Semiconductor User Information Service
Newsletters 1986–1987

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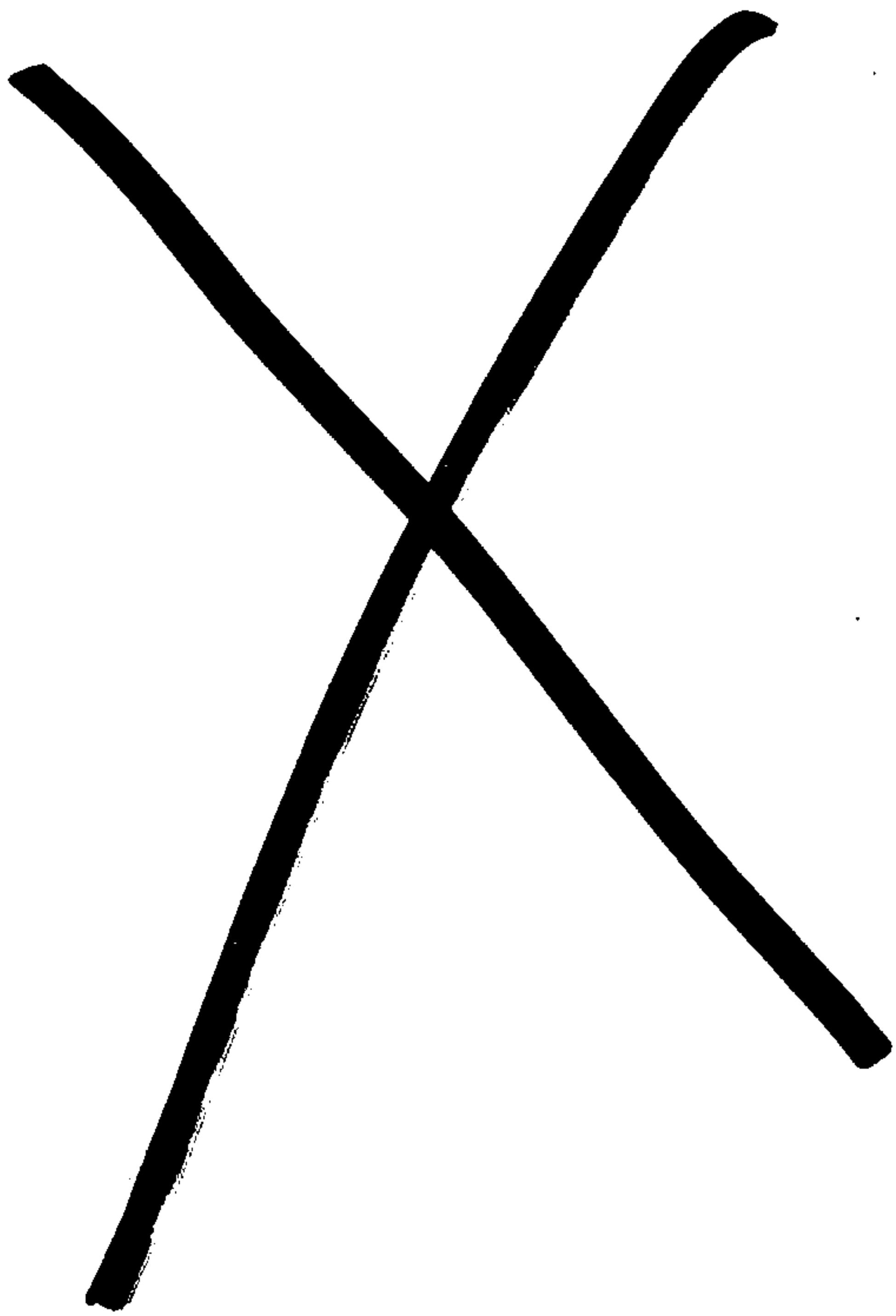

1987–1988 SUIS Newsletter Index

The 1987 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.
  - Pages 2 through 3 are a company list, e.g., LSI Logic.
  - Pages 4 through 7 are a subject list, e.g., Memory.
- The newsletter type, 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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Research Newsletter

SUIS Code: 1986–1987 Newsletters
1987–33

HIGH-SPEED CMOS STANDARD LOGIC SURVEY: USERS LEANING TOWARD FACT

SUMMARY

The ongoing demand for electronic systems with increased speed and reduced power has opened a new market for a high-speed CMOS (HSCMOS) logic family to replace the current higher-power TTL and slower CMOS logic devices. Two dominant suppliers of HSCMOS, National/Fairchild and Texas Instruments, now offer unique HSCMOS product families that differ in package configuration and perceived performance capabilities. The two families are: Fast Advanced CMOS Technology (FACT) developed by Fairchild, and Advanced CMOS Logic (ACL) developed by Texas Instruments. Much was written earlier this year comparing each company's products.

To better understand the logic user's perspective regarding these two alternatives, Dataquest recently conducted a survey of high-performance computer manufacturers to determine which, if any, had made decisions to use National/Fairchild's FACT or TI's ACL line. As shown in Figure 1, the sample of high-performance computer companies chosen represents a market that would likely push the limits of this technology. The survey revealed that although the majority of respondents have not decided on which type of HSCMOS to design into their systems, the FACT-compatible product was being looked at favorably by all for the following reasons:

- It has compatible pin-outs with older designs.
- There are more sources for FACT-compatible products.
- There are more FACT logic functions available.
- The product line provides necessary performance at an attractive price.

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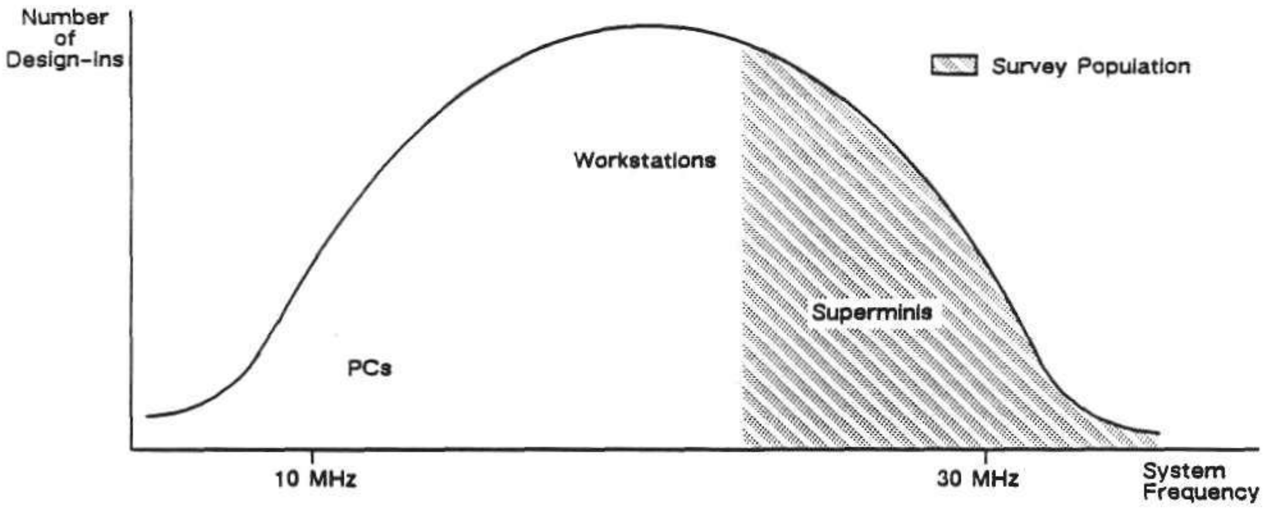
Figure 1

Advanced CMOS Standard Logic Applications



Source: Dataquest
December 1987

BACKGROUND

At the heart of the FACT/ACL controversy is a potentially fatal design problem known as the ground bounce effect (GBE). Ground bounce causes an unstable logic state that occurs in certain CMOS logic device applications. In its worst form, it causes false logic states in a system. GBE is usually not a concern in low-performance systems less than 20 MHz), but many believe that high-speed CMOS logic is particularly susceptible to it. National/Fairchild and TI have addressed GBE in their HSCMOS offerings using two entirely different methods.

The TI-ACL solution to the ground bounce effect has been to change the package configuration by adding an extra ground pin and moving the power voltage pins to the middle of the package. This reduces lead frame inductance and corresponding ground bounce and increases speed for all applications.

The National/Fairchild-FACT solution has used the old, standard pin configuration, enabling easy conversion of existing designs to the newer, higher-performance technologies. National/Fairchild purports that GBE is not a threat the majority of designs, and good design techniques could prevent it for the rest.

SURVEY RESULTS

Using a sample of six representative high-performance computer companies, Dataquest asked the following questions:

- Are you currently using high-speed CMOS logic in your designs? Two said yes, four are currently deciding.

- What type of high-speed CMOS are you using? Two respondents (33 percent) are using Fairchild's FACT family, four respondents (66 percent) favor the FACT solution.

- What determinants were used/are being used to decide on a HSCMOS solution (in order of importance)? All six respondents rated pin-out/package compatibility most important, multiple sourcing of product as second, and perceived performance equivalence as third most important. Four respondents considered the idea that FACT can be used as a TTL replacement to be important, ranking after those listed above.

- What is the decision flow used in deciding to go with HSCMOS? R&D decides system requirements, component engineering determines product availability/ manufacturability, and procurement determines cost.

- If you have decided on a HSCMOS vendor/solution, are you still studying alternatives? Of the two who are using HSCMOS, both said yes.

DATAQUEST CONCLUSIONS

The FACT-compatible product line appears to be the emerging volume HSCMOS family of choice by some high-end computer OEMs because of its adherence to design consistency, its availability (both vendor and number of products), its perceived performance equivalence, and its competitive pricing. Although all of the respondents to our survey were leaning toward or using the standard pin-out solution, those that are using FACT are also reviewing new designs where new sockets are needed. As additional products and sources become available for ACL, we believe that this family will become more attractive. In addition, another product line based on BICMOS technology (which TI and others are currently developing) promises to far exceed HSCMOS in GBE resistance, and offer superior performance as well.

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Research Newsletter

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1987–32

Q4 1987 PRICING TRENDS: BALANCE AT LAST

SUMMARY

This newsletter examines the results of the third-quarter price survey for four key areas; memory, standard logic, microprocessors, and ASICs. Overall pricing trends for 1988 show a gradual flattening for commodity semiconductor products, as supply comes into balance with demand. High-speed and high-density devices, as well as surface-mount packaged parts, will continue to have high prices due to the high demand for these parts. The impact of the relaxation of Japanese production controls has not yet been felt in the market but will become more pronounced by mid-1988, as the increased availability of affected memories will keep prices on a gradual decline. This may be tempered by further weakening of the dollar against the yen. For this reason, a close watch must be kept on the dollar/yen exchange rate, as any decline below ¥130 to the dollar will impact all Japanese semiconductor products. Any effect of stock market instability on semiconductor procurement patterns has yet to be felt and is being closely watched by our analysts.

PRICING TRENDS IN KEY SEMICONDUCTOR PRODUCTS

Memory

DRAM prices are flattening for the 256K density, while the 1Mb parts will gradually decline as demand increases and more vendors shift their capacity to meet the increased order rates. This trend is shown in Figure 1. Prices for faster or surface-mount products will take a 15 to 20 percent premium, due to the current high demand for these parts.

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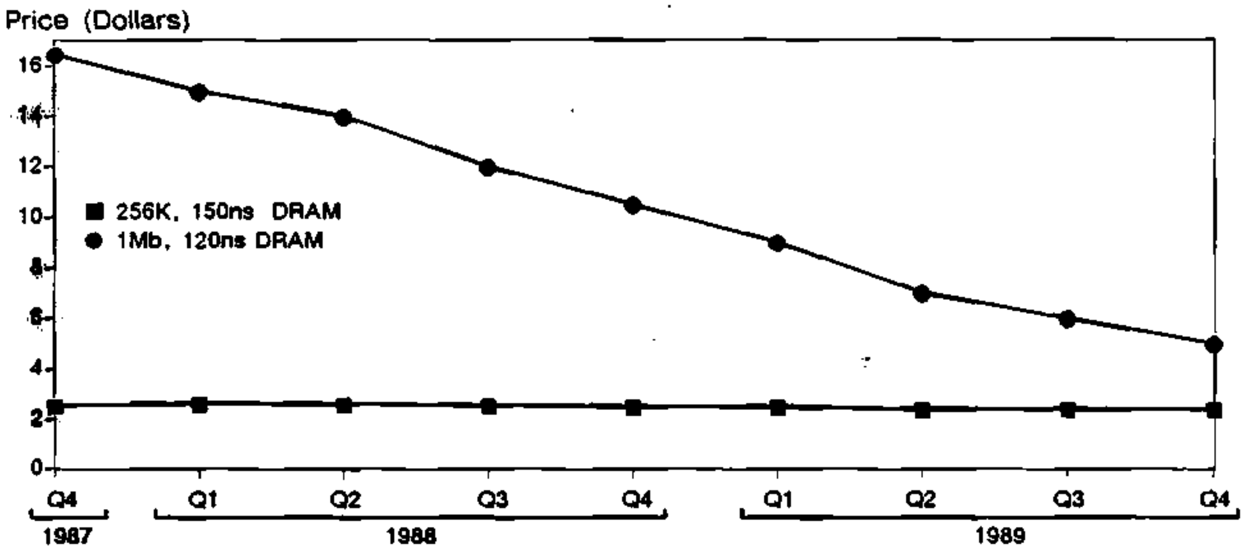
Figure 1

DRAM Price Trends



Source: Dataquest December 1987

DRAM lead times are currently ranging from 14 to 16 weeks and are expected to continue at this pace until mid-1988, when it is expected that they will decline as 1Mb production ramps up, meeting pent-up demand. EPROM pricing trends remain relatively stable, as the additional capacity put in place earlier this year begins to meet demand. As a result, lead times have come down to as low as 4 to 8 weeks for 256K EPROMs and have increased to as high as 16 to 26 weeks for 64K, 128K, and 1Mb densities. Slow SRAMs continue to show flat pricing in an indirect response to the close monitoring by the DOC and MITI. Fast SRAMs, on the other hand, show much more aggressive pricing trends, due to the number of vendors and products vying for market share. Low-density SRAM lead times range from 4 to 8 weeks, while lead times for high-density parts range from 8 to 10 weeks.

Standard Logic

Standard logic pricing trends can be differentiated into two areas: the mature families (74S, 74F, 74HC, and 74LS) and the new families (ACS and FACT/ACT). The mature standard logic pricing trends are expected to rise slightly in 1988, relative to the historically low prices seen throughout most of 1987. The new logic family prices will gradually decline throughout 1988, as capacity grows to meet demand and as these parts become more pervasive in the marketplace. The shift to ASIC solutions for logic consolidation continues to affect the standard logic arena, especially in the CMOS families and, now, also in the ECL area, as ECL gate arrays become more popular. The primary effect of the shift in demand to the ASIC solution has incrementally increased supply, thus moderating affected standard logic prices.

Microprocessors

Overall microprocessor prices are expected to decline gradually throughout 1988 and 1989. The rates of decline within the different bit families varies, however. The 8-bit arena will show the slowest declines in price (approximately negative 5 to negative 10 percent), while the prices of 16-bit devices will come down about 10 to 15 percent in 1988. The 32-bit market will see the steepest relative decline in price (from negative 15 to negative 20 percent), as increased availability of the Intel 80386 is expected by the second quarter of next year. The increased supply of 80386s due in early 1988 will be a delayed response to pent-up demand that has kept overall 1987 32-bit MPU price ranges relatively higher than was anticipated.

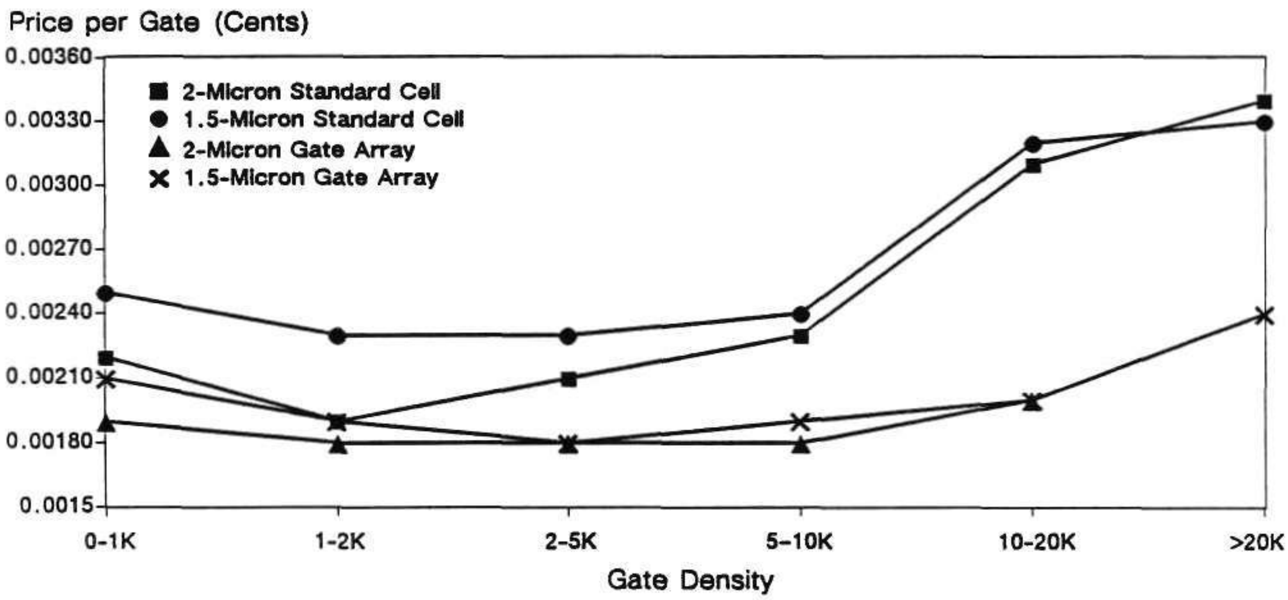
ASICs

ASIC prices have generally remained unchanged since our last survey, with one exception: a price trend differentiation between gate array technologies of more than 2 microns and less than 1.5 microns. The 1988 pricing trends for gate arrays of 2 microns in geometry show relatively flat pricing trends, with prices per gate ranging from $0.0018 to $0.0020. Depending on the density, per-gate prices of 1.5 micron devices will range from $0.0018 to $0.0024 in 1988. The current survey confirmed the trend of the trade-off between higher prices per gate and lower NRE charges, compared with lower gate costs and respectively higher NRE charges for a given density among different gate array vendors.

Figure 2 shows how gate arrays continue to hold a price edge over standard cell designs across all density ranges. This continuing preference for cost-efficient gate arrays over cell-based designs has relegated standard cells to applications in which size and speed requirements mandate this solution for proprietary designs.

Figure 2

1988 ASIC Pricing Trends



Source: Dataquest
December 1987

DATAQUEST CONCLUSIONS

As supply comes into balance with demand and market intervention effects are reduced, prices for commodity semiconductors are expected to flatten and then gradually decline, beginning in the second quarter of 1988. State-of-the-art, high-speed, high-density, or surface-mount packaged products will continue to take price premiums of 20 percent or higher, with lead-time adders of four to six weeks. Current Japanese pricing is at parity with U.S.-based dollar pricing. The dollar-to-yen exchange rate will adversely affect Japanese semiconductor prices if the yen falls below ¥130 to the dollar. Contracts for Japanese products should have a clause basing prices on the exchange rate at the time of the contract, in order to protect against fluctuations in the financial arena. Close communication between buyers and vendors remains a key differentiator for priority service.

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Research Newsletter

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1987–31

GOMAC-87: "CHALLENGES FACING GOVERNMENT ELECTRONICS IN THE 1990s"

The 1987 Government Microcircuits Applications (GOMAC) conference was held in Orlando, Florida, on October 27 through 29, 1987. Approximately 1,000 attendees participated in 21 sessions on subjects ranging from IC design concepts to discontinued parts. Due to time constraints, parallel sessions were held, up to four at a time, making it necessary for those involved in defense programs to split up their delegations in order to attend as many sessions as possible. Exhibits of products, services, and capabilities of more than 30 companies were on display in an area adjoining the lecture halls. This newsletter discusses some highlights of this important conference.

