments as necessary to keep these businesses growing.

Table 2

AT&T's Manufacturing Activities Overseas

Location	Partner	Products
Denmark	NKT	Fiber-optic cable
Hong Kong	Owned by AT&T	Printed circuit boards
	Radofin	Telephone equipment
	Termbray	Telephone equipment
Italy	Olivetti	AT&T: sell Olivetti microcomputers and office automation equipment in U.S. Olivetti: sell AT&T minicomputers and private branch exchanges in Europe
Japan	Shindengen Electronics (in process)	Power supply modules
Korea	Goldstar	Central office switches, fiber-optic cable
Mexico	Metamores (subsidiary)	Power equipment, transformers, inductors
Netherlands	Philips	Central office switches, network and transmission systems
PRC	Termbray	Telephone equipment
Singapore	AT&T Consumer Products	Telephone equipment
	PCI	Telephone equipment
	Subsidiary	Semiconductor assembly and test
Spain	CTNE	Semiconductors
Taiwan	AT&T Taiwan Telecommunications	Central office switches
Thailand	N/A	Telephone equipment
	Subsidiary	Semiconductor assembly and test

N/A = Not Available

Source: Dataquest
November 1988

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AT&T's manufacturing facilities in the United States are listed in Table 3. Two of these facilities are to be closed and others are being downsized either as production lines are being consolidated or as the production itself is being transferred to an overseas location. AT&T has continued to reorganize and shift personnel in an attempt to convert from a "U.S. company with a U.S.-only strategy" to a "U.S.-based company with a global strategy." Not all of AT&T's strategic alliances are with overseas companies. In the United States, for example, AT&T has entered into an agreement with Sun Microsystems that covers both software (e.g., the UNIX operating system) and hardware (e.g., SPARC—Scalable Processor ARChitecture). GTE and AT&T also have formed a joint venture (subject to regulatory approval) to manufacture ISDN-based switching products.

Table 3

AT&T's U.S. Design and Production Locations

Location	Activity	Products
Phoenix, AZ	Production	Cable
Little Rock, AK	Production	Printers, terminals, keyboards
Denver, CO	Production	PBXs, key systems
Orlando, FL	Production	Semiconductors
Norcross, GA	Production	Cable and optical fiber
Montgomery, IL	Production	Datacomm
Naperville, IL	Design	Central office switching equipment, computers
Skokie, IL	(To be closed)	Data terminals, peripherals
Shreveport, LA	Production	Office communications
North Andover, MA	Production	Carrier systems
Kansas City, MO	Production	Relays, discrete and hybrid semiconductors, connectors
Ohmaha, NB	Production	Cable apparatus
Clark, NJ	Production	Undersea cable repeaters
Holmdel, NJ	Design	Transmission systems
Lincroft, NJ	Design	Computer products, datacomm

(Continued)

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Table 3 (Continued)

AT&T's U.S. Design and Production Locations

Location	Activity	Products
Middletown, NJ	Design	Workstations, data networks, PBXs
Morristown, NJ	Design	Personal & minicomputers
Neptune, NJ	Design	Datacomm
Parsippany, NJ	Design	Power equipment
Piscataway, NJ	Design	Communication interfaces
W. Long Branch, NJ	Design	Datacomm
Whippany, NJ	Design	Military equipment
Greensboro, NC	Headquarters	Military equipment
Winston-Salem, NC	(To be closed)	Subscriber carrier systems
Columbus, OH	Production	Voice & data switching systems
Oklahoma City, OK	Production	Switching systems, computers
Allentown, PA	Production	Semiconductors
Reading, PA	Production	Semiconductors
Nashville, TN	Production	Capacitors
Mesquite, TX	Production	Power supplies
N. Radford, VA	Production	Transformers, inductors
Richmond, VA	Production	Printed circuit boards

Source: AT&T
Dataquest
November 1988

DATAQUEST CONCLUSIONS

Dataquest believes that AT&T is a fully vertically integrated company with all the right strategic elements it needs to survive. With its laboratory, components, equipment, network, and service divisions, we believe that the company has the expertise it needs in-house to develop and manufacture any product or system necessary to support its fundamental business of information movement and management.

AT&T is also a company that is still in transition from a regulated to a deregulated business environment. Prior to the 1984 divestiture of its local telephone services business, the company was not allowed to compete in the merchant market. Prior to 1984, it made sense for AT&T to have as many of its suppliers located in as many different political jurisdictions as possible, for example, because it was regulatory personnel who made the key external decisions that affected AT&T's profitability. Today, many of the key external decisions affecting the company's profit and loss are being made by industrial customers who are free to choose between AT&T and any of AT&T's competitors. Hence, the company is striving to become more marketing oriented, and, in our opinion, AT&T has made the right decision to do so. The company must now offer its customers the best deal competitively to win their business. To do this, AT&T must determine how to lower its costs; an important part of this cost-reduction thrust has been to reduce the supplier base. As an example of the transition that is under way, AT&T as a company is learning to apply a different set of criteria today when making a choice of suppliers.

In addition, the world has become smaller and the economies of the various nations are more linked together today than ever before. In its new deregulated position, AT&T recognizes this fact and now is pursuing both markets and manufacturing locations in the broader international arena. Dataquest also believes that, in doing so, AT&T is headed in a direction that will make the company more competitive.

Roger Steciak

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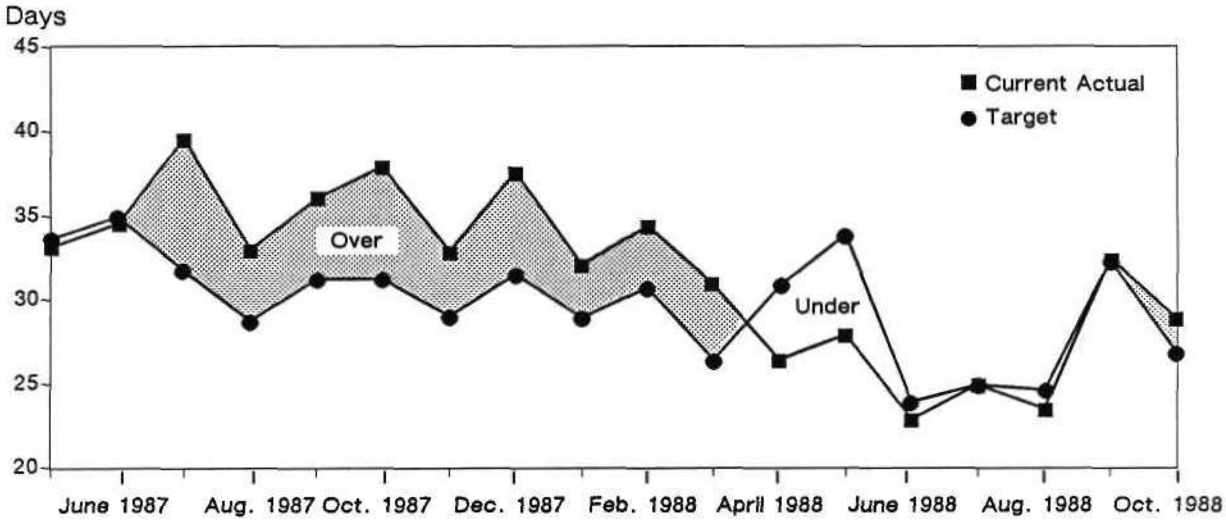
OCTOBER PROCUREMENT SURVEY:
INVENTORY CONTROL CONTINUES AS BOOKINGS FOR PARTS LEVEL OFF

Respondents to this month's survey are closely watching inventory levels and are quickly adjusting buying rates in line with inventories. Overall electronic system sales are expected to remain healthy, with the only softening currently being seen in the military segment. As seen in Figure 1, both target and actual inventory levels have declined slightly, with the overall target now at 27 days and the current level above that target at 29 days. Although above target, the lowering of overall levels is an improvement over last month's results and reflects the diligence of both buyers and sellers of semiconductors to keep communication lines open.

Figure 1

Current Actual versus Target Semiconductor Inventory Levels (All OEMs)