VHSIC INSERTION

Progress in VHSIC insertion was reported by most of the participating companies. Many of the exhibits featured examples of VHSIC chips and their application to defense electronics systems. The presentations indicate that VHSIC technology has been applied to a wide range of hardware including ruggedized computers, imaging systems, digital signal processing (DSP) functions, and radar electronics.

SIGNAL PROCESSING

Applications of silicon or Si/GaAs IC technology to signal processing problems have been accomplished by numerous defense electronics suppliers. For example, TRW described its superchip family and presented data on its high-performance 6-bit analog-to-digital converter (ADC). The TRW ADC uses a GaAs front end to drive a silicon bipolar flash quantizer.

Bipolar Integrated Technology, Inc. (Beaverton, Oregon), presented a family of integer and floating-point DSP circuits based on its 2.0μ silicon bipolar process. The company claims that the process offers the higher speeds of ECL at the VLSI functional density of CMOS.

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VTC (Bloomington, Minnesota) has developed a bipolar cell library of analog/digital cells for signal processing applications. The bipolar structures use complementary transistors with f_T of 6 GHz (NPNs) and 1 GHz (PNPs). The cell library is augmented with components for use in customization.

MIL-STD-1750A

Performance Semiconductor presented and displayed information on its 40-MHz VHSIC-class PACE 1750A system. The system is a CMOS three-chip set consisting of a central processor unit, a processor interface chip, and a memory management unit/combination support chip. The set provides system performance greater than 2 mips. Performance Semiconductor supports its PACE 1750A with a product line consisting of the world's fastest CMOS SRAMs, with chip densities ranging through 256Kx1.

Other companies presenting information on 1750A architectures and products included Allied Signal, General Electric, IBM, Loral, Texas Instruments, TRW, and UTMC.

GaAs SEMICONDUCTORS

GaAs has been applied to high-performance military electronics for several reasons, among which are frequency response and speed superior to silicon, and inherent radiation hardness. General Electric described innovations in using GaAs to implement radar transmit/receive modules.

Several companies, including AT&T, GAIN Electronics, Raytheon, TriQuint, and TRW, made presentations or displayed information about their progress in developing and producing GaAs ICs. AT&T is offering a 1-GHz divide-by-128/129 prescaler, the DG1096AX. The circuit is fabricated using GaAs E/D MESFET process and comes in 8-lead flatpack or DIP. The chip consumes less than 40mW and has TTL/MOS-compatible I/Os.

GAIN Electronics Corporation is marketing a family of gate arrays including its GFL6000. This product is a 5,776-gate array with 204 I/O buffers, 3W maximum power dissipation, and unloaded gate delays of 100ps. I/Os may be CMOS-, TTL-, or ECL-compatible. Package options include chip carriers and pin-grid arrays. The company is processing production orders for its gate arrays.

Raytheon offers GaAs IMPATT diodes for selected applications. The devices are specified to 60-GHz frequency and 10W output power, and to 44-GHz and 25W output. The devices are produced at the research division in Lexington, Massachusetts.

TriQuint is producing a 3,000-gate ASIC array called the TQ3000, which has 1,020 core cells and 64 I/Os. NRE charges are $80,000 including design manual and workstation software. The ASIC is supported by Daisy, Mentor, and Tek/CAE workstations.

TRW is developing microwave and millimeter wave ICs for communications and other defense applications. TRW, Honeywell, and General Dynamics compose one of the DOD teams developing this technology; TRW is the prime contractor for this team.

RELIABILITY AND FAULT TOLERANCE

The United States Air Force has launched a program called R&M 2000. In implementing this program, the Air Force Systems Command is challenging the electronics industry with specific goals, such as "double-R, half-M" (double the reliability and half the maintenance) and 2,000-hour MTBF for line-replaceable units (LRUs), to be met by defense contractors.

TRW summarized the historical development of fault diagnosis and presented fault-tolerant methodologies that lend themselves to present-day design activities. The discussion emphasized the need for increased focus on fault-tolerance in future designs.

Fault-tolerant software was the subject of a joint paper by Westinghouse, SRI International, and NASA. The authors described a distributed general-purpose, fault-tolerant operating system for use on VHSIC 1750A processors.

Intel reported close work between its Military Operation (Chandler, Arizona) and one of its major accounts to significantly reduce incoming VLSI reject rates. The company said it plans to extend the approach to other customers.

Lockheed described a design methodology for extending traditional fault-tolerant design techniques to analog functions. Included are techniques for self-test, self-diagnosis, and self-correction, previously used only in digital circuit design.

TESTABILITY

Honeywell made two presentations on VHSIC testability and maintainability. The first described a control function block to be included on-chip. The second described a standard design methodology for producing inherently testable systems on a consistent basis.

Teradyne has developed a tester calibration architecture for VHSIC modules. The company says the system calibration allows maintaining a maximum of ±1.5ns skew at 40-MHz frequency across more than 400 pins.

Silicon Compiler Systems described the growing importance of integrating test development into the design process. The company's exhibit included a demonstration of its automatic test generation (ATG) system.

A joint presentation was made by VTC, Inc., and Control Data Corporation describing a rad-hard standard cell testability structure. Other companies presenting information on testability included Mitre, Unisys, and UTMC.

RADIATION HARDNESS

Two of the GOMAC sessions and more than a dozen papers were devoted to radiation hardness. LockHeed, M/A-COM, Motorola, VTC, and others made presentations on this subject.

The UTMC exhibit included information on its UTB-R and UTD-R rad-hard gate array families and other rad-hard products. The UTMC products are designed to withstand these levels of radiation:

- Data sheet specification operation to 2×10^5 rads (Si) total dose
- Functional to 10^6 rads (Si) total dose
- No upset of less than 10^9 rads (Si)/s dose rate
- Dose rate latch-up $>10^{10}$ rads (Si)/s
- Neutron fluency 10^{14} N/cm

DISCONTINUED PARTS

The life cycles of many commercial IC devices and families are shorter than those of most military electronics equipment. As the rate of technological change increases, discontinued parts generate a growing set of problems to defense contractors. Four organizations made presentations of methods useful in resolving some of these problems.

Honeywell, for example, has developed a replacement for many of the (DTL) functions that are no longer procurable. The replacement device is a 16-pin bipolar generic array. Another company, SAIC, has worked with DESC on an R&D program to develop TTL, LSTTL, ECL, linear, and other emulation devices for fabrication on a bipolar baseline process at a silicon foundry.

PACKAGING AND INTERCONNECTION

Kyocera Corporation, Kyoto, Japan, displayed state-of-the-art packages at its exhibit. The company claims world leadership in technical ceramics. One of the more exotic of Kyocera's products was a 1,700-pin grid array (PGA) of approximately 15-square inches.

Kyocera has steadily increased its account penetration in the United States and is a leading supplier to VHSIC chip houses. This raises an interesting issue regarding DOD's dependence on foreign suppliers.

Dow Corning Corporation has developed materials for implementing a novel hermetic package concept for improved chip reliability. The approach is called surface protected electronic circuits (SPEC) and involves applying multiple layers of polymeric materials directly to the circuits.

Honeywell discussed a package design that may in many instances solve the problem of having to tool separate packages to accommodate various chip designs and multiple chip suppliers. A joint paper by Interamics and Texas Instruments described a package development to support multiple VHSIC chips in a single ceramic module.

DATAQUEST CONCLUSIONS

Although much progress has been made in semiconductors for military applications, major challenges remain. The R&M 2000 initiative, requiring doubling of MTBFs and halving maintenance, is but one example.

Although great strides are being taken in domestic chip technology, it appears that the U.S. defense industry still relies heavily on a sole foreign source for large-volume production of IC packages. This is not new; the situation has existed for several years. Two questions remain:

- Is reliance on non-United States-based sources of electronic parts really a high-priority matter?
- If so, who in the industry or in Washington is responsible for working on the packaging issue, and what is the timetable for resolution?

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Research Newsletter

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INTEL TARGETS "HIDDEN" MCU APPLICATIONS

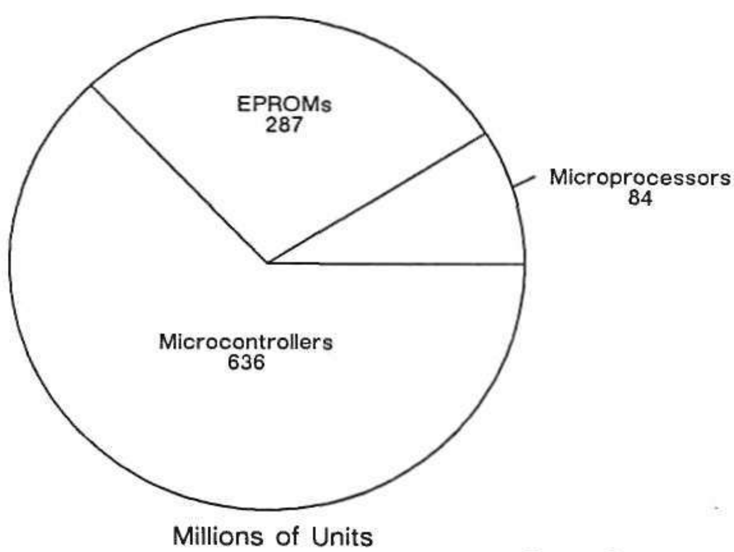
SUMMARY

Intel has launched an aggressive strategy to capture demand from users of systems incorporating embedded controllers—the "hidden intelligence" in everyday products like automobiles and VCRs. Embedded control is defined as nonreprogrammable applications that remain unchanged during a system's product life cycle. Figure 1 depicts the three component markets served by Intel. Key points in Intel's program are as follows:

- Strategy: to combine architectural leadership and low-cost manufacturing to win design-ins of systems with long life cycles
- Implementation: to cash in on Intel core architecture by growing a family of standard and application-specific products
- For users: a critical decision of whether to go with Intel for the long haul or to choose an alternative supplier

Figure 1

Markets Served by Intel in 1987



Source: Dataquest
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THE TARGETED MARKETS

As shown in the figure, the microcontroller business offers the largest market opportunity: more than half a billion units will be shipped on a worldwide basis in 1987. Designers of systems using 8-bit parts can expect a strong commitment from Intel now and in the future, and the company will certainly participate in the ramping up of 16-bit production that should occur later in this decade.

THE CORPORATE STRATEGY

Intel's strategy for serving demand for microcontrollers and microprocessors that are used in nonreprogrammable applications (i.e., "hidden intelligence" applications) derives from its three-pronged corporate strategy. The Intel corporate attack calls for the following:

- Technological leadership
- World-class manufacturing capability
- "Vendor of choice" status among the customer base

INTEL'S SEMICONDUCTOR APPLICATION MARKETS (SAMs)

Figure 2 depicts Intel's SAMs for embedded controllers as of 1985. Although these end markets are shifting, the figure gives a good picture of Intel's current demand mix, provides a basis for discussing future trends, and holds one surprise, given Intel's high visibility in the office automation business. The surprise is that computers and office systems constitute less than half (i.e., 46 percent) of the end demand for Intel microcontrollers. The other semiconductor application markets represent significant business opportunities that the firm fully intends to cultivate over the long term.

Other Significant SAMs

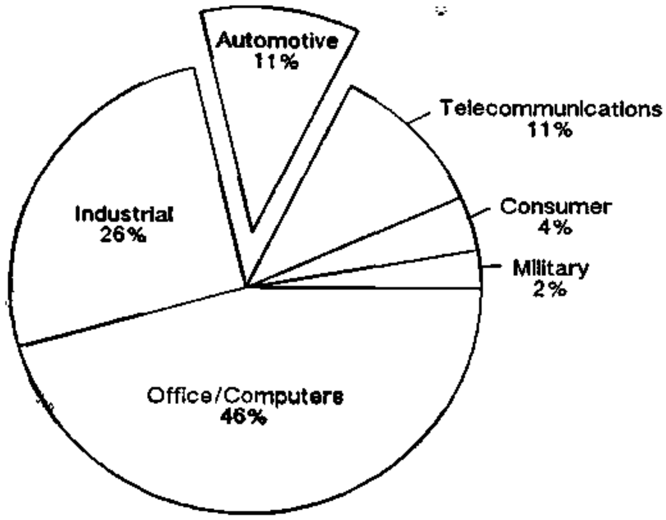
As Figure 2 shows, Intel's other SAMs include the following: industrial (26 percent); automotive (11 percent and growing), telecommunications (11 percent), consumer (4 percent), and military (2 percent). The exploding automotive electronics marketplace represents a major growth opportunity for the company. Intel takes great pleasure in pointing to the fact—unbeknownst to most users of the product—that the Ford Taurus uses Intel's embedded controllers, which are crucial to its award-winning performance. In fact, Ford Motors is Intel's second largest customer (IBM is first).

The relatively small consumer and military segments have also caught the eye of Intel corporate strategists. The military segment may be small in terms of overall revenue, but it is a strong contributor to profits and product positioning/development (e.g., the 80386 chip).

Similarly, Intel sees an opportunity for application-specific 8- and 16-bit designs geared for the consumer market. Service to users with application-specific objectives like this marks a keystone of Intel's future product direction.

Figure 2

Intel Embedded Controllers by Segment
(Intel Shipments—1985)



Source: Intel
Dataquest
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IMPLEMENTATION OF INTEL'S STRATEGY IN THE 8–, 16–, and 32–BIT MARKETS

Architectural Leadership

The first prong of Intel's embedded microcontroller market strategy entails the preservation and extension of its leadership position in microcontroller/microprocessor architecture. The strategy is quite straightforward: to build upon successful 8-bit parts (e.g., 8086/8, 8048, 80C51) as the road to achievement in 16-bit (80186/80C186, 8096/80C196) and 32-bit segments, as well as application-specific standard products (for high-volume applications) and ASICs. In the 32-bit arena, Intel plans to introduce the 80376 device during the second quarter of 1988.

Designer's Vendor of Choice

To win new design-ins, Intel offers design engineers three "flexible" product delivery vehicles derived from given Intel microcontroller core architectures. The three product vehicles are standard products, application-specific standard products (as noted, for high-volume applications), and ASICs.

Intel will use its large microcontroller sales and field-application forces to aggressively implement the corporate strategy. Another key to establishing the firm as the vendor of choice for systems designers is expansion of the global network of training and support centers, and the development of new CAD/CAE and hardware tools.

World-Class "Low-Cost" Manufacturing Capability

To establish itself as the vendor of choice among purchasing managers, Intel has strengthened its capacity toward the goal of high-volume/low-cost production that competes in terms of both cost and quantity against Asian manufacturers. Intel tripled its capacity between 1985 and 1987.

AGGRESSIVE PRODUCT DEVELOPMENT STRATEGY

Intel plans a very aggressive product development strategy in the embedded controller marketplace for two reasons. First, these devices are consumed in a wide diversity of applications. Second, the life cycles of both the microcontrollers and the systems using them can be quite long: 10 to 15 years for the embedded controllers and up to 50 years for some systems (e.g., power distribution systems). These twin realities--the tremendous diversity of applications and long product life cycles--create both opportunity and challenge for Intel in terms of customer support.

To illustrate, a design-win leader like the 80186 part can secure as many as 2,000 applications. Embedded usage contributes to both the broader utilization and longer life cycle of the 80386 device. The long-term results can be summarized by the 8048 chip: its wide diversity of applications and consequently long life cycle has resulted in the greatest number of these embedded controllers being shipped in its tenth year of production (i.e., 1987).

Embedded Microcontroller Applications

A representative (although nonexhaustive) listing of the applications for embedded controllers is as follows: alarm clocks, thermostats, TV channel decoders, VCRs, lighting systems, electronic scales, watering systems, hot water systems, CD players, coffee makers, microwaves, automobiles (four per auto), pool control systems, traffic light systems, automotive radar, gas pumps, cash registers, facsimile equipment, copiers, personal computers (keyboards, disk drives/controllers, interface, and printers), PBXes, typewriters, and telephones.

A Challenge for Intel: Expanding 8-Bit Functionality

Although Intel promises users of 8-bit through 32-bit embedded controllers that it will dependably and "flexibly" meet demand over long product life cycles, some concern exists among users of 8-bit devices regarding the pressing need for increased on-board functionality.

For designers and builders of systems employing 8-bit embedded controllers, systems innovation could be stifled and costly upgrades mandated because of the lack of timely availability of desired features.

8- and 16-Bit Cash Cores/Prolific Calves

Nevertheless, users of 8- and 16-bit microcontrollers and microprocessors should find themselves in a supportive environment. Intel's strategy calls for a set of "cash cow" (or "cash core") devices like the 8051 and 80186 families to serve as the basis for a prolific set of application-specific cash calves. For example, the 8051 device leads simultaneously to a growing set of standard parts (80C51, 8052), application-specific standard parts (80C452, 80C51FA, 80C152) and ASICs (UC51). Users should receive a dependable supply of low-cost, high-volume standard products and application-specific standard parts, and an option for proprietary ASICs. In turn, Intel earns revenue and profits on its technological expertise at every turn without killing the original cash core.

IMPACT ON USERS

Intel's embedded controller strategy is part and parcel of the well-defined megatrend in the semiconductor industry toward closer, long-term vendor/customer relationships. Intel plans to win the hearts and minds of systems designers through technological leadership and customer support, and to win purchasing managers through dependable, lower-cost supply over long product life cycles.

Users of Intel's embedded controllers consistently report several system advantages through use of these devices, and just as consistently demand more of the same in terms of Intel product improvement. Users report enhanced system-design flexibility and associated ease of software configuration. Embedded control reduces system size and component count, and thus cost. Superior system maintenance capability also contributes to cost savings. By "converting" system hardware into firmware, embedded control loads many mundane system processes from the main control complex and pushes system functionality downward from the main complex to the portboard. The overall result is smaller, more reliable, and less costly systems that offer higher levels of performance and functionality.

For future systems, users demand higher performance (e.g., high-speed direct memory access), increased on-board functionality (such as 14-bit A/D conversion), and lower cost. Intel will be pressed to meet these kinds of user needs quickly.

DATAQUEST CONCLUSIONS

For Users in General

The Intel embedded controller strategy signals the supplier's effort to reassert itself in the microcontroller arena. This is a large market and still growing. The prospect of Intel core architecture in high volume and at competitive cost marks a genuine opportunity that should be explored by systems designers and purchasing managers. For users, embedded control can mean smaller, less costly systems offering higher performance. Intel faces a dual challenge, however, in carrying through as a dependable low-cost supplier and in meeting on a timely basis users' incessant demands for increased on-board chip functionality.

Regarding Intel-Committed Customers

For users already committed to Intel as the vendor of choice for embedded controllers, the strategy should simplify long-term procurement. Intel's strategy calls for a host of 8-, 16-, and 32-bit devices and three vehicles for delivering these products. Strong vendor support from Intel for users can be expected into the 1990s. Intel is committed to supplying users over the long life cycle of the users' systems, but as noted, a tension will exist between user demand for increased on-board chip functionality and Intel's ability and willingness to serve that need in a timely fashion.

For Uncommitted Users

For users who have not made a long-term commitment to a vendor, careful assessment must be given to the major points contained herein. Uncommitted designers and buyers should also give careful scrutiny to alternative suppliers like AMD, Motorola, National Semiconductor, NEC, Signetics, and Zilog, which are also aggressively pursuing this growing market.

Ronald Bohn

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Research Newsletter

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1987-29

HIGHER DRAM PRICES FORECAST: THE POLITICS OF PRICING

DRAM prices are followed religiously by manufacturers, buyers, and industry watchers because of their dollar significance. Lately, the trend in DRAM prices has confounded observers because of political influences that are shaping the prices, availabilities, and vendor shares of both 256K and 1Mb DRAMs. Dataquest expects political forces to influence DRAM prices through the end of 1988. As a result, we predict a continuing rise in 256K DRAM prices coupled with a slow decline in 1Mb DRAM prices in the United States through the end of 1988, as shown by Table 1. The effect will be the postponement of a 5X price-per-bit crossover from the first quarter to the third quarter of 1988 and the postponement of a 4X crossover to the end of next year. The crossover is expected to be driven more by the 256K DRAM price increase than by the drop in 1Mb DRAM prices, contrary to historical patterns.