Source: Dataquest
October 1988

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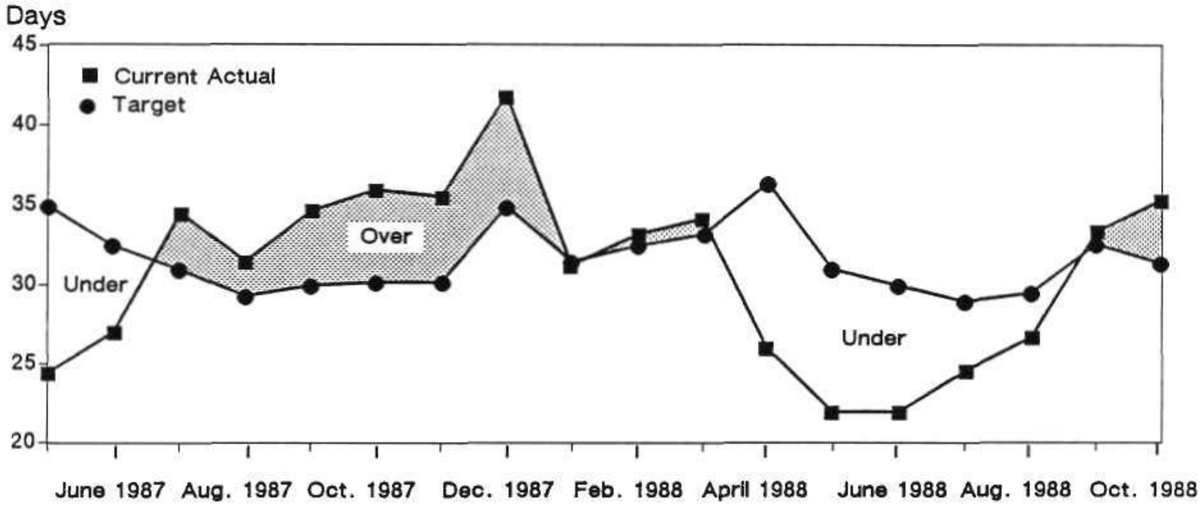
Actual computer OEM inventories have also overshot lower targeted levels as adjustments to booking rates continue. The lower inventory target of 31.4 days versus the higher current level of 35.4 days shown in Figure 2 illustrates how inventory adjustments often do not immediately correlate.

Figure 2

Current Actual versus Target Semiconductor Inventory Levels (Computer OEMs)



Source: Dataquest October 1988

Pricing of semiconductors has remained stable or has declined since our last survey, while lead times continue to come down. Orders to distributors have remained unchanged. The ongoing problem with memory availability (low-density SRAMs in particular) continues, with improved 1Mb DRAM availability the only bright spot in this bleak picture. Surface-amount packaging, for the most part, is no longer a major problem, but some users still find it difficult to obtain high-speed memory or high-pin-count chip carriers.

DATAQUEST ANALYSIS

The ongoing inventory adjustment programs are putting companies' forecasting and procurement systems to task as the industry shows signs of downshifting from overdrive into fourth gear. Increasing 1Mb memory supplies combined with the leveling of demand and good buyer-vendor communications will result in tempering any down market spiral since inventory levels are still historically low. We expect this adjustment period to continue for the next two to three months as system market growth levels stabilize.

Mark Giudici

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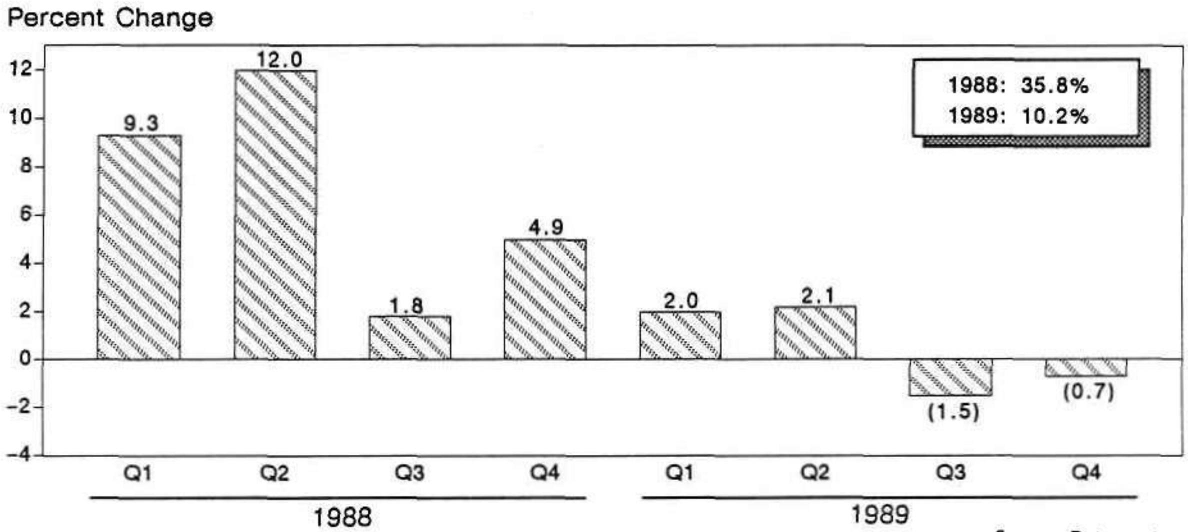
WORLDWIDE SEMICONDUCTOR INDUSTRY UPDATE: WHEN WILL THE DOWNTURN HIT?