Table 1

U.S. DRAM PRICE TRENDS*

	1987				1988			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
256K DRAM (150ns)	$ 2.15	$ 2.37	$ 2.50	$ 2.65	$ 2.75	$ 2.85	$ 2.95	$ 3.00
1Mb DRAM	$20.00	$18.00	$15.50	$17.00	$16.00	$15.00	$13.00	$11.00

*Volume: 100,000/year

Source: Dataquest
September 1987

FORECAST ASSUMPTIONS

The major reasons and assumptions behind this forecast are as follows:

- Contract prices in Japan have recently increased to $2.30 for 256K DRAMs and $14.70 for 1Mb DRAMs, from approximately $1.80 and $12.50, respectively. This increase will tend to raise Japan-made DRAM prices in the United States to avoid dumping and cover the extra costs and profit margins of selling in the United States. It is also an indication that Japanese manufacturers are not likely to significantly increase their 256K DRAM production levels and that they expect their 1Mb DRAM supply to be short with respect to demand.

- U.S. 1Mb DRAM merchant vendors are lagging sorely behind their Japanese counterparts. If 1Mb DRAM prices are allowed to follow their present course, U.S. manufacturers may be unable to sell at prices that allow recovery of development costs, causing damage in the long run to the U.S.-based DRAM industry. To prevent another trade conflict, it is likely that the Japanese government will not allow this, instead slowing 1Mb DRAM prices until U.S. vendors hit acceptable production volumes--expected about the middle of 1988.

- Most 256K DRAM manufacturers are at full capacity and have shown few signs of significantly increasing capacities. The buildup of 1Mb DRAM capacity has been slow, hindered by wide gaps in foreign market values (FMVs) as determined by the U.S. Department of Commerce and with most new production volumes expected in third quarter 1988. This reluctance to add capacity partially stems from the red ink that flowed during the overcapacity months of 1986.

- Dataquest expects a healthy 20 percent growth in semiconductor consumption in 1988. DRAM manufacturers' attitude is still one of caution in raising production capacity; this supply/demand disparity will help buoy prices. We further expect MITI to continue its export controls and strong advisories on DRAM production levels. Although MITI attempts to fine-tune production to demand, Dataquest believes that the resources dedicated to this activity are few and that there is a greater tendency toward being conservative in production increases.

DATAQUEST ANALYSIS

Increased demand in 1988, near-capacity DRAM production, reluctance to increase capacity, and continuation of MITI production controls are factors supporting the forecast increase in DRAM prices through 1988. We believe that FMVs will be academic and the gray market will continue to flounder. The driving force behind this is the will of the Japanese government to comply with the semiconductor trade arrangement, in the hope of lifting the trade sanctions. The recently beleaguered DRAM manufacturers stand to gain, having shown more of a concern for profits than for costly market share. However, this will not sit well with DRAM buyers.

Are the motivations behind these events justified? It is true that DRAM manufacturers cannot continue building leading-edge DRAMs at a loss or with meager profit margins, and that the existence of U.S. DRAM manufacturers is strategically important to the long-term competitiveness of the U.S. electronic equipment industry. The cost to many DRAM buyers, however, may be too high. Many of them may ask: Has this semiconductor trade arrangement really helped?

Mark Giudici
Victor de Dios

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Research *Bulletin*

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NATIONAL SEMICONDUCTOR ACQUIRES FAIRCHILD

National Semiconductor Corporation's acquisition of the worldwide semiconductor business of Fairchild Semiconductor Corporation, announced Monday, August 31, sent ripples of surprise through the industry, despite earlier rumors that National had tended an offer for Fairchild. The surprise was not only that Fairchild's parent company, Schlumberger of France, had decided against the management buy-out proposed by Fairchild president Don Brooks, but that Fairchild was sold for the bargain basement price of $122 million in National Semiconductor common stock and warrants.

Once the U.S. Justice Department approves the merger, which National expects it to do by the end of September, all of Fairchild's assets will be transferred to National, with the exception of Fairchild's wafer fabrication facilities in Nagasaki, Japan, and Wasserburg, West Germany. For the time being, Fairchild will operate as a wholly owned subsidiary of National, with all its current products and programs remaining intact. Over time, however, the Silicon Valley company that spawned Advanced Micro Devices, Intel, National Semiconductor itself, and Signetics and will exist only as a memory of high technology's halcyon days.

Through the acquisition of Fairchild, National emerges as a more formidable world power in the semiconductor business. Based on its 1986 semiconductor revenue of $990 million, combined with Fairchild's revenue of $495 million, National now ranks as the sixth largest chip maker in the world. Without including Fairchild's revenue, National would rank in 11th place in 1986 (see Table 1).

The sheer size of a combined National Semiconductor/Fairchild is of less significance than the impact of this monumental merger on specific semiconductor markets. In the integrated circuit (IC) segment of the semiconductor market, National now vies with Motorola as the second largest supplier among U.S. manufacturers. Table 2 provides National/Fairchild's market share rankings in a number of key IC product areas.

Of particular potency in the ASIC market is the combination of National's strength in bipolar programmable logic devices and Fairchild's leadership in emitter-coupled logic (ECL) gate arrays. Together with the merged clout in the overall bipolar digital domain, one can appreciate National President Charlie Sporck's statement that a combined National/Fairchild becomes "a major factor in supplying the data processing industry."

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Table 1

REVISED 1986 WORLD SEMICONDUCTOR MARKET SHARE RANKING
AFTER NATIONAL/FAIRCHILD MERGER
(Millions of Dollars)

1985	1986	Company	1985	1986	Percent Change
1	1	NEC	$1,984	$2,638	33.0
4	2	Hitachi	$1,671	$2,305	37.9
5	3	Toshiba	$1,468	$2,261	54.0
2	4	Motorola	$1,830	$2,025	10.7
3	5	Texas Instruments	$1,742	$1,782	2.3
9	6	National	$ 925	$1,485	60.5
6	7	Philips	$1,068	$1,361	27.4
7	8	Fujitsu	$1,020	$1,309	28.3
10	9	Matsushita	$ 906	$1,204	32.9
11	10	Mitsubishi	$ 642	$1,140	77.6

Table 2

NATIONAL SEMICONDUCTOR/FAIRCHILD 1986 MARKET SHARE RANKINGS
IN SELECTED IC PRODUCT SEGMENTS
(Millions of Dollars)

IC Segment	1985 Rank	1986 Rank	1985 Revenue	1986 Revenue	Percent Change
Linear	2	1	$370.0	$481.0	30
Bipolar Digital	8	2	$194.0	$547.0	282
Standard Logic	5	2	$211.0	$500.5	237
ASIC	*	7	$ 31.9	$118.1	370

*Not in top ten
Note: Standard logic and ASIC revenue includes MOS and bipolar products.

Source: Dataquest
September 1987

While it is not clear what the near future holds for Fairchild's management, Dataquest salutes the efforts that Don Brooks and his team have expended in turning around a Silicon Valley pioneer and pointing it in a bold new direction. Dataquest believes that by the fourth quarter of this year, the combined operations of National Semiconductor and Fairchild will be running at a revenue rate of $2 billion. Managing the destiny of the sixth largest semiconductor company in the world will require the best management skills the new monolith can apply from both of its combined members.

Penny Sur
Michael J. Boss

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Research Newsletter

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REGIONAL SHIFTS IN SEMICONDUCTOR MARKET SHARE

SUMMARY

U.S. companies' share of the worldwide semiconductor market (measured in U.S. dollars) declined to 40 percent in 1986, down from 45 percent in 1985. Correspondingly, Japanese companies' share increased to 47 percent in 1986, up from 42 percent in 1985. Rest of World companies also gained share, supplying 2 percent of the worldwide semiconductor market in 1986. The apparent gain in share by Japanese companies was largely due to the effect on the valuation of the worldwide market due to the rise in the exchange rate of the Japanese yen against the U.S. dollar. The U.S. dollar declined 42.5 percent against the yen in 1986.

U.S. companies' share of the North American semiconductor market declined only slightly, from 78 percent in 1985 to 77 percent in 1986. Japanese companies' share of the Japanese semiconductor market was a steady 91 percent in both 1985 and 1986. Japanese companies' share of the North American market rose slightly from 14 percent in 1985 to 15 percent in 1986. North American companies lost some share of the Japanese market, dropping from 9 percent in 1985 to 8 percent in 1986.

WORLDWIDE SEMICONDUCTOR MARKET

U.S. companies captured 40 percent of the worldwide semiconductor market in 1986, down from 45 percent in 1985 and 48 percent in 1984 (see Figure 1). Japanese companies' share increased to 47 percent in 1986, up from 42 percent in 1985 and 40 percent in 1984. European companies held 11 percent in 1986, 12 percent in 1985, and 11 percent in 1984. Rest of World companies' share grew from 1 percent in 1984 and 1985 to 2 percent in 1986.

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The Japanese market has become the largest regional segment of the worldwide semiconductor market. Based on our annual census of worldwide semiconductor manufacturers, 39 percent of 1986 shipments were to Japan, up from 33 percent in 1985 and 30 percent in 1984. North America received 33 percent of worldwide semiconductor shipments in 1986, down from 39 percent in 1985 and 45 percent in 1984 (see Figure 2). Semiconductor shipments to the Rest of World region reached 9 percent of worldwide shipments in 1986.

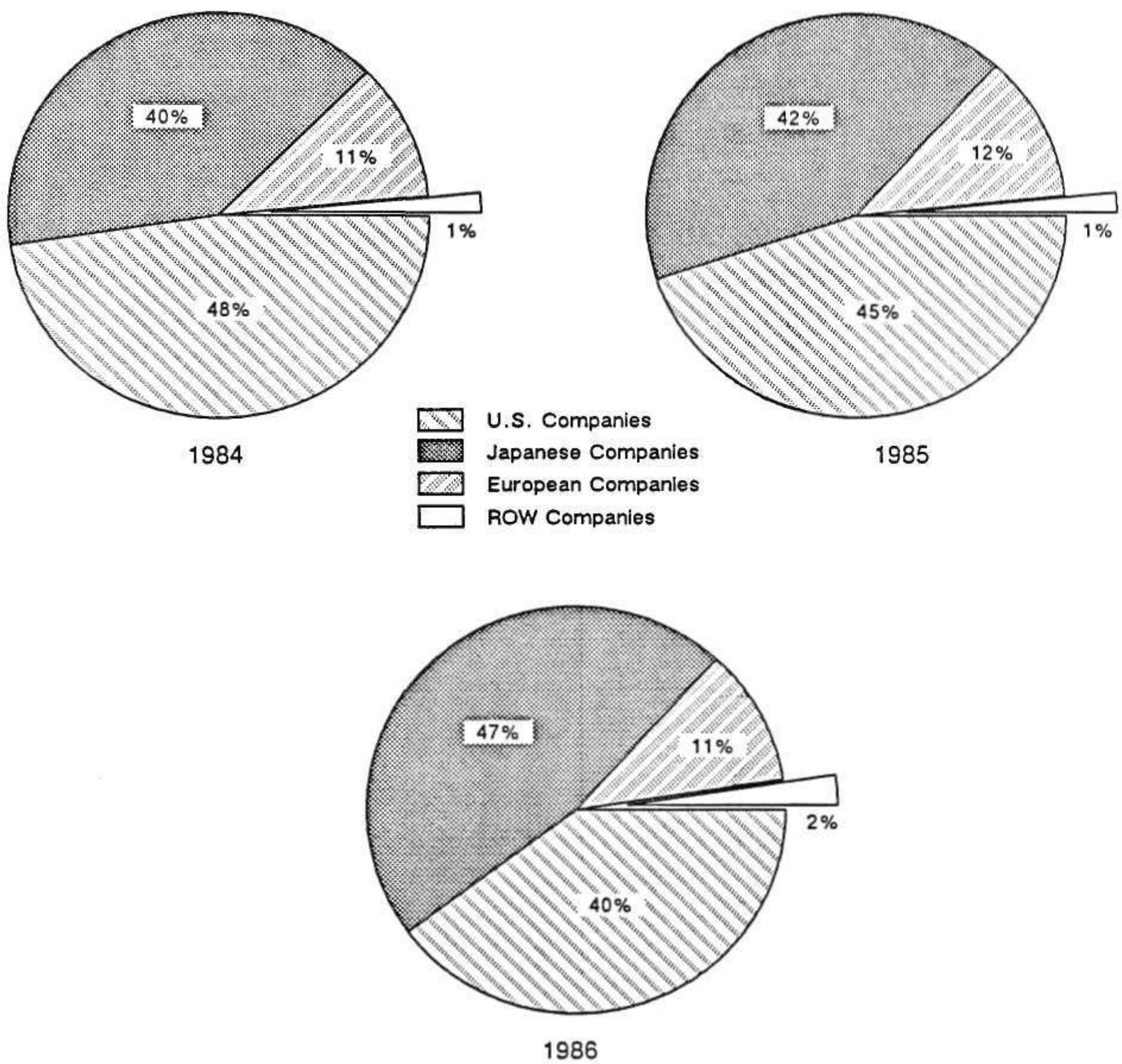
Japanese companies held the dominant position among the top ten worldwide semiconductor manufacturers in 1986 (see Table 1), confirming the rankings Dataquest reported in January 1986. Nine companies each earned more than $1 billion in semiconductor revenue in 1986, six of which were Japanese. All six Japanese companies gained market share in 1986 over 1985, while all three U.S. companies in the top ten lost share. This occurred in the wake of a steep 42.5 percent fall of the U.S. dollar against the Japanese yen in 1986.

NEC, Hitachi, and Toshiba captured the top three positions, with Motorola dropping to the fourth position. Motorola barely participated in the largest regional segment, i.e., the Japanese semiconductor market, deriving only 5 percent of its 1986 semiconductor revenue from that market. Intel dropped to the last position in the top ten, displaced by Fujitsu, Matsushita, and Mitsubishi. Intel lost share in all regions in its bread-and-butter MOS microdevice category.

The worldwide industry concentration in 1986 remained roughly the same as in 1985, with the top five companies holding 36 percent and the top ten companies holding 56 percent of the worldwide semiconductor market.

Figure 1

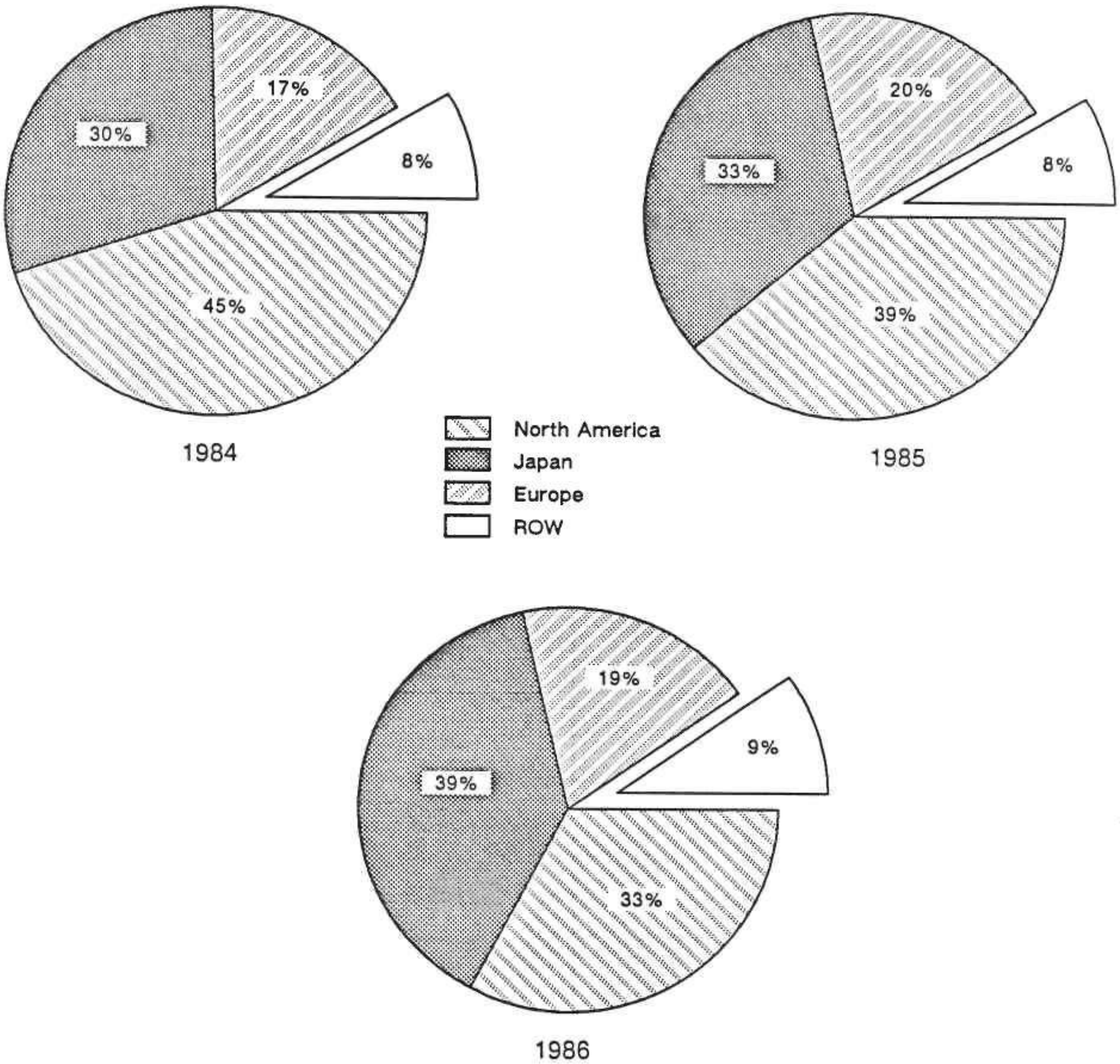
WORLDWIDE SEMICONDUCTOR MARKET SHARE
BY REGIONAL COMPANIES



Source: Dataquest
September 1987

Figure 2

WORLDWIDE SEMICONDUCTOR MARKET
SIZE BY REGIONS



Source: Dataquest
September 1987

Table 1

WORLDWIDE SEMICONDUCTOR MARKET

1986 Rank	1985 Rank	Company	1986 Share	1985 Share
1	1	NEC	8.7%	8.2%
2	4	Hitachi	7.6%	6.9%
3	5	Toshiba	7.5%	6.0%
4	2	Motorola	6.7%	7.5%
5	3	Texas Instruments	5.9%	7.2%
6	6	Philips-Signetics	4.5%	4.4%
7	8	Fujitsu	4.3%	4.2%
8	10	Matsushita	4.0%	3.7%
9	11	Mitsubishi	3.8%	2.7%
10	7	Intel	3.3%	4.2%

Source: Dataquest
September 1987

NORTH AMERICAN SEMICONDUCTOR MARKET

U.S. companies dominated the North American market in 1986, capturing a 77 percent share, compared with 78 percent in 1985 and 74 percent in 1984. Japanese companies' share was 15 percent, compared with 14 percent in 1985 and 17 percent in 1984. European companies lost share from 9 percent in 1984 to 8 percent in 1985 and 7 percent in 1986. Rest of World companies supplied only 1 percent of the North American market in 1986.

The top ten companies in the North American semiconductor market are listed in Table 2. The top five places were held by U.S. companies, but four of these companies lost market share in 1986. The market leader, Motorola, maintained share by growing faster than the market in bipolar logic and MOS microdevice categories, offsetting lost share in the MOS memory market.

Though there were no shifts in the rankings among the top five, the industry concentration dropped from 41 percent held by the top five in 1985 to 37.5 share held by the top five in 1986. Toshiba and NEC were the only companies in the top ten that gained market share and edged up in rankings. The industry concentration of the top ten dropped from 57 percent market share in 1985 to 53.5 share in 1986. For the most part, this fall in concentration is due to the emergence of smaller companies that opened up growth areas such as ASICs.

Table 2

NORTH AMERICAN SEMICONDUCTOR MARKET

1986 Rank	1985 Rank	Company	1986 Share	1985 Share
1	1	Motorola	13.0%	13.0%
2	2	Texas Instruments	8.4%	9.8%
3	3	Intel	6.2%	7.4%
4	4	National Semiconductor	6.0%	6.4%
5	5	Advanced Micro Devices	3.9%	4.3%
6	7	Hitachi	3.9%	3.9%
7	6	Philips-Signetics	3.4%	4.0%
8	8	Fairchild	3.2%	3.5%
9	10	Toshiba	2.9%	2.3%
10	13	NEC	2.6%	2.1%

Source: Dataquest
September 1987

JAPANESE SEMICONDUCTOR MARKET

Japanese companies maintained an overwhelming 91 percent of the Japanese semiconductor market in both 1985 and 1986, up from 89 percent in 1984. The U.S. companies' share of this market declined from 11 percent in 1984 to 9 percent in 1985 and to 8 percent in 1986.

The top five companies in the Japanese semiconductor market are shown in Table 3. NEC remained the market leader in 1986, despite losing some share to Toshiba and Mitsubishi, both of which gained significant share. Nine of the top ten are Japanese companies, the exception being ninth-ranked Texas Instruments (TI). The Japanese semiconductor industry is the most highly concentrated in the world, with the top five companies in the Japanese semiconductor market maintaining a 61 percent share and the top ten holding a whopping 82 percent share in both 1985 and 1986.

Table 3

JAPANESE SEMICONDUCTOR MARKET

1986 Rank	1985 Rank	Company	1986 Share	1985 Share
1	1	NEC	17.0%	18.4%
2	3	Toshiba	13.4%	12.0%
3	2	Hitachi	12.9%	12.6%
4	4	Matsushita	9.1%	9.8%
5	6	Mitsubishi	8.2%	6.8%

Source: Dataquest
September 1987

EUROPEAN SEMICONDUCTOR MARKET

U.S. companies saw their share of the European semiconductor market erode from 53 percent in 1984 to 51 percent in 1985 and 46 percent in 1986. This drop occurred in the wake of a 26.5 percent decline in the U.S. dollar against the weighted-average European currencies (ECU) in 1986. European companies gained share from 36 percent in 1984 to 38 percent in 1985 and 41 percent in 1986. Japanese companies increased their share to 13 percent in 1986 from 11 percent in both 1984 and 1985.

The top five companies in the European semiconductor market are shown in Table 4. Though the rankings remained stable from 1985 to 1986, Texas Instruments and Motorola lost share to the European companies. TI grew much slower than the market in its bread-and-butter bipolar logic category, and it lost share in the MOS memory and linear markets. Motorola outpaced the market in MOS microdevices but lost significant share in MOS memory, MOS logic, and bipolar logic. Philips-Signetics gained share as a result of the consolidation of Signetics into Philips. If we were to consolidate SGS into Thomson, it would place the combined entity at the second rank in 1986, displacing TI.

The concentration of the European semiconductor industry rose slightly with the top five companies improving their share from 41 percent in 1985 to 42 percent in 1986. The top ten companies' share of the market was about 62 percent in 1985 and 1986.

Table 4

EUROPEAN SEMICONDUCTOR MARKET

1986 Rank	1985 Rank	Company	1986 Share	1985 Share
1	1	Philips-Signetics	14.4%	12.4%
2	2	Texas Instruments	8.3%	9.8%
3	3	Motorola	7.5%	8.1%
4	4	Siemens	6.5%	5.6%
5	5	Thomson	5.3%	5.0%

Source: Dataquest
September 1987

REST OF WORLD SEMICONDUCTOR MARKET

Japanese companies maintained the dominant share of the Rest of World (ROW) semiconductor market, with 46 percent in 1984, 47 percent in 1985, and 48 percent in 1986. U.S. companies lost share from 33 percent in 1984 to 28 percent in 1985 and 26 percent in 1986. European companies and ROW companies each maintained a 13 percent share in 1985 and 1986.

The top five companies in the ROW semiconductor market are shown in Table 5. Motorola lost share to the Japanese companies in the ROW market, growing slower than the market in all categories other than MOS microdevices. Again, Philips-Signetics gained share as a result of the consolidation of Signetics into Philips.

Table 5

ROW SEMICONDUCTOR MARKET

1986 Rank	1985 Rank	Company	1986 Share	1985 Share
1	1	Toshiba	10.9%	10.1%
2	3	NEC	6.7%	5.6%
3	2	Motorola	6.6%	7.2%
4	4	Hitachi	6.6%	5.4%
5	10	Philips-Signetics	6.0%	3.3%

Source: Dataquest
September 1987

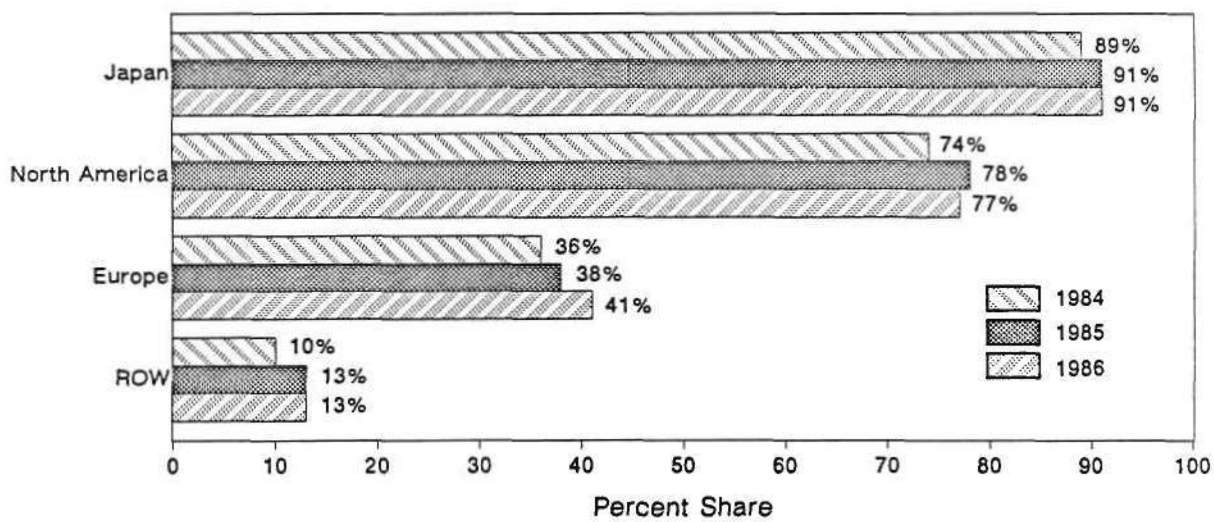
The concentration in the ROW semiconductor industry rose with the top five companies improving their share from 33 percent in 1985 to 37 percent in 1986. The top ten companies increased from 52 percent of the market in 1985 to 57 percent in 1986.

INDUSTRY ANALYSIS

Regional semiconductor industries in North America and Japan continue to derive the bulk of their revenue from native markets (see Figure 3). The dependence on local markets increased for all industries from 1984 to 1986. Local revenue in 1986 made up 77 percent of the ROW semiconductor industry revenue, 75 percent of the Japanese industry revenue, 67 percent of the European industry revenue, and 65 percent of the U.S. industry revenue. This analysis is based on regional industries defined by regional ownership rather than location of production.

Figure 3

NATIVE COMPANIES' SHARES OF NATIVE MARKETS



Source: Dataquest
September 1987

The dependence on foreign market revenue in 1986 was most pronounced for the U.S. semiconductor industry (22 percent of revenue from the European market), followed by the European industry (21 percent of revenue from the North American market), the ROW industry (17 percent of revenue from the North American market), and the Japanese industry (15 percent of revenue from the North American market). North America was the largest foreign market for the world companies.

The Japanese semiconductor industry had the largest share of a foreign market in 1986 (48 percent of ROW market), followed by the U.S. industry (46 percent of European market). The U.S. industry's share of the Japanese market in 1986 was 8 percent, down from 9 percent in 1985 and 11 percent in 1984. Conversely, the Japanese industry's share of the North American market in 1986 was 15 percent, compared with 14 percent in 1985 and 17 percent in 1984.

Detailed semiconductor market share information is available from Dataquest through various specific services. The Semiconductor Industry Service (SIS) provides worldwide semiconductor market share information. The Japanese Semiconductor Industry Service (JSIS) provides market share information for the Japanese market. The European Semiconductor Industry Service (ESIS) provides market share information for the European market. The Asian Semiconductor and Electronic Technology Service (ASETS) provides market share information for the Asia-Pacific market.

Joseph Borgia

Dataquest

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Conference Schedule

1987

Western European Printer	September 9-11	Palace Hotel Madrid, Spain
Computer Products	September 21-22	The Westford Regency Inn Westford, Massachusetts
Asian Information Systems	October 5-9	Tokyo American Club Tokyo, Japan
Technical Computers	October 5-7	Hyatt Regency Monterey Monterey, California
Semiconductor	October 19-21	The Pointe at Squaw Peak Phoenix, Arizona
Office Equipment Dealers	November 5-6	Hyatt Regency Monterey Monterey, California
Electronic Typewriter	November 6	Hyatt Regency Monterey Monterey, California
Electronic Publishing	November 16-17	Stouffer Hotel Bedford, Massachusetts
Asian Semiconductor and Electronics Technology	December 7	Asiaworld Hotel Taipei, Taiwan, ROC

1988

Semiconductor Users/ Semiconductor Application Markets	February 22-24	Westin St. Francis Hotel San Francisco, 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 16-18	Pier 66 Hotel and Marina Fort Lauderdale, Florida
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	Tokyo, Japan
Computer Storage	April 18-20	Silverado Country Club Napa, California
European Semiconductor	June 8-10	Gleneagles Hotel Auchterarder, Scotland
Display Terminals/Graphics and Imaging	June 13-15	Hyatt Regency Monterey Monterey, California

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Research *Newsletter*

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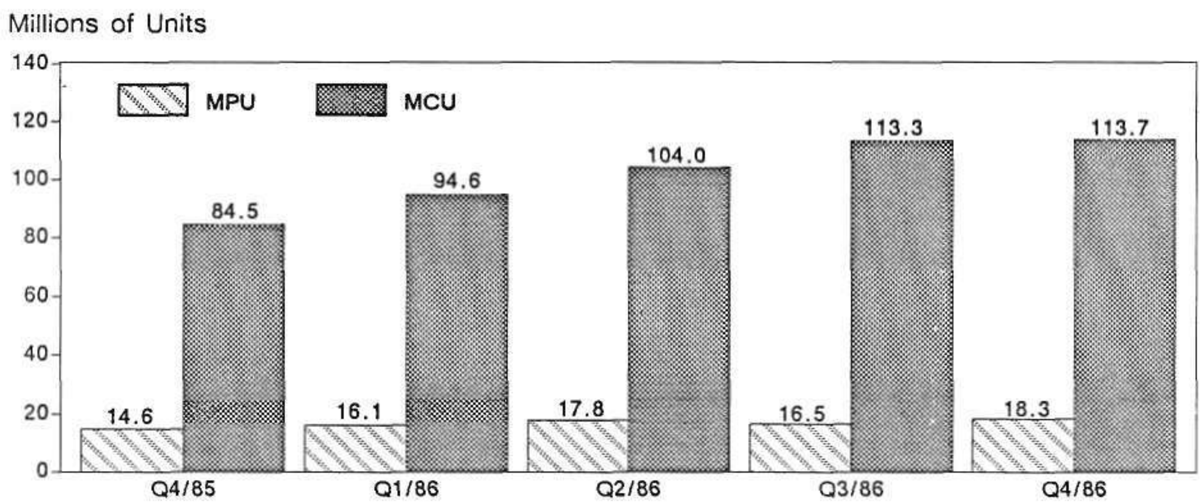
FOURTH QUARTER 1986 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the fourth quarter of 1986, worldwide microprocessor and microcontroller unit shipments increased by approximately 2.7 million units, or 2 percent, from second quarter 1986. Estimated shipments of all microcontroller devices totaled approximately 113.7 million units. Estimated shipments of all microprocessor devices totaled approximately 18.3 million units. Shipments of all MPU categories increased in the fourth quarter over the prior quarter's shipments, particularly shipments of 16-bit MPUs, displayed significant growth. Figure 1 shows MCU and MPU unit shipments from the fourth quarter of 1985 through the fourth quarter of 1986.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986
(Millions of Units)



Source: Dataquest
September 1987

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Table 1 shows the quarterly revenue for microcontrollers and microprocessors from the fourth quarter 1985 through the fourth quarter 1986.

Table 1

TOTAL MICROCONTROLLER AND MICROPROCESSOR REVENUE
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986
(Millions of Dollars)

	Q4/85	Q1/86	Q2/86	Q3/86	Q4/86
MCU	$300.0	$321.0	$358.0	$359.0	$340.0
MPU	104.8	122.0	136.0	143.0	171.0
Total	$404.8	$443.0	$494.0	$502.0	$511.0

Source: Dataquest
September 1987

MICROPROCESSOR COMMENTARY

Table 2 shows the change in total microprocessor unit shipments from the third quarter of 1986 through the fourth quarter of 1986, and Figure 2 illustrates the changes in 8- and 16-bit microprocessor shipments from fourth quarter 1985 through fourth quarter 1986.

Table 2

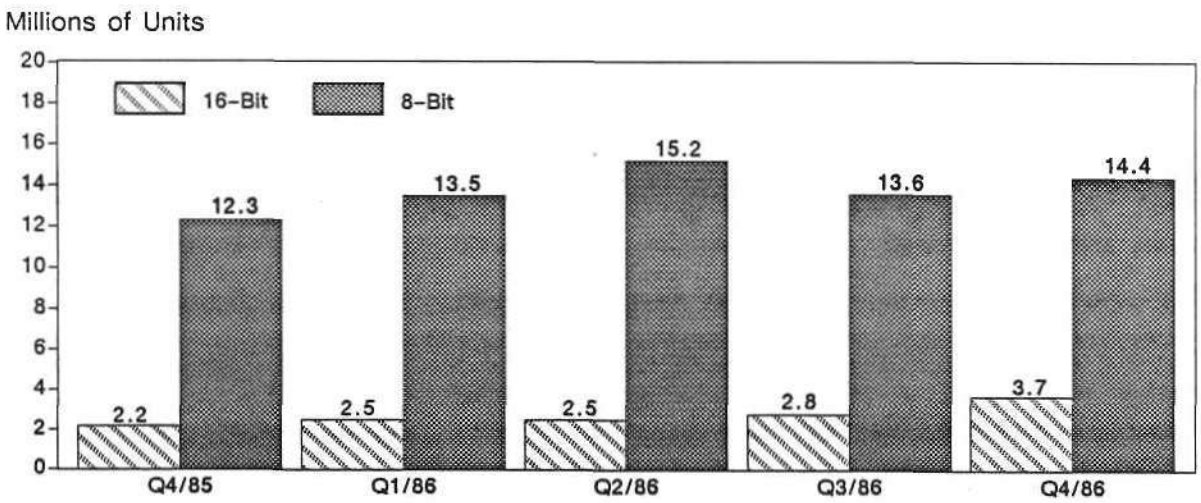
TOTAL MICROPROCESSOR UNIT SHIPMENTS
THIRD QUARTER 1986 THROUGH FOURTH QUARTER 1986
(Thousands of Units)

	Q3/1986		Q4/1986		Percent Growth
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
8-Bit	13,628	82.4%	14,385	78.7%	5.6%
16-Bit	2,789	16.8	3,733	20.4	33.9%
Others	129	0.8	164	0.9	27.1%
Total	16,546	100.0%	18,282	100.0%	10.5%

Source: Dataquest
September 1987

Figure 2

8- AND 16-BIT MICROPROCESSOR UNIT SHIPMENTS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986
(Millions of Units)



Source: Dataquest
September 1987

Table 3 shows the change in shipments of the leading 8-bit MPUs from the third quarter of 1986 through the fourth quarter of 1986, and Table 4 shows the changes in estimated shipments of 16-bit microprocessors from the third quarter of 1986 through the fourth quarter of 1986.

Table 3

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1986 THROUGH FOURTH QUARTER 1986
(Thousands of Units)

	Q3/1986		Q4/1986		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
Z80	5,411	39.7%	6,343	44.1%	17.2%
8085	2,290	16.8	2,103	14.6	(8.2%)
8088	1,530	11.2	1,502	10.5	(1.8%)
6802	910	6.7	954	6.6	4.8%
6809	796	5.8	759	5.3	(4.6%)
Others	2,091	19.8	2,724	18.9	1.2%
Total	13,628	100.0%	14,385	100.0%	5.6%

Source: Dataquest
September 1987

Table 4 shows the changes in estimated shipments of 16-bit microprocessors from the third quarter of 1986 through the fourth quarter of 1986.

Table 4

16-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1986 THROUGH FOURTH QUARTER 1986
(Thousands of Units)

Device	Q3/1986 Units	Q3/1986 Percent of Shipments	Q4/1986 Units	Q4/1986 Percent of Shipments	Percent Growth Q3 to Q4
80286	590	19.8%	1,210	21.3%	105.1%
68000/10	751	26.8	736	26.4	(2.0%)
8086	625	20.5	673	21.4	7.7%
80186	425	13.4	556	14.4	30.8%
V30	170	6.4	240	6.2	41.2%
Z8000	101	6.9	135	4.3	33.7%
32016	77	3.5	91	3.4	18.2%
Others	50	2.6	92	2.6	84.0%
Total	2,789	100.0%	3,733	100.0%	33.8%

Source: Dataquest
September 1987

Table 5 shows the market share changes in 8- and 16-bit MPU shipments (not consumption) by geographical region from fourth quarter 1985 through fourth quarter 1986.

Table 5

MARKET SHARE BY REGION FOR 8- AND 16-BIT MICROPROCESSORS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986

	Region	Q4/85	Q1/86	Q2/86	Q3/86	Q4/86
8-Bit MPUs	United States	37.3%	40.7%	51.5%	47.5%	48.8%
	Japan	55.0	41.0	38.1	43.5	40.9
	Europe	7.7	12.3	10.4	9.0	10.3
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
16-Bit MPUs	United States	73.6%	64.5%	73.4%	73.1%	73.6%
	Japan	22.0	29.0	17.9	19.3	18.8
	Europe	4.4	6.5	8.7	7.5	7.6
	Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
September 1987

MICROCONTROLLER COMMENTARY

Table 6 shows the change in total microcontroller unit shipments from the third quarter of 1986 through the fourth quarter of 1986, and Figure 3 illustrates the growth in 4- and 8-bit microcontroller shipments from fourth quarter 1985 through fourth quarter 1986.