SUMMARY

The year 1988 has been a booming one for the worldwide semiconductor industry, with estimated total growth of 35.8 percent, continuing the good times of 1987 (a year of 22.8 percent growth). During the third quarter of 1988, bookings began to soften, and many semiconductor manufacturers experienced poorer than usual August bookings. However, the existing backlog, combined with shortages in key product areas—most notably, DRAMs and SRAMs—should keep shipments strong through the end of the year. Dataquest forecasts much slower growth in the first two quarters of 1989. This slow growth will be followed by negative growth in the second half of 1989, as supply catches up with and then exceeds demand and both unit shipments and ASPs fall. The short-term forecast is summarized in Figure 1.

Figure 1

Worldwide Semiconductor Shipment Forecast



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WORLDWIDE FORECAST

A summary of the worldwide forecast by region is shown in Tables 1 and 2.

Table 1

Estimated Worldwide Semiconductor Market
(Billions of U.S. Dollars)

	1988	1989	1990	1991	1992	1993	CAGR 1988-1993
North America	15.7	17.2	17.5	20.4	24.8	26.7	11.2%
Japan	19.5	21.3	21.5	25.2	30.5	33.3	11.3%
Europe	8.2	8.8	8.8	9.8	11.3	12.5	8.8%
Rest of World	6.1	7.3	7.9	9.9	12.7	14.3	18.4%
Total World	49.5	54.6	55.7	65.3	79.3	86.8	11.9%

Source: Dataquest
October 1988

Table 2

Estimated Worldwide Semiconductor Market
(Percent Change, U.S. Dollars)

	1988	1989	1990	1991	1992	1993
North America	32%	10%	1%	17%	22%	8%
Japan	36%	9%	1%	17%	21%	9%
Europe	29%	7%	0	12%	15%	11%
Rest of World	57%	19%	9%	25%	28%	13%
Total World	36%	10%	2%	17%	22%	10%

Source: Dataquest
October 1988

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North America

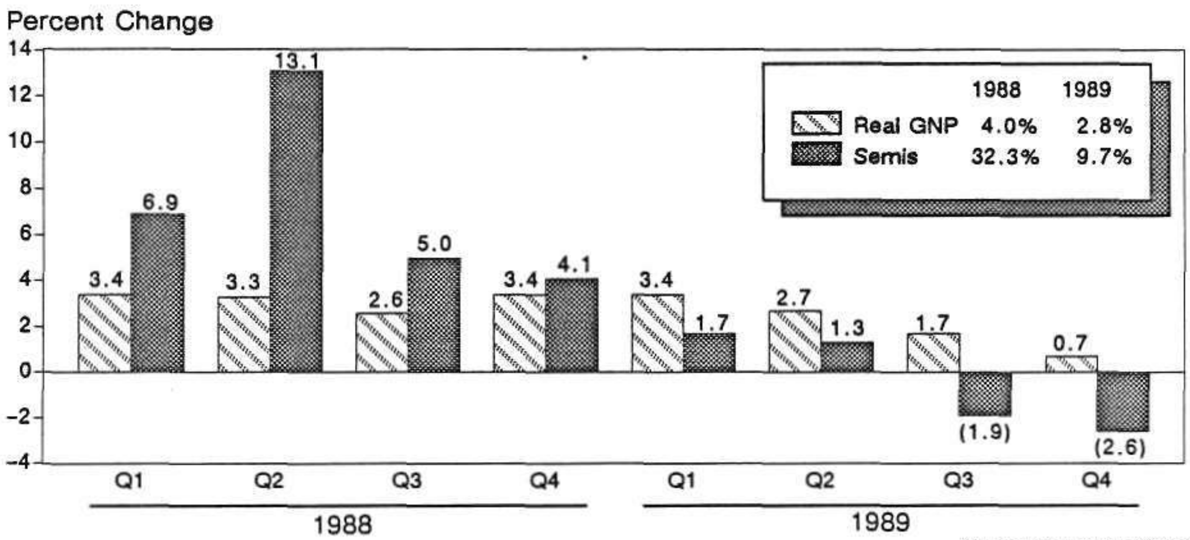
Both in the 1988 to 1989 time frame and over the long term, we believe that North America will be the second slowest growing market after Europe; through 1993, however, it will remain second largest in overall size after Japan. In 1988, North America will account for 31.7 percent of worldwide semiconductor consumption. Although capital spending in North America will increase by some 40.0 percent in 1988, this growth is modest compared with the capacity buildup in 1983 and 1984, which led to the 1985 market glut.