Table 6

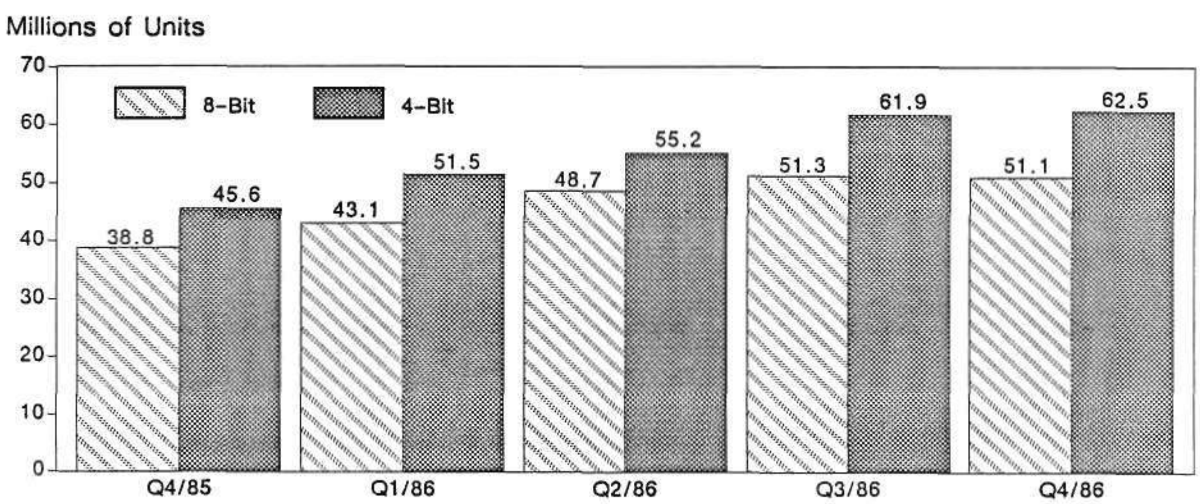
TOTAL MICROCONTROLLER UNIT SHIPMENTS
THIRD QUARTER 1986 THROUGH FOURTH QUARTER 1986
(Thousands of Units)

	Q3/1986		Q4/1986		Percent Growth
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
4-Bit	61,947	54.7%	62,512	55.0%	0.91%
8-Bit	51,255	45.2	51,104	44.9	(0.3%)
16-Bit	117	0.1	127	0.1	8.5%
Total	113,319	100.0%	113,743	100.0%	0.4%

Source: Dataquest
September 1987

Figure 3

4- AND 8-BIT MICROCONTROLLER UNIT SHIPMENTS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986
(Millions of Units)



Source: Dataquest
September 1987

Table 7 shows the changes in estimated shipments of 8-bit microcontrollers from the third quarter of 1986 through the fourth quarter of 1986.

Table 7

8-BIT MICROCONTROLLER SHIPMENTS
THIRD QUARTER 1986 THROUGH FOURTH QUARTER 1986
(Thousands of Units)

	Q3/1986		Q4/1986		Percent Growth
Device	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
8049	7,622	14.9%	7,699	15.1%	1.0%
6805	7,557	14.7	7,413	14.5	(1.9%)
8051	4,855	9.5	5,381	10.5	10.8%
8048	3,583	7.0	3,226	6.3	(10.0%)
Others	27,638	53.9	27,385	53.6	(0.9%)
Total	51,255	100.0%	51,104	100.0%	(0.3%)

Source: Dataquest
September 1987

Table 8 shows the market share changes in shipments (not consumption) by geographical region for 4- and 8-bit MCUs, from the fourth quarter 1985 through fourth quarter 1986.

Table 8

MARKET SHARE BY REGION FOR 4- AND 8-BIT MICROCONTROLLERS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986

	Region	Q4/85	Q1/86	Q2/86	Q3/86	Q4/86
4-Bit	United States	14.3%	19.6%	20.7%	20.2%	22.7%
	Japan	82.8	77.8	76.7	77.1	74.4
	Europe	2.9	2.7	2.6	2.7	2.9
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit	United States	44.1%	40.0%	38.3%	37.1%	38.6%
	Japan	42.4	44.4	45.4	46.8	44.1
	Europe	13.5	15.6	16.3	16.1	17.3
	Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
September 1987

Table 9 shows market share by technology for 8-bit microcontroller and microprocessor devices from the fourth quarter of 1985 through the fourth quarter of 1986, and indicates slightly increased shipments of 8-bit CMOS microcontrollers.

During fourth quarter 1986, approximately 80.3 percent of all 8-bit CMOS MCU shipments were Japanese-manufactured and shipped, and approximately 50.5 percent of all 8-bit CMOS MPU shipments were U.S.-manufactured and shipped.

Table 9

**MARKET SHARE BY TECHNOLOGY FOR MICROCONTROLLERS AND MICROPROCESSORS
FOURTH QUARTER 1985 THROUGH FOURTH QUARTER 1986**

Device	Technology	Q4/85	Q1/86	Q2/86	Q3/86	Q4/86
8-Bit MCU	CMOS	21.6%	23.3%	25.2%	26.6%	26.3%
8-Bit MCU	NMOS	78.4	76.7	74.8	73.4	73.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	19.5%	20.2%	19.1%	24.7%	25.1%
8-Bit MPU	NMOS	80.5	79.8	80.9	75.3	74.9
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
September 1987

DATAQUEST ANALYSIS

Dataquest estimates that revenue from microprocessor and microcontroller shipments for fourth quarter 1986 was $517 million, an increase of approximately 1.8 percent from the previous quarter. The preliminary data indicate that in terms of unit growth, total microcontroller and microprocessor shipments grew approximately 24.0 percent in 1986 over 1985, and corresponding revenue grew approximately 26.4 percent for the same period.

Ron Bohn
Patricia Galligan

Dataquest

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Dataquest

Conference Schedule

1987

Western European Printer	September 9–11	Palace Hotel Madrid, Spain
Computer Products	September 21–22	The Westford Regency Inn Westford, Massachusetts
Asian Information Systems	October 5–9	Tokyo American Club Tokyo, Japan
Technical Computers	October 5–7	Hyatt Regency Monterey Monterey, California
Semiconductor	October 19–21	The Pointe at Squaw Peak Phoenix, Arizona
Office Equipment Dealers	November 5–6	Hyatt Regency Monterey Monterey, California
Electronic Typewriter	November 6	Hyatt Regency Monterey Monterey, California
Electronic Publishing	November 16–17	Stouffer Hotel Bedford, Massachusetts
Asian Semiconductor and Electronics Technology	December 7	Asiaworld Hotel Taipei, Taiwan, ROC

1988

Semiconductor Users/ Semiconductor Application Markets	February 22–24	Westin St. Francis Hotel San Francisco, 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 16–18	Pier 66 Hotel and Marina Fort Lauderdale, Florida
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	Tokyo, Japan
Computer Storage	April 18–20	Silverado Country Club Napa, California
European Semiconductor	June 8–10	Gleneagles Hotel Auchterarder, Scotland
Display Terminals/Graphics and Imaging	June 13–15	Hyatt Regency Monterey Monterey, California

Dataquest
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Research Newsletter

SUIS Code: 1986-1987 Newsletters
1987-25

WHAT'S BEHIND OUR SEMICONDUCTOR FORECAST?

SUMMARY

Recently, Dataquest raised its 1987 North American semiconductor consumption forecast to 18 percent growth over 1986, up from the prior forecast of 12 percent. In terms of dollars, consumption will rise to $12.0 billion in 1987, up from $10.2 billion in 1986. Apart from the promising surge in bookings, our optimism is founded on an analysis of the trends in electronic equipment markets.

Dataquest's Semiconductor Industry Group examines the industry trends from several vantage points. The quarterly industry forecast of semiconductor consumption is based on a confluence of these viewpoints.

Besides our own independent survey and census procedures, we also analyze survey and census data published by sources such as the U.S. Department of Commerce (DOC) and the World Semiconductor Trade Statistics program (WSTS).

The Vantage Points

Dataquest views the semiconductor industry from several different perspectives. The industry participants are surveyed to assess the business conditions, the competitive environment, and product market directions. The pervasiveness and penetration of semiconductor applications are analyzed to gauge the long-term prospects for semiconductors. Semiconductor users provide valuable insight into the status of the electronic equipment markets and semiconductor buying patterns. Capital spending, capacity buildup, and capacity utilization are monitored to assess their impact on semiconductor availability and pricing, as well as prospects for equipment and materials suppliers to the semiconductor industry. Last but not least, the perspectives of constituents such as the investors, international trading partners, and the government are considered in our industry analysis.

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398, (408) 971-9000, Telex 171973

How to Interpret the Data

This newsletter presents an analysis of the trends in electronic equipment markets derived from the monthly data published by the DOC. Also included is a comparison of the trends in U.S. electronic equipment shipments with trends in U.S. semiconductor consumption.

The following figures show a three-month moving average of monthly data and rate of change measured as "12/12" or "1/12." The three-month moving average is a smoothing mechanism that brings out short-term variations along the trend line. The rate of change expressed as an annualized growth rate, or "12/12," is an averaging mechanism that points out the long-term trends and turning points, while smoothing out short-term seasonal variations. The 12/12 rate of change is the growth during the most recent 12-month period over a like 12-month period immediately preceding the current one. Note that for the month of December, the 12/12 rate of change is identical to the calendar year growth rate. The 1/12 rate of change is the change relative to the corresponding month a year ago.

CURRENT ELECTRONIC EQUIPMENT TRENDS

We are beginning to see signs of a turnaround in the electronic equipment markets. The major U.S. electronic equipment markets are segmented into computers and data processing equipment, communications, electronic instruments, and radio and television.

Computers and communications equipment accounted for more than half of U.S. semiconductor consumption in 1986, according to Dataquest Semiconductor Applications and Markets (SAM) estimates. The projected uptrend in these broad equipment segments points to a sustained recovery in semiconductor consumption in 1987 and 1988.

The computer industry is now poised for a bounce back to healthy growth. Though the three-month average shipments and bookings are down in computers and data processing equipment (see Figure 1), 12/12 shipments and bookings have turned (see Figure 2). The rate of decline in computers has been slowing since the last quarter of 1986 when the rate of decline in shipments reached an annual rate of 12 to 13 percent. Although bookings declined at an increasing rate during 1986, the annual rate reached flat levels in March 1987. We now look ahead to increasing growth in bookings. Inventories have been declining since early 1986 and are now at an all-time low. Inventory levels are now in the 9- to 10-weeks range compared with a 10-year average of about 12 weeks of average sales (see Figure 3). In short, the computer industry has turned around, and we should see strengthening growth by midyear as the trend continues.

Communications shipments trudged along (see Figure 4) and hit a cyclical low of about 6 percent annual growth rate in the last quarter of 1986 (see Figure 5). The rate of change has increased since then to about 8 percent annual growth this March, and the trend suggests that the run rate should continue to increase in the coming months. Bookings have been flat for more than a year now and should stage a comeback over the next few months as we enter the beginning of a two-year up cycle in this industry. Inventories declined to the current low level of about 12 weeks of average sales, compared with a 10-year average of about 13 weeks (see Figure 6).

We expect growth to pick up in electronic instruments because a similar turnaround also occurred in this industry at the turn of the year (see Figure 7) and inventory levels remain flat. Radio and television shipments have been on an up cycle for more than a year now, with a current run rate of about 15 percent annual growth in shipments (see Figure 8). We expect strong growth in this industry in 1987, followed by some weakening in 1988.

SEMICONDUCTOR CONSUMPTION

The U.S. semiconductor book-to-bill ratio had a strong showing at 1.20 for two months in a row in March and April of 1987. Three-month average bookings and billings have turned up (see Figure 9), and the book-to-bill trend is healthy (see Figure 10). Industry sources confirm a breadth in bookings momentum, allaying fear that we are seeing yet another PC bubble. The 12/12 trend in semiconductor bookings and billings (see Figure 11) suggests a stabilizing period prior to continued strength into 1988.

A monthly index (1977 = 100) of U.S. electronic equipment shipments and U.S. semiconductor consumption is shown in Figure 12. The long-term growth rates are comparable for electronic equipment shipments and semiconductor consumption. Note the deviation in 1983-1984 that is due to the abrupt takeoff in semiconductor consumption and the equally abrupt fall back to the trend line. The semiconductor index is now up sharply at 350. We expect the electronic equipment index to rise to the trend line, supporting further rise in the semiconductor index.

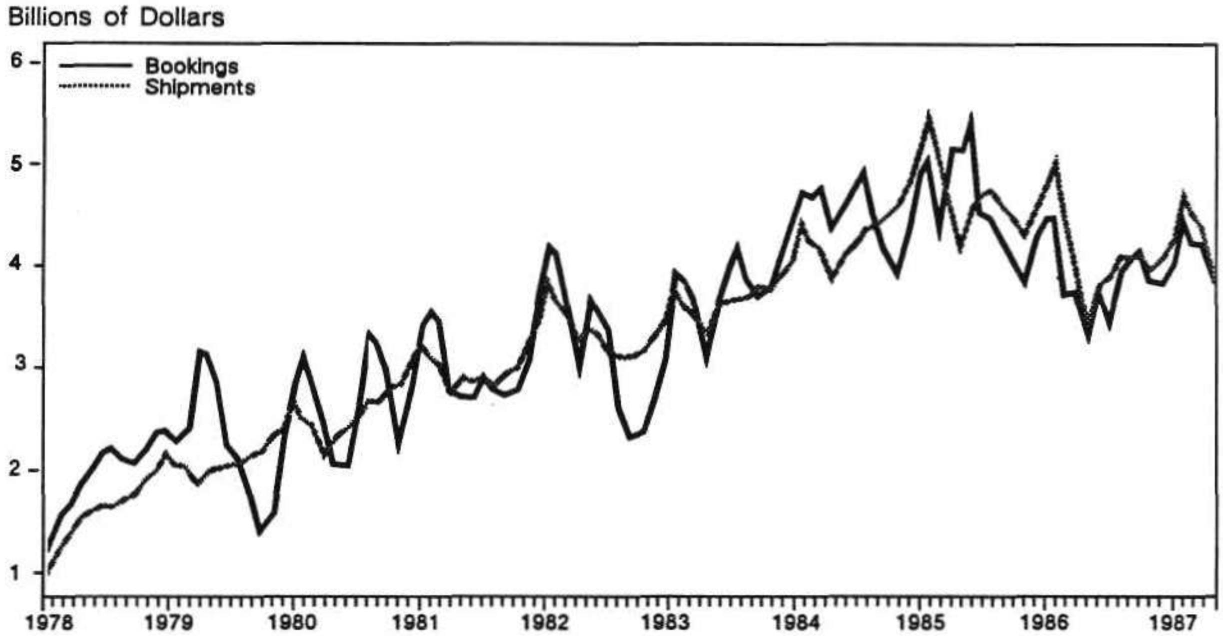
DATAQUEST CONCLUSIONS

The current strength in semiconductor bookings and the rising backlog point to a healthy growth in U.S. semiconductor consumption. Projected recovery in the computer and communication industries should sustain semiconductor consumption through the rest of 1987. As the recovery in the computer industry gathers momentum, semiconductor consumption will rebound in 1988.

Joseph K. Borgia

Figure 1

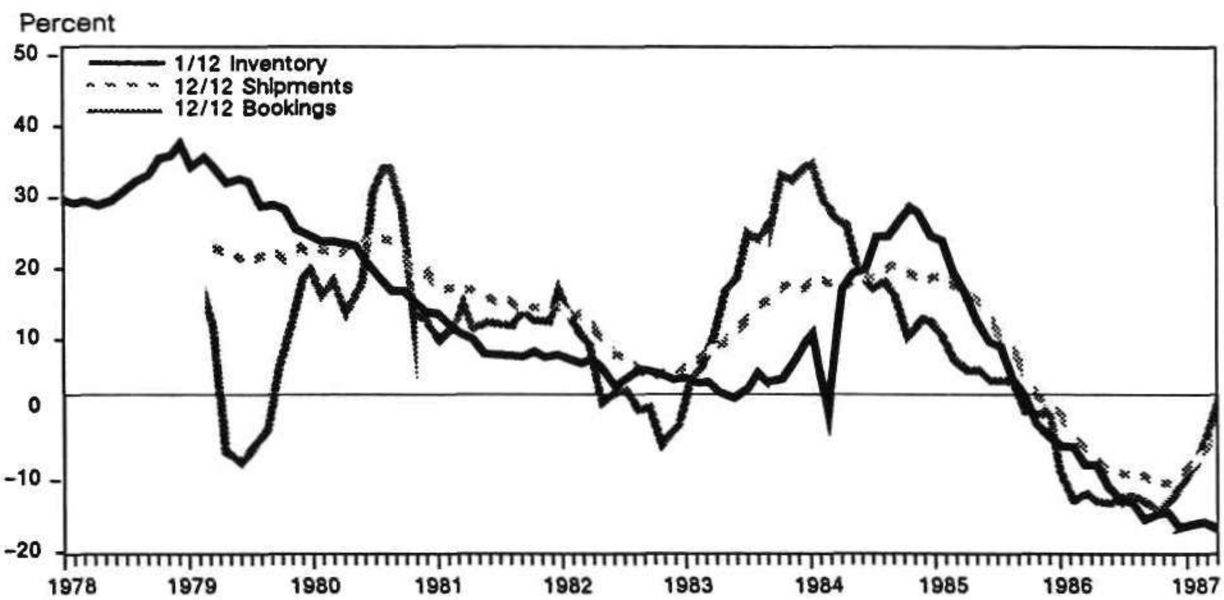
COMPUTERS AND OFFICE EQUIPMENT
THREE-MONTH AVERAGE SHIPMENTS AND BOOKINGS



Source: Dataquest
July 1987

Figure 2

COMPUTERS AND OFFICE EQUIPMENT
RATE OF CHANGE



Source: Dataquest
July 1987

Figure 3

COMPUTERS AND OFFICE EQUIPMENT
AVERAGE WEEKS OF INVENTORY

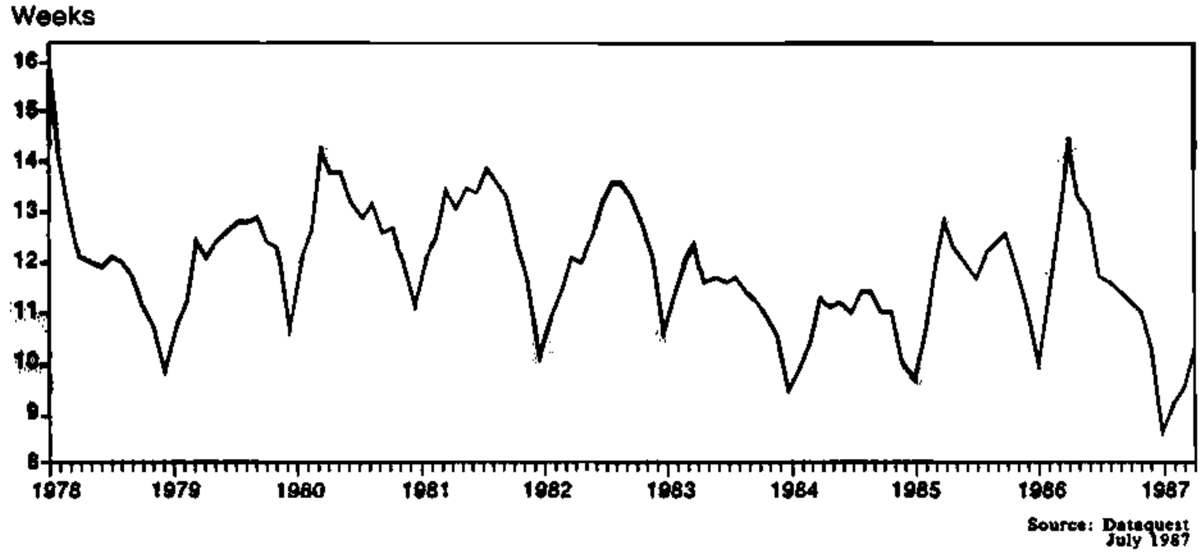


Figure 4

COMMUNICATIONS EQUIPMENT
THREE-MONTH AVERAGE SHIPMENTS AND BOOKINGS

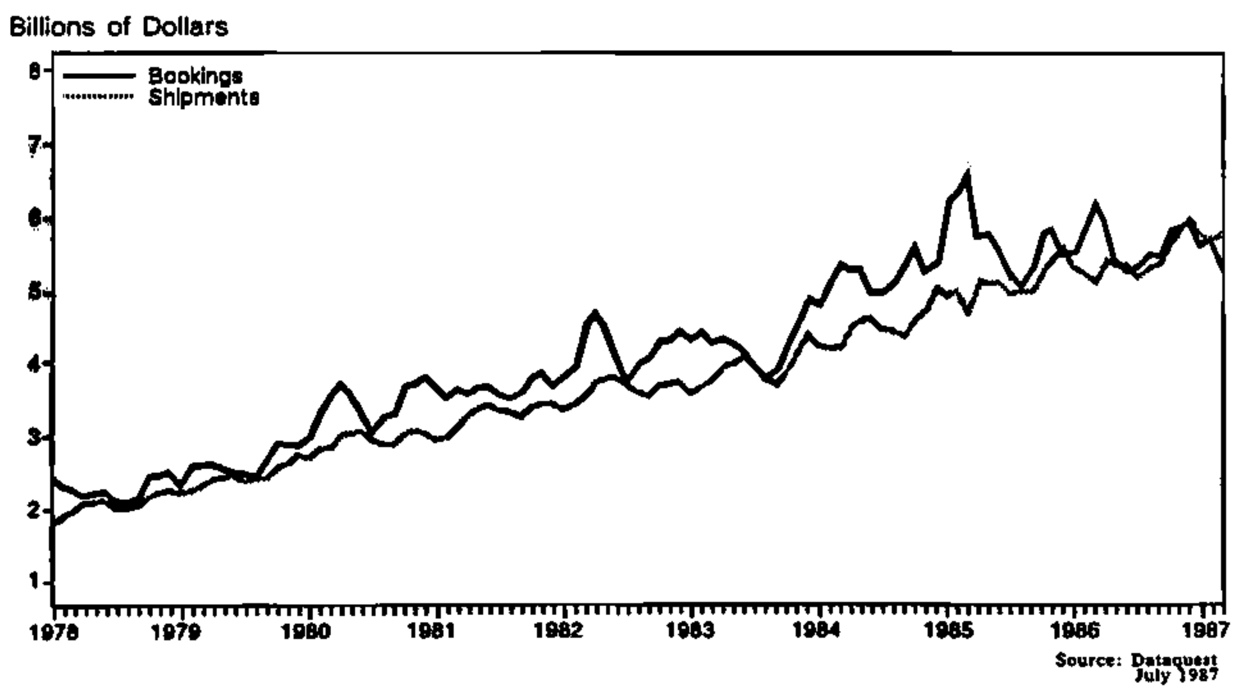
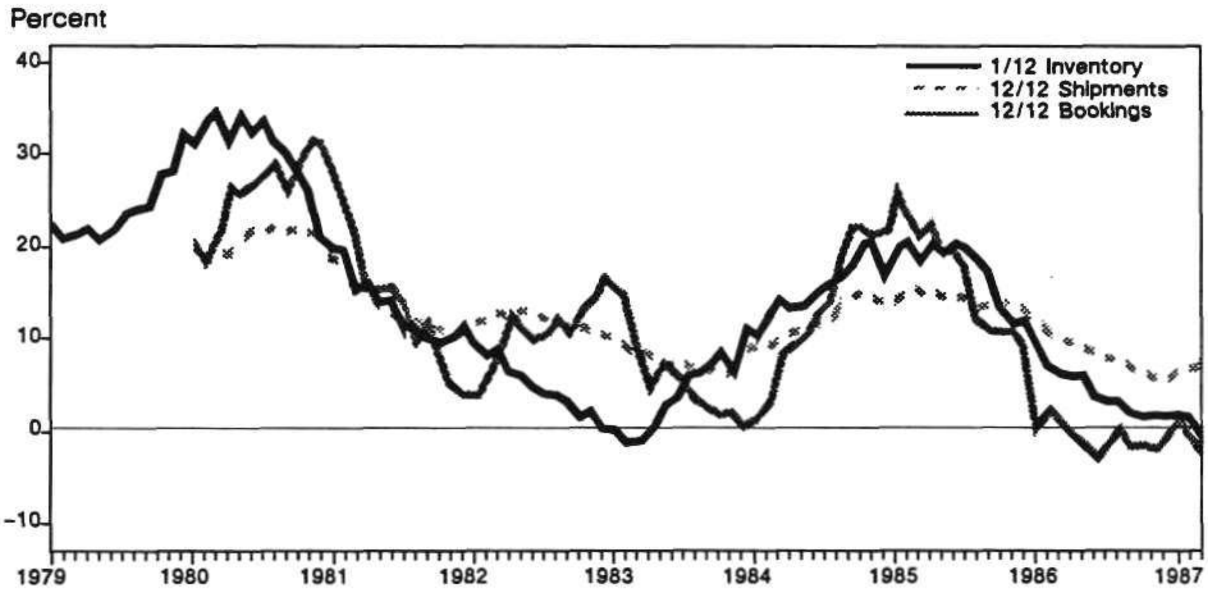


Figure 5

COMMUNICATIONS EQUIPMENT
RATE OF CHANGE



Source: Dataquest
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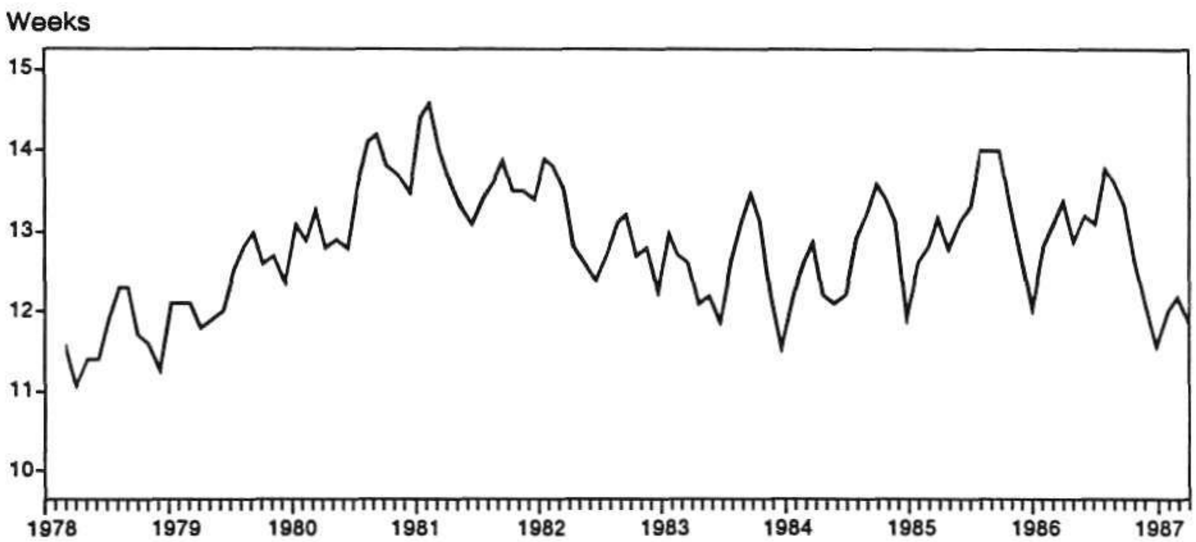
Figure 6

COMMUNICATIONS EQUIPMENT
AVERAGE WEEKS OF INVENTORY



Source: Dataquest
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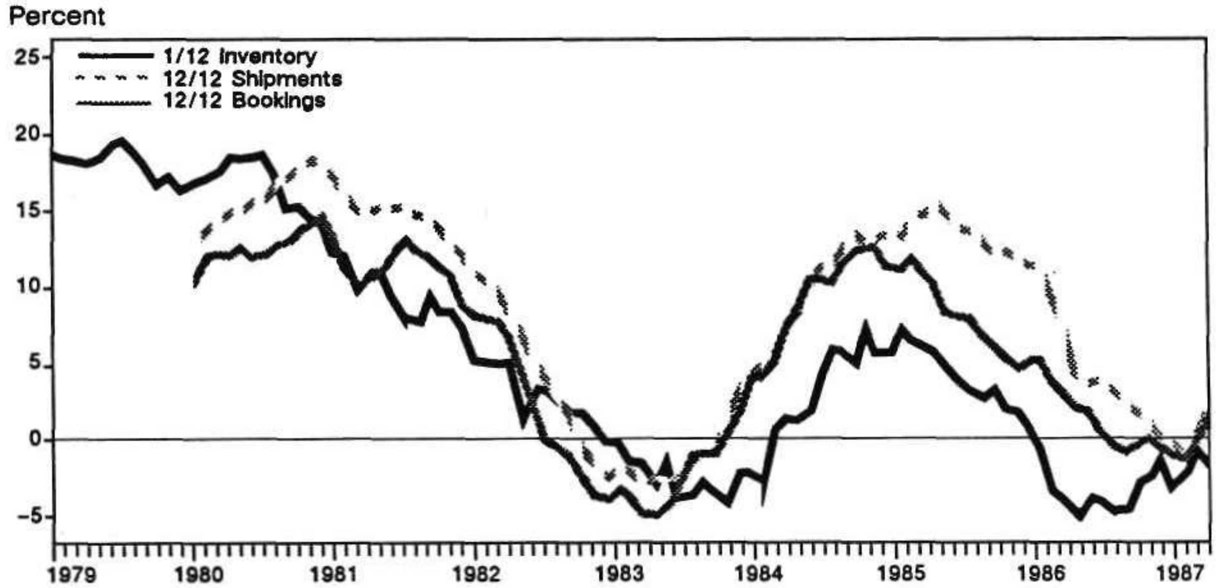
Figure 7

**ELECTRONIC INSTRUMENTS
RATE OF CHANGE**



Source: Dataquest
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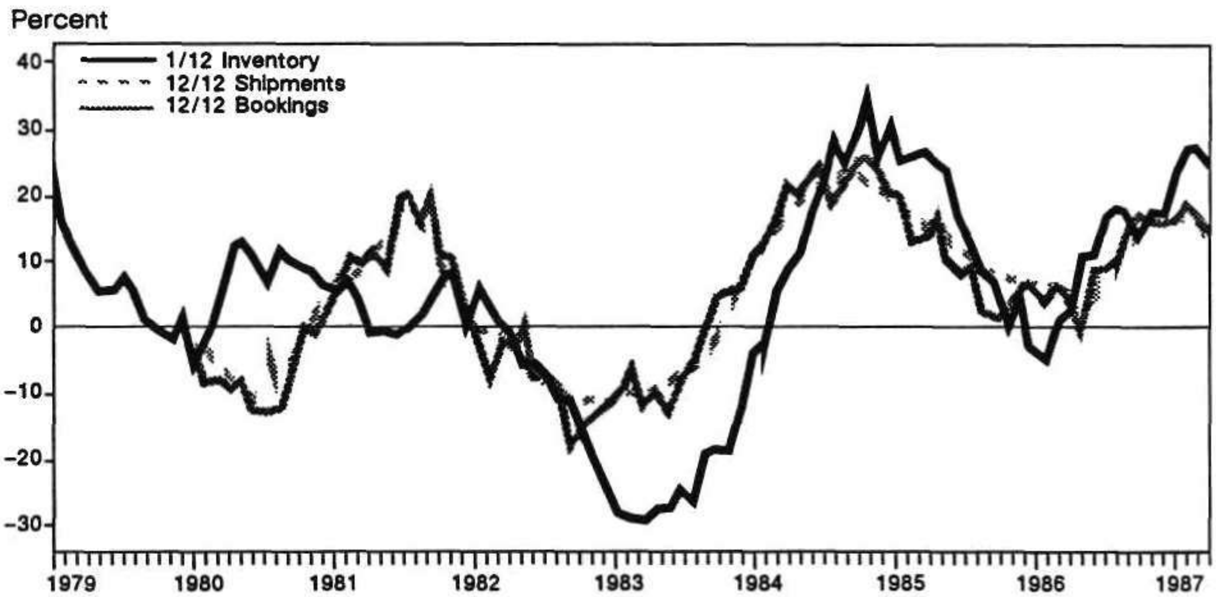
Figure 8

**RADIO AND TELEVISION
RATE OF CHANGE**



Source: Dataquest
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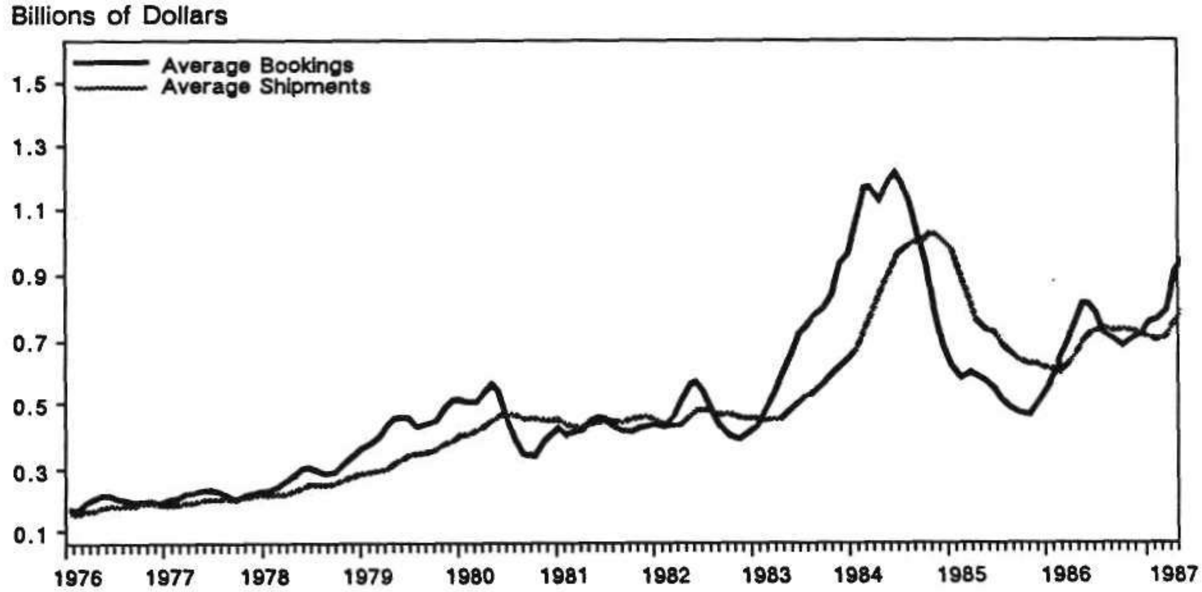
Figure 9

U.S. SEMICONDUCTORS
THREE-MONTH AVERAGE SHIPMENTS AND BOOKINGS



Source: Dataquest
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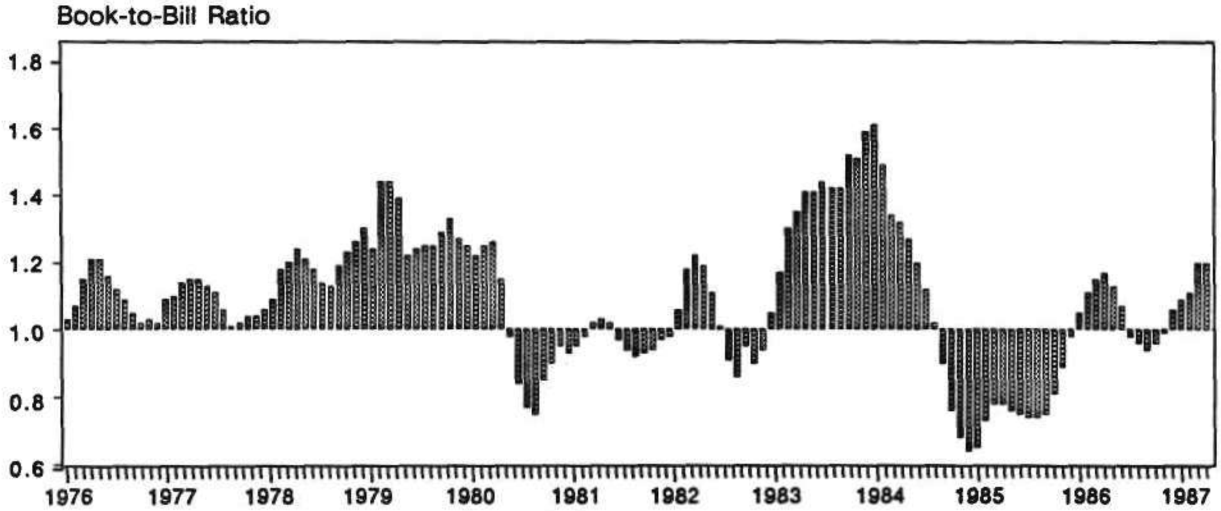
Figure 10

U.S. SEMICONDUCTORS
BOOK-TO-BILL RATIO



Source: Dataquest
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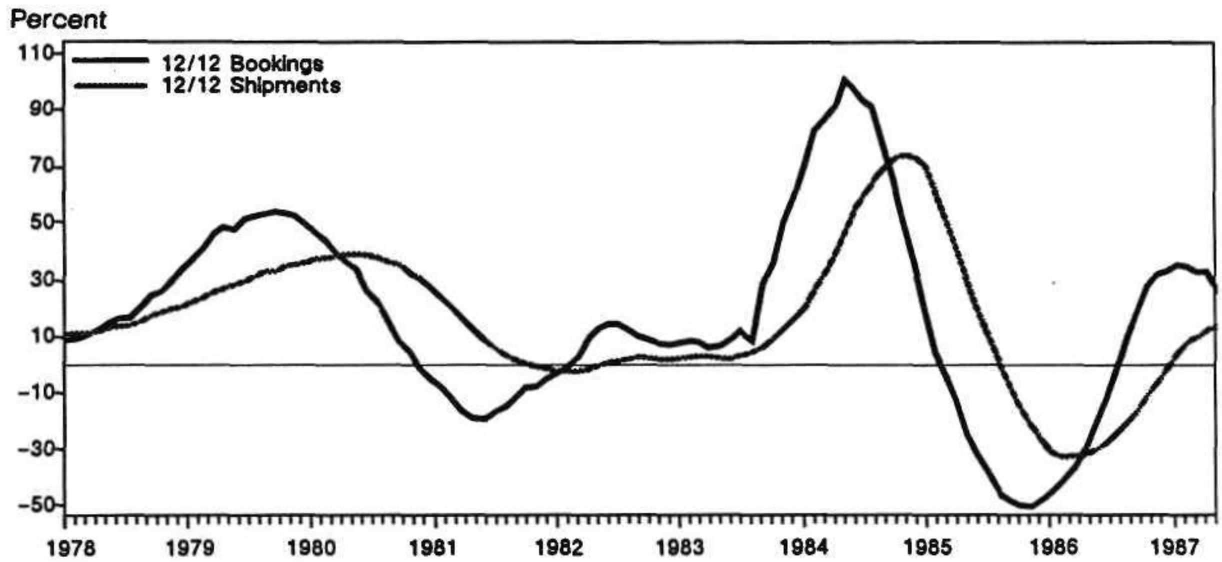
Figure 11

U.S. SEMICONDUCTORS
RATE OF CHANGE



Source: Dataquest
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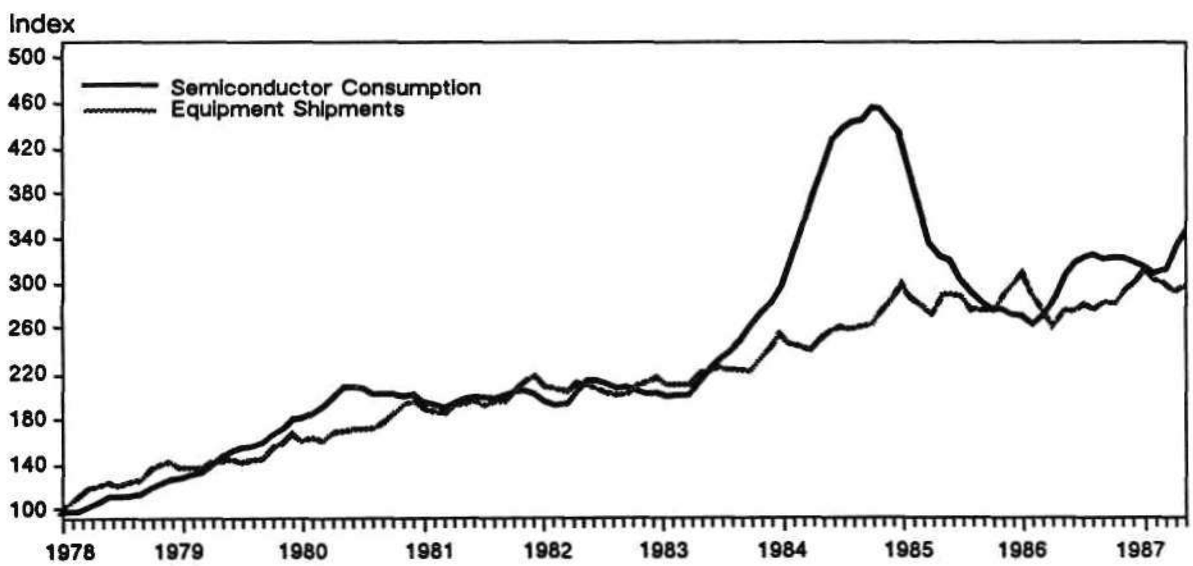
Figure 12

U.S. ELECTRONIC EQUIPMENT VERSUS SEMICONDUCTORS



Source: Dataquest
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Research Newsletter

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SECOND QUARTER START-UP UPDATE

The second-quarter update on start-up companies includes information on new company formations, acquisitions, and company announcements made in the second quarter. It also includes information on financing raised and agreements made in the first half of 1987.