Historical patterns of billings and bookings show that bookings may begin to fall on a 12/12 basis any time now, but billings will not start to decline until 9 to 10 months later (i.e., mid-1989). Semiconductor inventory levels are rising, but they are being held in better check by OEMs than in 1984, due to careful tracking of target and actual inventory levels.

Dun & Bradstreet forecasts show that the U.S. economy will slow in 1989, with real GNP growth of 2.8 percent, versus 4.0 percent growth in 1988. This reduced GNP growth, combined with slower electronic equipment production growth and lowered capital expansion plans, will slow the semiconductor industry as well. We believe that the sluggishness in semiconductors will last through the first half of 1990. Figure 2 compares U.S. GNP growth with North American semiconductor consumption growth.

Figure 2

U.S. Economy versus Semiconductors



Source: Dun & Bradstreet
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October 1988

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Japan

The GNP outlook for Japan is very strong, with growth rates forecast at 4.6 percent for fiscal 1988 and 3.5 percent for fiscal 1989. We expect Japan to be the second fastest growing market after the ROW market, in both the short and long term. We expect prices to remain firm through the second half of this year, with shortages of DRAMs and SRAMs continuing at least until the first quarter of 1989 (one quarter sooner than in the United States). Although Japanese capital spending will grow 56.0 percent in dollar terms in 1988, the yen growth will be significantly lower, at 40.0 percent.

Europe

PCs are the driving factor in European semiconductor growth this year, particularly in MOS microdevices, memory, and bipolar digital logic. The PC build rate has slowed substantially, and bookings are collapsing, except for 1Mb DRAMs. We expect Europe to be the slowest growing market in the long term, and we believe that ROW will surpass Europe in dollar size in 1991.

ROW

The 1988 Seoul Olympics drove 1988 consumer demand worldwide, stimulating the ROW semiconductor market. Currently, PC shipments are slowing because of memory shortages. The telecommunications industry is growing extremely quickly in ROW, but telecommunications is still a small market. We expect the ROW market to be the fastest growing in both the short and long term. ROW will surpass Europe in total dollar consumption in 1991 to become the world's third largest market.

Shipments by Product

Tables 3 and 4 give Dataquest's short- and long-term forecasts, respectively, for the worldwide semiconductor industry. By 1993, we forecast a total market of $86.7 billion. In the long term, the fastest growing products will continue to be MOS ICs. Bipolar memory is forecast to decline steadily through 1993, as BICMOS memory edges it out. Optoelectronics growth will continue to be strong over the long term, as its use in consumer and telecommunications products continues to grow; at the same time, new applications such as medical, dental, machine vision, and submarine communications are proliferating.

Table 3

Estimated Worldwide Semiconductor Shipments
(Millions of U.S. Dollars)

	1987	Q1/88	Q2/88	Q3/88	Q4/88	1988	% Chg. 1988
Total Semiconductor	$36,449	$11,112	$12,442	$12,669	$13,286	$49,509	35.8%
Total IC	$28,619	$ 8,718	$ 9,885	$10,128	$10,672	$39,403	37.7%
Bipolar Digital	$ 4,672	$ 1,297	$ 1,359	$ 1,419	$ 1,495	$ 5,570	19.2%
Memory	565	154	163	166	169	652	15.4%
Logic	4,107	1,143	1,196	1,253	1,326	4,918	19.7%
MOS Digital	$16,739	$ 5,385	$ 6,380	$ 6,561	$ 6,924	$25,250	50.8%
Memory	6,019	2,182	2,762	2,785	2,904	10,633	76.7%
Micro	4,770	1,521	1,765	1,813	1,906	7,005	46.9%
Logic	5,950	1,682	1,853	1,963	2,114	7,612	27.9%
Linear	$ 7,208	$ 2,036	$ 2,146	$ 2,148	$ 2,253	$ 8,583	19.1%
Discrete	$ 6,112	$ 1,805	$ 1,918	$ 1,887	$ 1,939	$ 7,549	23.5%
Optoelectronic	$ 1,718	$ 589	$ 639	$ 654	$ 675	$ 2,557	48.8%
Exchange Rate Yen/$	144	128	125	134	134	130	(9.7%)
European Basket/$	1.25	1.17	1.17	1.20	1.20	1.18	(5.6%)

	1988	Q1/89	Q2/89	Q3/89	Q4/89	1989	% Chg. 1989
Total Semiconductor	$49,509	$13,556	$13,843	$13,636	$13,536	$54,571	10.2%
Total IC	$39,403	$10,882	$11,104	$10,917	$10,833	$43,736	11.0%
Bipolar Digital	$ 5,570	$ 1,518	$ 1,519	$ 1,451	$ 1,400	$ 5,888	5.7%
Memory	652	169	161	151	146	627	(3.8%)
Logic	4,918	1,349	1,358	1,300	1,254	5,261	7.0%
MOS Digital	$25,250	$ 7,058	$ 7,209	$ 7,101	$ 7,057	$28,425	12.6%
Memory	10,633	2,950	3,022	2,972	2,953	11,897	11.9%
Micro	7,005	1,944	1,990	1,969	1,959	7,862	12.2%
Logic	7,612	2,164	2,197	2,160	2,145	8,666	13.8%
Linear	$ 8,583	$ 2,306	$ 2,376	$ 2,365	$ 2,376	$ 9,423	9.8%
Discrete	$ 7,549	$ 1,976	$ 2,010	$ 1,996	$ 1,988	$ 7,970	5.6%
Optoelectronic	$ 2,557	$ 698	$ 729	$ 723	$ 715	$ 2,865	12.0%
Exchange Rate Yen/$	130	134	134	134	134	134	3.1%
European Basket/$	1.18	1.20	1.20	1.20	1.20	1.20	1.2%

Source: Dataquest
October 1988

Table 4

Estimated Worldwide Semiconductor Shipments
(Millions of U.S. Dollars)

	1988	1989	1990	1991	1992	1993	CAGR 1988-1993
Total Semiconductor	$49,509	$54,571	$55,600	$65,230	$79,233	$86,730	11.9%
Total IC	$39,403	$43,736	$44,767	$53,295	$65,734	$73,213	13.2%
Bipolar Digital	$ 5,570	$ 5,888	$ 5,878	$ 6,737	$ 7,813	$ 8,509	8.8%
Memory	652	627	606	595	546	530	(4.1%)
Logic	4,918	5,261	5,272	6,142	7,267	7,979	10.2%
MOS Digital	$25,250	$28,425	$29,333	$35,487	$44,610	$49,663	14.5%
Memory	10,633	11,897	12,141	14,762	18,562	20,262	13.8%
Micro	7,005	7,862	7,993	9,800	12,482	13,867	14.6%
Logic	7,612	8,666	9,199	10,925	13,566	15,534	15.3%
Linear	$ 8,583	$ 9,423	$ 9,556	$11,071	$13,311	$15,041	11.9%
Discrete	$ 7,549	$ 7,970	$ 7,917	$ 8,668	$ 9,712	$ 9,254	4.2%
Optoelectronic	$ 2,557	$ 2,865	$ 2,916	$ 3,267	$ 3,787	$ 4,263	10.8%
Exchange Rate Yen/$	130	134	134	134	134	134	
European Basket/$	1.18	1.20	1.20	1.20	1.20	1.20	

Source: Dataquest
October 1988

DATAQUEST CONCLUSIONS

We believe that worldwide semiconductor shipments will slow down through the first half of 1989 and begin to decline slightly in the second half of 1989, continuing into the first half of 1990. However, due to careful OEM management of semiconductor inventory, careful semiconductor manufacturer management of capacity (capacity utilization is at 86 percent in 1988, and we expect it to be a still-healthy 80 percent in 1989 and 78 percent in 1990), and a generally healthy world economy, we forecast the downturn to be modest, particularly in comparison with the 1985 industry depression.