HIGHLIGHTS

Second-quarter highlights include the following:

- Four companies were formed in 1987.
- European Silicon Structures and Microwave Technology have made acquisitions.
- VTC became a wholly owned subsidiary of Control Data Corporation.
- Approximately $238.3 million was raised in new and additional funding in the first half.
- Twenty-six agreements were signed by start-up companies in the first half.
- Significant management announcements were made.
- International Microelectronic Products went public.
- VLSI Technology broke ground on a 25,000-square-foot wafer fab in Texas.

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NEW COMPANIES

GL Micro Devices

GL Micro Devices was formed in February 1987 to develop high-performance, advanced CMOS products. The company was founded by Norman Godinho and Frank Lee, both formerly with Integrated Device Technology. Glenwood Management and El Dorado Ventures participated in $2.4 million seed financing, which was completed in April of this year.

Mr. Godinho served as vice president and general manager of IDT's digital signal processing division, and Mr. Lee was codirector of IDT's corporate research and development group.

LOGICSTAR Inc.

LOGICSTAR was formed in 1987 to design, manufacture, and sell high-performance PC AT logic, VLSI graphics, and local area network chips. The company is addressing the PC AT market and is using a VLSI design methodology to bring products to market quickly.

LOGICSTAR was formed by Mark Kaleem, who was formerly president of OSM Computer and Unilogic. Vice president of marketing is Saeed Kazmi, who was formerly with VLSI Technology Inc. in technical sales support.

LOGICSTAR's initial products are a five-chip PC AT chip set that is pin-for-pin compatible with Chips & Technologies' chip set, a monographics controller, a dual-channel NRZI encoder/decoder, and a STARLAN interface chip. Future products will include a VGA chip, PS/2 chip, 386 chip sets, additional data communication chips, and disk controllers.

Foundry services are being provided by companies in the United States and Japan.

Ramax Limited

Ramax Limited is an Australian-based company that is being formed through a $45 million joint venture between Australia's state of Victoria and other investors. A development company owned by the state of Victoria is providing $850,000, for which the state will receive between 7 and 13 percent equity in the company, with the balance in first-round equity coming from both U.S. and Australian investors. The financing should be complete by September 30.

Peter J. Solomon is executive director of Ramax, and Dr. Bruce Godfrey is manager of product and technology development. Dr. Godfrey has been an adjunct assistant professor at the University of Colorado and one of the researchers involved in developing technology the company will be using.

Ramax has licensed high-speed, nonvolatile memory technology using a ferroelectric semiconductor process and a companion technology that uses a thin-film process from Ramtron, an Australian R&D company located in Colorado Springs, Colorado. Ramax acquired a 12 percent stake in Ramtron for $8.0 million and paid $6.9 million in licensing fees.

Initially, the company will produce prototype silicon-based circuits using Ramtron's technology. Future plans include the manufacture of GaAs circuits using the ferroelectric thin-film technology under terms of a license that gives Ramax exclusive worldwide rights to use the Ramtron technology on GaAs.

SIMTEK Corporation

On May 15, 1987, Dr. Richard L. Petritz and Dr. Gary F. Derbenwick announced the formation of SIMTEK Corporation, which will develop, manufacture, and market a broad range of advanced semiconductor products. The company will initially focus on new memory components for consumer, commercial, and government markets.

Dr. Petritz, a founder of Mostek and Inmos, will serve as chairman and chief executive officer of the company. Dr. Derbenwick, who was formerly product technology manager at Inmos, will serve as president and chief operating officer.

The initial capitalization for SIMTEK is from Nippon Steel Corporation of Japan, which will own about 20 percent of the company and have a seat on the board. Nippon Steel produced 28 million tons of steel products in 1986, with sales of $15 billion. The investment by Nippon Steel is part of a diversification plan to expand into other business areas.

SIMTEK's headquarters are located in Colorado Springs, Colorado. During the next three months, the company will be conducting studies for its permanent U.S. facilities, which will include a substantial manufacturing capability. The company plans to begin manufacturing within the next 18 months.

MERGERS AND ACQUISITIONS

European Silicon Structures

European Silicon Structures (ES2) is negotiating to acquire Lattice Logic Ltd., an Edinburgh-based silicon compiler software house. ES2 has been marketing Lattice Logic's compilers in Europe since 1985. The merger should give Lattice Logic financial security and the finances to develop software with ES2.

Microwave Technology, Inc.

Microwave Technology, Inc. (MwT), completed the acquisition of Monolithic Microsystems, Inc., of Santa Cruz, California, in June 1987. Monolithic Microsystems makes detector log video amplifiers (DLVAs), logarithmic video amplifiers (LVAs), and threshold detectors, based on its proprietary monolithic silicon LVA ICs. Monolithic Microsystems is manufacturing devices used in various electronic warfare systems and other defense electronic applications.

MwT designs, manufactures, and sells GaAs epitaxial materials, GaAs field-effect transistor devices and monolithic circuits, hybrid microwave ICs, and microwave subassemblies.

Monolithic Microsystems will operate as a wholly owned subsidiary of MwT and will continue its manufacturing operations in its 8,200-square-foot Santa Cruz facility.

VTC, Inc.

VTC has signed a merger agreement under which it will become a wholly owned subsidiary of Control Data Corporation, its largest investor and major customer. The companies declined to disclose the terms of the proposed purchase. Control Data has invested $56 million in VTC since it was founded and holds nonvoting preferred shares in the company that are convertible to 49 percent of the company's voting stock.

The arrangement provides VTC with revenue and financial support. VTC's founders, Thomas E. Hendrickson and John R. Hodgson, will continue to manage the company.

Table 1 lists financing raised by start-up companies in the first half of 1987.

Table 1

FINANCING RAISED BY START-UP COMPANIES
FIRST HALF 1987

Company	Month	Round	Amount ($M)	Investors
Dallas Semiconductor	April 1987	3	$ 5.0	Abingworth; Alex Brown & Sons Emerging Growth Stocks; British Petroleum BP Ventures; HLM Partners; Merifin N.V.; New Enterprise Associates; Southwest Enterprise Associates; T. Rowe Price; Threshold Fund; Ventech Partners
Gigabit Logic	May 1987	3	$ 15.0	Analog Devices; Cray Research; Digital Equipment; First Interstate Capital; General Electric Venture; Interfirst Venture; New Enterprises Associates II; Riodan Venture; Union Venture
GL Micro Devices	April 1987	Seed	$ 2.4	Glenwood Management; El Dorado Ventures
International CMOS Technology	June 1987	3	$ 2.0	Undisclosed institutional investors
LSI Logic	April 1987	Eurobond Offer	$125.0	Convertible subordinated debentures offered on London's Unlisted Securities Market
Ramax Limited	June 1987	1	$ 0.8	State of Victoria, Australia

(Continued)

Table 1 (Continued)

FINANCING RAISED BY START-UP COMPANIES
FIRST HALF 1987

Company	Month	Round	Amount ($M)	Investors
Saratoga Semiconductor	March 1987	3	$ 11.5	Initial investors: Berry Cash Southwest Partners; Dougery, Jones & Wilder; Interwest Partners; Matrix Partners; MBW Venture Partners; Merrill, Pickard, Anderson & Eyre; Sierra Ventures; Sigma Partners; Weiss Peck & Greer Venture Partners
			$ 7.6	New investors: Bank of America Capital; HLM Management; John Hancock Venture Capital; New York Life Insurance; Security Pacific Capital; T. Rowe Price Associates
Vitesse Semiconductor	Feb. 1987	2	$ 10.0	Bryan & Edwards; J.H. Whitney; New Enterprises Associates; Oxford Venture Corporation; Robertson, Colman & Stephens; Sequoia Capital; Suez Technology Fund; Walden Capital
VLSI Technology	April 1987	Bond Offer	$ 48.75	Offered convertible subordinated debentures

(Continued)

Table 1 (Continued)

FINANCING RAISED BY START-UP COMPANIES
FIRST HALF 1987

Company	Month	Round	Amount ($M)	Investors
Xilinx	Jan. 1987	3	$ 3.4	Fleming Ventures Ltd.; Hambrecht & Quist; Kleiner, Perkins, Caufield & Byers; Interfirst Venture; Interwest Perkins; Matrix Partners; Morgan Stanley; Rainier Venture Partners; Security Pacific Venture Capital; J.H. Whitney
Zoran	April 1987	4	$ 6.8	Adler & Company; Concorde Partners; Elron Electronics; Grace Ventures Corp.; Kleiner, Perkins, Caufield & Byers; Mitsui & Company; Montgomery Securities; Vista Ventures; Welsh, Anderson & Stowe

Source: Dataquest
July 1987

Table 2 lists agreements start-up companies formed in the first half of 1987.

Table 2

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
Altera WaferScale Sharp	Jan. 1987	Altera and WSI agree to a five-year technology exchange focused on developing new user-configurable logic products. Sharp will manufacture the products using WSI's process.
Altera Cypress	June 1987	Cypress Semiconductor Corporation and Altera Corporation announced a five-year technology development agreement focused on new high-performance, high-density, user-configurable logic products. Altera will provide the architecture, circuit design, and software support. Cypress will provide its CMOS process and EPROM device development and manufacturing capacity from its new Austin, Texas fab. The first devices, designated MAX (for Multiple Array Matrix), promise to extend the EPLD density capability up to 5,000 equivalent gates.
Catalyst Oki Electric	March 1987	Catalyst and Oki Electric agreed to a second-source agreement covering a wide range of CMOS EEPROMs. This is another phase of their continuing CMOS memory technology partnership, which was signed in July 1986. The two companies will jointly introduce a 1K serial EEPROM, which will be followed with 256-bit and 512-bit serial EEPROMs, 16K and 64K CMOS EEPROMs, and a 256K CMOS EEPROM that will be introduced at the end of the year.
CDI IST	April 1987	California Devices Inc. (CDI) and Innovative Silicon Technology (IST) have reached an agreement that provides for joint product development and second-sourcing of two families of ASICs using channelless ASIC architectures. The first family will be based on a 2-micron, double-metal layer CMOS and will have a complexity of up to 24,000 gates. The second family, which is slated for introduction in 1988, will be based on 1.5-micron technology and will have more than 100,000 gates.

(Continued)

Table 2 (Continued)

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
Crystal Asahi Chemical	Jan. 1987	Asahi Chemical has acquired an 8 percent share in Crystal Semiconductor for about $4 million. Asahi will provide foundry services in exchange for a license to all of Crystal's existing products and for principle distribution rights in the Far East. Both companies will develop new products.
Custom Silicon NCR	Feb. 1987	NCR has licensed CSi's standard cell library, that includes 342 TTL macrocells and microcomputer building blocks of up to 5,863-gates. CSi's library was built from NCR's existing library, which CSi licensed.
Dallas Xecom	May 1987	Dallas Semiconductor Corporation and Xecom Inc. signed a second-source agreement giving both companies marketing rights for several of their existing products. In addition, the companies will cooperate on developing, manufacturing, and marketing future modem-related products--the area of Xecom's expertise. As part of the agreement, Dallas will alternate-source two of Xecom's modem components--the XE1251 and XE1253 modem development kits and the standalone XE0002 Data Access Arrangement unit, which is registered by the FCC. Xecom will second-source Dallas' SmartSocket and the SmartWatch families of products.
ES2 N.V. Philips TI	Feb. 1987	Texas Instruments Ltd. of England and Philips International N.V. will offer accelerated prototyping for the SystemCell Library of standard cells in cooperation with ES2. The SystemCell Library is the result of a collaborative relationship between TI and Philips, which provides high-volume manufacturing and standard prototyping.

(Continued)

Table 2 (Continued)

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
GigaBit Logic Seattle Silicon WTC	April 1987	GigaBit Logic, Seattle Silicon Corp., and the Washington Technology Center (WTC) announced that a joint design project has resulted in the fabrication of a functional compiler-based GaAs IC design. The design is based on GigaBit's standard cell library and uses Seattle Silicon's Concorde Blue Chip Compiler. WTC provided design and engineering support and will be involved in the packaging and testing of the ICs. The device is equivalent to the 100K ECL 4-bit ALU (100181).
ICT Asahi Chemical	Jan. 1987	Asahi Chemical Industry will receive technology from International CMOS Technology (ICT) and will also market its EEPROMs.
IDT VTC	Jan. 1987	VTC will second-source Integrated Device Technology's FCT product line of TTL-compatible CMOS logic devices.
IST SDA Systems	May 1987	Innovative Silicon Technology Corp. (IST), a wholly owned subsidiary of SGS Corp., signed an agreement with SDA Systems Inc. to develop CAD systems based on SDA technology for use by IST customers.
Lattice SGS	Feb. 1987	Lattice Semiconductor signed a technology agreement with SGS Semiconductor, giving SGS a license to second-source Lattice's Generic Array Logic (GAL) products. SGS will manufacture GAL products for Lattice, and both companies will cooperate on the design of future PLD products.
Lattice National	May 1987	National Semiconductor Corporation made a minority capital investment in Lattice Semiconductor Corporation and licensed its Generic Array Logic (GAL) technology. The five-year agreement includes codevelopment of denser architectures of both standard and in-system programmable GALs, as well as a new line of FPLAs and sequencer devices.

(Continued)

Table 2 (Continued)

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
LTC TI	March 1987	Linear Technology Corporation (LTC) and Texas Instruments Inc. (TI) agreed to a five-year alliance for advanced linear ICs. TI will select six products each six months from LTC's line to manufacture and market as TI parts. TI will pay LTC $500,000 and undisclosed royalties on a descending scale for a 10-year period and will directly purchase a number of products for resale. In addition, TI will invest approximately $1 million for warrants to purchase 735,000 shares of LTC stock at $17.50 per share over a four-year period. TI is also free to add the LTC parts to its standard cell library in exchange for specific royalty payments outlined by the agreement. LTC designers are to gain access to TI's CAD system and will also be able to design parts, thereby taking advantage of TI's advanced processes. The two companies plan joint designs in the near future. LTC will be able to situate its own test systems at TI assembly facilities.
LSI Logic Case Technology	March 1987	Case Technology Inc. and LSI Logic have completed a joint development effort that allows LSI Logic's LL5000, LL8000, and LL9000 schematic libraries to be designed on Case Technology's PC-based workstations.
LSI Logic Logic Automation	May 1987	LSI Logic Corporation and Logic Automation Inc. have signed a joint development agreement to make available LSI Logic's LL5000, LL7000, LL8000, and LL9000 channeled gate arrays on Logic Automation's Mentor Graphics workstations.
LSI Logic ASIX Systems	June 1987	LSI Logic Corporation will license design verification software to ASIX Systems Corporation of Fremont.

(Continued)

Table 2 (Continued)

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
Samsung Intel	June 1987	Samsung Semiconductor will supply Intel with 64K, 256K, and 1Mb DRAMs, which Intel will sell to its customers in the United States. Shipments will begin from Korea in July.
Tachonics CMD	March 1987	California Micro Devices Corporation (CMD) signed an agreement with Tachonics for the production of gallium arsenide (GaAs) based ICs. Tachonics will manufacture the commercial and military products, and CMD will provide cell design and tools in the 0.5- to 1.0-micron range. Initial products will be a series of GaAs gate arrays with 500 to 2,500 gates and with radiation-hardened capabilities.
TriQuint TRW	June 1987	TRW Components and TriQuint Semiconductor have agreed to jointly supply gallium arsenide devices for space applications. Both companies are working together on procedures for producing Class S-level GaAs components. TriQuint will provide microwave and digital GaAs technology in addition to foundry services.
Vitesse Ford	June 1987	Vitesse Semiconductor Corporation and Ford Microelectronics are close to a second-source agreement involving gallium arsenide (GaAs) IC foundry services. The two companies have an agreement in principle to develop common design rules. Vitesse and Ford each use an enhancement/depletion mode, self-aligned gate technology. Initially, the agreement involves custom and semicustom circuits but may be extended to standard products.

(Continued)

Table 2 (Continued)

AGREEMENTS WITH START-UP COMPANIES
FIRST HALF 1987

Company	Date	Comments
VLSI Technology TCMC	March 1987	VLSI Technology Inc. and Thomson Components-Mostek Corporation (TCMC) have signed a comprehensive agreement for mutual second-sourcing and future new product development in specialized memory products. Each company will provide five existing memory designs for immediate second-sourcing. Both companies will incorporate the devices into megacells for use in their respective ASIC product families and plan to develop future products. Products covered include FIFOs, dual-ported RAMs, cache-tag RAMs, and lithium cell-powered nonvolatile SRAMs.
VLSI Technology Zilog	May 1987	Zilog signed VLSI Technology Inc. as a second source for its Super8 microcontroller. Included in the agreement are the Super8, the Z8038 FIFO I/O interface unit, and the Z8060 FIFO buffer unit and FIFO expander.
VTC Inc. TRW Components	March 1987	VTC and TRW Components International have signed a three-year agreement to cross sample space-quality Class S devices. VTC will supply TRW with unpackaged, high-performance ICs that meet the military Class S specifications. The devices include radiation-hardened CMOS SRAMs and high-speed comparators, op amps, and transceivers that are manufactured with VTC's radiation-hardened bipolar technology. TRW will assemble, test, qualify, and market these devices to customers that require Class S products, including radiation lot qualification where required.
Weitek Hewlett-Packard	May 1987	Weitek Corporation and Hewlett-Packard (HP) have formed a supplier/end-user agreement involving product and manufacturing exchanges. HP will incorporate the Weitek model 2264/65 chip set for high-performance, floating-point computation in current and future HP Precision Architecture computers. HP will also manufacture the chip set using its 1.2-micron CMOS process.

Source: Dataquest
July 1987

COMPANY ANNOUNCEMENTS

Altera Corporation

Altera and Monolithic Memories Incorporated (MMI) have settled the patent infringement suit brought against Altera by MMI. Altera agreed to entry of a consent of judgment, and the parties have agreed to license each other under certain patents in the programmable logic field.

Catalyst Semiconductor

Stephen Michael, one-time vice president of GE Semiconductor's Custom Integrated Circuit department, joined Catalyst as executive vice president and chief operations officer. He will have responsibility for all day-to-day operations at Catalyst, reporting directly to B.K. Marya, president and chief executive.

Dallas Semiconductor

Dallas Semiconductor began producing chips in a newly constructed $10 million wafer fabrication facility adjacent to its Dallas headquarters. The Class 1 facility produces CMOS chips with geometries down to 0.7 microns.

GigaBit Logic

GigaBit Logic named president and chief executive John Heightly chairman of the board. Mr. Heightly takes over the chairman's post from Henrich Krabbe, who will remain on GigaBit's board as director. Mr. Krabbe is vice president of new business development for Analog Devices, an investor in GigaBit.

GigaBit Logic announced that Cray Research, Inc., has increased its 1987 order to $5.5 million from $3.2 million. Cray will use the logic and memory device procured under this order to enter the next phase of development of a GaAs-based parallel processor supercomputer.

Integrated Device Technology (IDT)

IDT has established a company in Japan named Integrated Device Technology K.K. It is capitalized at $142,857 and plans to begin contract assembly in Japan, by Japanese semiconductor makers, sometime this year.

International Microelectronic Products (IMP)

IMP made an initial public offering of 6.5 million shares of common stock on June 10, 1987. The company provided 4.5 million shares and 2 million were from certain shareholders. The offering was underwritten by Shearson Lehman Brothers and Montgomery Securities. Proceeds will be used to acquire capital equipment, make leasehold improvements, redeem Series A preferred stock, and provide working capital for general corporate purposes. The company will have about 25 million shares outstanding after the offering.