Patricia S. Cox

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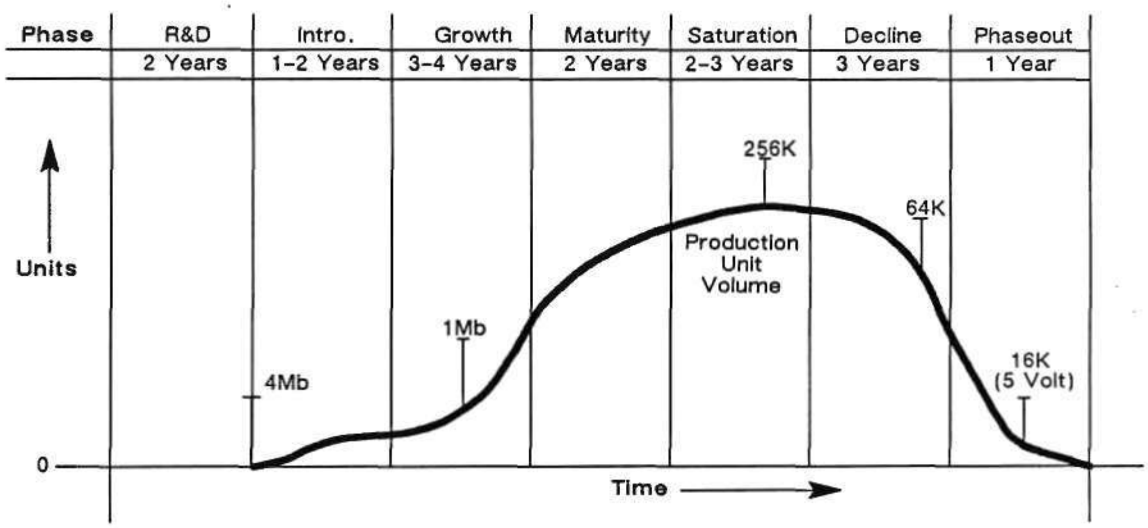
SUPPLY–BASE MANAGERS CONTINUE TO GRAPPLE WITH DRAM PROCUREMENT CHALLENGES

EXECUTIVE SUMMARY

This research bulletin analyzes the challenge for supply–base managers in sourcing 64K, 256K, 1Mb, and 4Mb DRAM during the period from 1988 to 2001. Figure 1 shows DRAM life cycles by density for this period.

Figure 1

DRAM Product Life Cycle as of September 1988



Source: Dataquest
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As shown in Figure 1, users face the phaseout of 64K DRAM during 1990. At the opposite extreme, the life cycle of the soon–to–be–sampled 4Mb device extends to 2001. Of more immediate concern to many users, as Figure 1 also reveals, the 256K DRAM is now approaching the decline stage of the cycle, with the 1Mb part moving up the growth slope of the curve.

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The information in Figure 1 translates into the following blunt messages to DRAM users:

- 64K DRAM availability will plummet from 140 million units this year to just 14 million by 1991, with price escalating as vendors depart the business.

- 256K DRAM production is dropping 20 percent between 1988-1989. However, Dataquest foresees a mild long-term decline in price as the trade-related pricing perturbations of 1987-1988 recede. By 1991, users can look forward to the worldwide availability of 300 million units of 256K DRAM.

- Supply of 1Mb DRAM will nearly triple in 1989 over the 1988 level and will hit almost 1 billion units during 1991. Over the midterm, 1Mb DRAM prices will drop from the current $15-$20 range to less than $8 per unit by the end of 1989.

- Users can expect production of 4Mb DRAM to begin during the second half of 1990, totaling 2.2 million units for the year. Barring a new round of aggressive U.S.-Japanese trade friction, the orderly price/production crossover associated with prior-density DRAM should take place in the 1992-1993 time frame as users move from 1Mb DRAM to 4Mb devices.

DATAQUEST RECOMMENDATIONS

For supply-base managers and strategic planners grappling with system design/redesign decisions and related DRAM procurement issues, Dataquest makes the following recommendations:

- Users of 64K DRAM must make plans now for an orderly migration to higher-density DRAM. These users should give careful consideration to skipping the 256K device in systems redesigns and opt instead for the 1Mb device.

- Moving through 1989, the worst will be over for users of 256K DRAM in terms of price escalation. However, the narrowing of the supplier base means some users should begin shifting now to 1Mb devices.

- Users of 1Mb devices can look to an ample supply of these parts during the early 1989 through 1992 period, while design engineers can begin designing 4Mb parts into systems now.

- Finally, in applications that are not space-constrained, the use of single in-line memory modules (SIMMs) affords design flexibility and cost savings. For example, users of 256K DRAM SIMM can design 1-Mb systems that can be readily upgraded into 4-Mb systems as warranted by market conditions.

Ron Bohn

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HARRIS CORPORATION TO ACQUIRE GE SOLID STATE

Since GE's acquisition of RCA in mid–1986, there has been much speculation regarding its intentions in the merchant semiconductor market. Over the past year, the company frequently intimated its willingness to sell its semiconductor business. These rumors were put to bed, with the August 15 announcement of an agreement for Harris Corporation to acquire GE Solid State.

Specific details of the agreement have not been released. However, it was announced that GE's dedicated facility, the Microelectronics Center in Research Triangle Park, North Carolina, will be excluded from the deal, along with certain other military semiconductor operations that were acquired from RCA and are part of GE's aerospace business.

Harris

Dataquest estimates that Harris' 1987 semiconductor revenue remained essentially flat at $268 million. Semiconductor revenue represented 13 percent of the company's total revenue for calendar year 1987. If GE Solid State's 1987 semiconductor revenue were added to this, the percentage would jump to about 38 percent of total company revenue, giving the combined entity a number–16 ranking worldwide.

Profiles of the companies' respective participation in the semiconductor market are quite different, based on 1987 semiconductor revenue.

What Do the Numbers Mean?

Three primary areas—military, linear, and standard logic—seem to emerge as the significant items in this proposed transaction. Harris' main strength within the semiconductor market stems from its position in the military market segment where it is one of the leading suppliers. Sources at GE claim that the GE/Harris businesses are very complementary from a military perspective. The venture probably would rank Harris as one of the top two suppliers to the military market. National Semiconductor, the current leader, had estimated 1987 military revenue of $250 million. The deal also would result in the consolidated supply of super radiation–hardened devices by Harris, already a leading supplier.

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Harris concentrates its linear business on amplifiers, whereas GE distributes its linear products fairly evenly over the areas of amplifiers, interface, data conversion, consumer, and other linear products. More than one-fourth of GE Solid State's semiconductor revenue is derived from sales of discrete products, while Harris has no presence in this market. Often this product area is considered a good source of steady revenue, so it may be Harris' intention to benefit from GE's established position in this market.

GE's solid standard logic business, which it inherited from RCA, would be another area of appeal to Harris. GE Solid State ranked among the top 10 standard logic suppliers in 1987, with revenue of $110 million, and was the leading MOS logic supplier to the military market. We note that Harris pulled out of the bipolar gate array market in 1987, but the companies' combined MOS gate array revenue would move Harris up toward a top-10 spot. However, the more significant development would occur with respect to cell-based ICs: Revenue amalgamation, viewed in terms of 1987 revenue, would place the company as the second target supplier worldwide. Although Harris currently participates in the MOS PLD market, it does not do so to any great extent, and it retreated from the bipolar PLD market in 1985.

Why the Merger?

One has to wonder about Harris' objectives in undertaking this acquisition. Harris certainly would expand its presence in the semiconductor market, but more importantly, would expand its presence in the military semiconductor market. Harris reported fiscal 1988 sales and earnings showing a fourth-quarter decline in sales of 4 percent, to $538.4 million, and a 93 percent decline in income to $1.8 million. Sales were flat at $2.1 billion, and without the adoption of FAS No. 96 to offset a $33.1 million charge for asset revaluations and restructuring costs, the company would have reported a 23 percent decline in income for fiscal 1988, as opposed to the reported 19 percent increase.

From GE's perspective, its semiconductor operations did not fit into its long-term strategy of focusing on jet engines and major household appliances—markets where it is a leading supplier. This view is consistent with the company-stated goal of remaining among the top two suppliers in the markets that it serves. GE's semiconductor operations constituted one of the company's smaller support operations. Apparently, GE had decided that it needed only research, design, and limited manufacturing capability to support its aerospace and medical equipment businesses. GE's acquisition of RCA presented the challenge of integrating both captive and merchant operations. However, morale at GE, and more particularly at RCA, suffered somewhat as a result of the takeover.

Now Harris will face the challenge of integrating GE Solid State to its semiconductor sector reporting to Vice President Jon Cornell. Negotiations are not expected to be completed until year end. Many questions are still outstanding, such as: What are the implications of this transaction for GE's gate array agreement with VLSI Technology and for the agreement to cooperate with IBM on ASICs and power BICMOS products?

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