IXYS Corporation

IXYS has relocated into a new 53,000-square-foot facility in San Jose. The facility, which is six-times larger than its former one, will be occupied by a highly automated assembly line and custom-packaging facility. The automated manufacturing line for commercial products is expected to be operational in eighteen months. IXYS plans to invest $2 million to $3 million in this line over the next two years.

Laserpath

Jim Hively, formerly general manager of Monolithic Memories Inc. semicustom division, has joined Laserpath as president and chief executive officer. Mr. Hively replaces former Laserpath president Michael Watts, who resigned last summer to participate in venture financing. He will report to Laserpath chairman John Mumford.

Lattice Semiconductor Corporation

Lattice filed for Chapter 11 protection to ensure that new funding will be applied only toward financing the company's ongoing operations.

LSI Logic Corporation

LSI Logic announced that it will take its Canadian affiliate, LSI Logic Corporation of Canada Inc., public and offer 4 million newly issued shares. The company plans to raise more than $20 million in the offering.

LSI Logic and Sun Microsystems Inc. announced that they are joining forces to support San Jose State University with the establishment of an ASIC laboratory (ASIC Laboratory Project) at the university. LSI will contribute instructional versions of its LDS-III logic design and verification software and instructional versions of a macrocell library to develop ASICs. Sun Microsystems will donate the SUN-3/160C color workstation and three SUN-3/50 monochrome workstations, as well as the operating system (SunOS) and networking software.

NMB Semiconductor Corporation

William C. Connell, vice president of NMB (USA) Inc., is acting president of NMB Semiconductor. Gary Ater, who was vice president and general manager of U.S. Operations, has left NMB Semiconductor to join Vitelic Corporation as vice president of Sales and Worldwide Marketing.

NMB Semiconductor relocated its domestic headquarters to Garden Grove, California, in April. NMB will share existing facilities with HI-TEK Corporation, another subsidiary company of NMB (USA) Inc. The new location provides additional space for engineering and test and evaluation functions. The existing Santa Clara, California, facility will be maintained as a regional office for the northwestern United States.

The new location is:

11621 Monarch Street
Garden Grove, CA 92641
(714) 897-6272; fax: (714) 891-0895; Telex: 67-8486

Samsung Semiconductor Inc.

Samsung Semiconductor, Goldstar Semiconductor Inc., and Hyundai Electrical Engineering Co. announced that they are preparing to launch full-scale production of a 1Mb DRAM chip jointly developed by the three South Korean firms last year.

Samsung Semiconductor formally opened its national headquarters in San Jose. The new $36 million facility will be used for administration, including sales, marketing, and product support, as well as for chip manufacturing. The company employs 250 people at the site and expects to increase that number to 400 within a year.

Silicon Systems Inc.

Chairman Carmelo J. Santoro retook operational control of Silicon Systems in May 1987, after Stephen E. Cooper, president and chief operating officer, and John V. Crosby, senior vice president, resigned.

Mr. Santoro said the reason for the change was to move toward a leaner, more efficient organization to "substantially improve profitability."

Taiwan Semiconductor Manufacturing Company (TSMC)

Dr. Morris Chang, former president and chief executive officer of General Instrument Corporation and president of the Industrial Technology Research Institute (ITRI) in Hsinchu, was made chairman of TSMC. Dr. Chang is also chairman of United Microelectronics Corporation.

Jim Dykes, who set up General Electric Company's Semiconductor Division, will join TSMC as president and chief executive officer.

Stephen L. Pletcher, who had been vice president of sales and marketing for GE Semiconductor, was named director of the new North American and European marketing and sales operation of TSMC.

TSMC, formed in late 1986, has already made its first wafer shipment from its 6-inch CMOS fab line in Hsinchu, Taiwan.

Three-Five Semiconductor Corp.

Three-Five Semiconductor has closed down its gallium arsenide facility in Troy, Michigan, idling about 50 workers.

United Microelectronics Corporation (UMC)

Dr. Morris Chang has been elected chairman of UMC. Dr. Chang is also chairman of the newly established Taiwan Semiconductor Manufacturing Corporation (TSMC) and president of the Industrial Technology Research Institute (ITRI) in Hsinchu. Formerly, Dr. Chang was a vice president at Texas Instruments and president and chief executive officer of General Instrument Corporation.

Vitesse Semiconductor

Vitesse has elected Pierre R. Lamond, cofounder of National Semiconductor and a general partner of Sequoia Capital, as chairman of the board. Mr. Lamond recently organized a $10 million financing of Vitesse and also serves on the boards of Cypress Semiconductor, Convex Computer, and several private companies.

VLSI Technology Inc.

VLSI Technology has broken ground on a 25,000-square-foot 6-inch wafer fabrication facility in San Antonio, Texas. Initially, the plant, equipped with a Class 1 clean room, will fabricate CMOS ASIC devices with minimum feature sizes down to 1.2 microns. The company plans features below 1.0 micron. The facility is expected to begin operation with 100 employees in late 1988.

VLSI Technology Inc.

VLSI Technology sold $48.75 million worth of 7 percent subordinated debentures convertible to common stock in an issue managed by Goldman Sachs & Co., Hambrecht & Quist, and Cowen & Co. VLSI plans to use money to fund new ASIC designs and defray expenses incurred by acquiring Visic Inc. and finance the new fab under construction in San Antonio, Texas.

In April, VLSI Technology repurchased a $7.6 million warrant that had been issued to Bendix Corporation six years ago.

VTC Inc.

VTC announced that it was awarded a $7.5 million contract from Control Data Corp., Government Systems Division, to supply chips for the U.S. Navy's AN/AYK-14(V) standard airborne computer. The contract calls for the production of five VLSI chip types designed with VTC's 1-micron CMOS standard cell library.

Xicor, Inc.

In April 1987, Xicor announced a public offering of 2.1 million shares of common stock at a price of $11.50 with Montgomery Securities and Smith Barney, Harris Upham & Co. Incorporated acting as underwriters. Net proceeds will be used for repayment of a bank debt of approximately $1.5 million and the balance will be added to working capital.

Intel Corporation has terminated a contract worth more than $7 million with Xicor on EEPROM technology and has begun end-of-life procedures on 64K and 256K ICs.

Zoran Corporation

John Ekiss resigned as president and chief executive officer of Zoran. Before joining Zoran in mid-1985, Mr. Ekiss was general manager of Intel's special components division. Terry Martin, vice president of operations, is acting president and chief executive.

ZyMOS Corporation

David Handorf has joined ZyMOS as president and chief executive officer from VLSI Technology Inc., where he was general manager of application-specific memories. He replaces the president's office of Haller Moyers, B.J. Chang, and Alex Young, who were appointed to serve until a successor was named.

Penny Sur

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Research Bulletin

SUIS Code: 1986-1987 Newsletters
1987-23

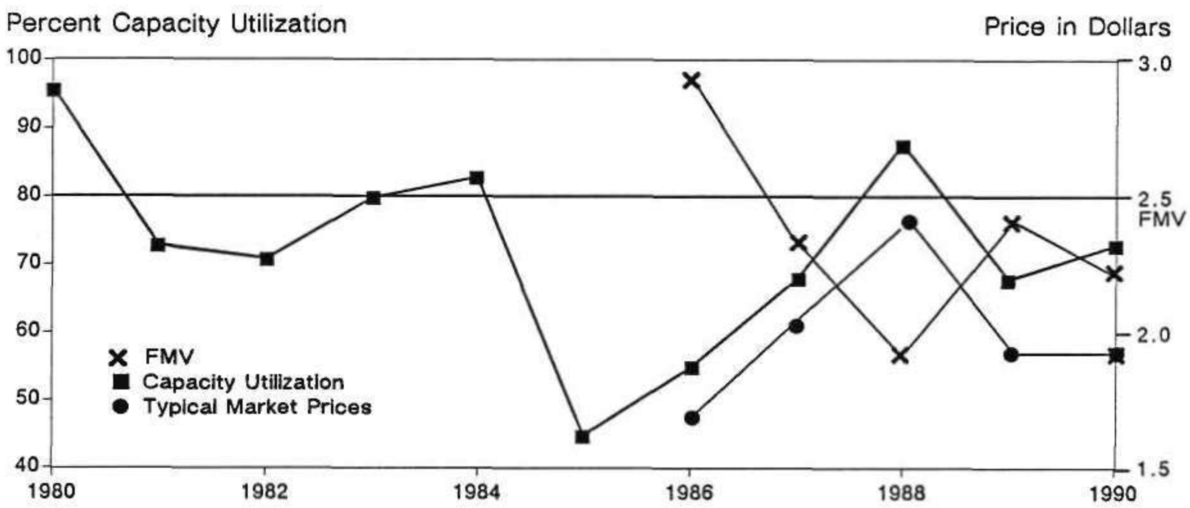
THE FMV SYSTEM AT WORK: PRICE FLOORS LEGITIMIZED

The current semiconductor market illustrates how the Foreign Market Value (FMV) system has impacted the price of DRAM devices. The combination of Japanese shipment restrictions, steady demand, and lack of enough alternative sources have made market pricing predominate over "constructed" FMV pricing. Depending on capacity utilization, the FMV system prevents import pricing from falling below prescribed levels that U.S. producers can take advantage of.

Figure 1 illustrates that, when the majority of the supply is set at constructed higher prices (FMVs), the remaining unmonitored supply will be in higher demand. This, in turn, raises the prices of the unmonitored supply, although not as high as the FMV floor. Low demand corresponds to low capacity utilization, which results in higher costs per unit that must be translated into higher FMV prices, as shown in Table 1. In effect, FMVs prevent the low prices normally experienced in a down market when demand is low.

Figure 1

CAPACITY UTILIZATION



Source: Dataquest
June 1987

Table 1

CAPACITY UTILIZATION

	100%	75%	50%	25%
256K DRAM FMV	$1.78	$2.25	$2.98	$5.08

Source: Dataquest
June 1987

The result of this program has been to create opportunities for U.S. semiconductor manufacturers to reenter the MOS memory market at an acceptable price, but at a cost to the U.S. electronics industry. This is shown in Table 2, which gives worldwide regional pricing in March and June of this year for the 256K DRAM.

Table 2

256K DRAM PRICES

	United States	Japan	Taiwan	Europe
March 9	$1.95	$1.61	$1.55	$1.90
June 15	$2.40	$1.91	$2.40	$2.50

Source: Dataquest
June 1987

In March, Far East pricing was attractive to U.S. and European companies. By June, the Japanese shipment cutbacks (negative 32 percent) effectively eliminated the gray market for this product, making pricing roughly equal everywhere outside of Japan. Responding to demand and political pressures, incremental shipment increases of Japanese memories should keep prices level through the third and fourth quarters of this year.

The benefits and penalties of the current FMV situation are listed below:

Benefits

- U.S. suppliers regain EPROM market position
- U.S. and European suppliers reenter DRAM market

Penalties

- Competitive disadvantage for non-Japanese electronics manufacturers due to lower prices in Japan
- Product shortages for non-Japanese customers

Ironically, in trying to stabilize the volatile MOS memory market, the customer's supply base has been destabilized, particularly in EPROMs. Down markets "FMV" Japanese suppliers out of the market, and up markets allow them to reenter it. Unfortunately, at that point many Japanese companies would rather manufacture non-FMV products. However, users prefer to procure parts from long-term suppliers. Until the worldwide supply of commodity semiconductors is balanced, this situation will continue.

Mark Giudici

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Research Newsletter

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1987-22

THE AMERICAN-JAPANESE TRADE WAR AND ITS EFFECT ON THE ASIAN ELECTRONICS INDUSTRY

INTRODUCTION

In the press these days, much has been written on the deterioration of trade relations between Japan and the United States. Tariffs recently imposed by the United States on $300 million of Japanese electronics imports are the latest chapter in the escalation of the trade war. This newsletter examines the current and expected future impact of this friction on the Asian newly industrialized countries' (NICs) electronics industry.

In the short run, Dataquest expects Asian electronics producers to capture U.S. market share from the Japanese. The current rift in U.S.-Japanese trade relations, Japan's record trade surpluses, and the record high value of the yen should foster this outcome. In the long run, the outcome is less clear. The evolving semiconductor and electronics product cycle--whereby relatively low-value production is shifted from relatively more mature, more industrialized nations to less mature, less industrialized nations--should enable the Asian NICs to retain their short-run gains.

SHORT-RUN EFFECTS

Trade Balance and U.S.-Japanese Semiconductor Trade

The United States' trend in running trade deficits culminated in a record deficit of about $147.7 billion in 1986. Japan's trade surplus with the United States in 1986 was about $58.6 billion, a record, making Japan the most important foreign country contributing to the imbalance. Table 1 shows that, while every Asian NIC is also running a surplus with the United States, their surpluses are $32.9 billion, or 56 percent of the value of Japan's.

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Japan's record surplus, in combination with recent U.S. charges of unfair trade practices in semiconductors, has put the Japanese in an unfavorable light among politicians in Washington. Witness the recent imposition of tariffs by the United States on $300 million worth of Japanese electronics imports. Given that some of the targeted items are electronic goods such as television sets and black and white computer terminals--goods of which the Asian NICs, particularly the South Koreans, are big producers (see Table 2)--these tariffs should for the most part play into the hands of the Asian producers. Since their largest export market for these goods is the United States, the Asian electronics producers should benefit, at least in the short run, by filling the gap created by the tariffs.

Table 1

1986 U.S. TRADE BALANCE
(Millions of U.S. Dollars)

	Exports	Imports	Change
South Korea	$ 6,355	$13,490	($ 7,135)
Taiwan	$ 5,524	$21,251	($15,727)
Hong Kong	$ 3,030	$ 9,474	($ 6,444)
China	$ 3,106	$ 5,240	($ 2,134)
Singapore	$ 3,380	$ 4,884	($ 1,504)
Total	$21,395	$54,339	($32,944)
Japan	$26,880	$85,450	($58,570)

Source: U.S. Department of Commerce

Table 2

SOUTH KOREAN ELECTRONICS EXPORTS TO THE UNITED STATES

1986

Item	Millions of U.S. Dollars	Percent
Consumer	$1,796	43.0%
Color Television	568	13.6
B & W Television	190	4.5
VCR	388	9.3
Other	650	15.6
Industrial	$1,081	25.9%
PC	395	9.4
Monitor	200	4.8
Telephone	125	3.0
Others	361	8.6
Parts and Component	$1,303	31.2%
Total	$4,180	100.0%

Source: Dataquest
June 1987

Foreign Exchange Markets

The other key short-run force at work is the recent activity in the foreign exchange markets. The yen has appreciated 60 percent against the U.S. dollar since September 1985, far more than any other Asian currency (see Table 3). In fact, the yen has recently achieved a postwar high of about 139 yen per dollar. Since both Japan and Asia's largest export market is the United States, and since Japan's tariff-targeted electronics and Korea's electronics exports are reasonably close substitutes for each other, the Asian electronics industry should be expected to capture some of the U.S. market from Japan.

In sum, in the short run, the current rift in trade relations between the United States and Japan, combined with the record appreciation of the yen against the dollar, and its relative appreciation against other Asian currencies, should lead to a greater penetration of Asian electronics exports into the United States, and thus enhanced opportunities for growth.

Table 3

FOREIGN CURRENCIES
TO US$

Year	Won	NT$	HK$	S$	Yen
1982	749	40	6.0	2.12	248
1983	796	40	7.8	2.12	235
1984	827	40	7.8	2.12	237
1985	870	40	7.8	2.14	238
1986	860	36	7.8	2.16	167
5/3/87	835	33	7.8	2.12	140

Source: Dataquest
June 1987

LONG-RUN EFFECTS

Capital Movements and Strategic Alliances

The U.S. trade balance indicates a net flow of investment capital into the United States from its trading partners. As shown in Table 4, however, there is positive and significant growth in U.S. direct investment in the Asian community. Since Japan is the most developed economy in far eastern Asia, of course the capital inflow to Japan ranks first. Key, though, are the healthy 1986 growth rates that indicate no shortage of foreign investment opportunities for U.S. investors in Asia.

What makes far eastern Asia different from Japan in this regard, though, is that the former, South Korea in particular, welcome alliances and foreign ownership. Table 5 indicates the recent strategic alliances with American firms. From 1982 to 1986, the four largest native South Korean semiconductor manufacturers entered into more than 20 technical and production alliances with U.S. firms. The point here is that the Japanese have probably, at least as of late, fueled the trade-war fires by denying U.S. firms opportunities for direct investment into their semiconductor industry, and by mass manufacturing established products. On the other hand, direct investment opportunities in Asian semiconductor ventures have been relatively plentiful. Foreign investment may also provide the means of a more balanced manufacturing base, combining high-profit, high-value specialty products with low-profit, low-value commodity products. In the long run, this trend in cooperation should help to maintain open trade channels between the United States and Asian electronics producers.

Table 4

U.S. DIRECT INVESTMENT ABROAD
(Millions of U.S. Dollars)

	1985 Position	Estimated Capital Flow	1986 Position	Percent Change
South Korea	$ 757	$ 65	$ 822	8.6%
Taiwan	$ 754	$ 200	$ 954	26.5%
Hong Kong	$3,124	$ 240	$ 3,364	7.7%
China	$ 242	$ 85	$ 327	35.1%
Singapore	$1,897	$ 220	$ 2,117	11.6%
Japan	$9,095	$1,800	$10,895	19.8%

Source: U.S. Department of Commerce

Table 5

STRATEGIC ALLIANCES

Company	Number of Agreements
South Korea	
Samsung	12
Gold Star	11
Korea Electronics	3
Hyundai	5
Daewoo	1
Taiwan	
UMC	4
ERSO	1

Source: Dataquest
June 1987

Mutual Benefits of (Relatively) Open Trade

The United States and its Asian trading partners have too much at stake to allow the trade war to escalate much beyond its current state, and to let the ill will between the United States and Japan spill over to the rest of the Asian community.

First, as the semiconductor and electronics product cycle evolves (that is, as new products are introduced, then mature as they spread to other less industrialized countries and are finally standardized), the U.S. producers will continue to rely on open trade as a means of maintaining their comparative advantage and cost competitiveness. This was true several years ago as assembly and test began its movement offshore and continues to play a vital role today.

Second, open trade has meant that, in the face of recent record U.S. federal budget deficits, U.S. interest rates have remained at relatively reasonable levels due to the "free" inflow of foreign capital.

Continued open trade is equally important to Asian countries since their exports, particularly those to the United States, represent a significant share of their respective GNPs. For example, 1985 exports to the United States as a share of GNP for South Korea, Taiwan, and Hong Kong were 12.9 percent, 24.6 percent, and 25.5 percent, respectively. Provided these nations continue to orient the structure of their economies toward exports, their economic growth will depend vitally on access to U.S. markets.

Equally important to Asian economic vitality is the maintenance of imports, particularly semiconductors from Japan. Tables 6 and 7 illustrate the importance to the Asian electronics community of maintaining open trade channels. From 1982 to 1986, the compound annual growth rate (CAGR) of Asian semiconductor consumption exceeded production. This shortfall was made up by growing semiconductor imports (see Table 8).

Table 6

ASIAN SEMICONDUCTOR CONSUMPTION
(Millions of U.S. Dollars)

							CAGR	
	1982	1983	1984	1985	1986	1990	1982-1986	1986-1990
South Korea	$ 154	$ 227	$ 304	$ 235	$ 623	$ 1,200	41.8%	17.8%
Taiwan	$ 379	$ 415	$ 560	$ 496	$ 694	$ 1,207	16.4%	14.9%
Singapore	$ 133	$ 200	$ 300	$ 249	$ 350	$ 700	27.4%	18.9%
China	$ 202	$ 247	$ 301	$ 367	$ 448	$ 1,146	22.0%	26.5%
Japan	$4,082	$5,651	$8,845	$8,599	$12,356	$19,039	31.9%	11.4%

Source: Dataquest
June 1987

Table 7

ASIAN SEMICONDUCTOR PRODUCTION
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986	CAGR 1982-1986
South Korea	$ 648	$ 850	$ 1,259	$ 994	$ 1,292	18.8%
Taiwan	$ 456	$ 471	$ 659	$ 522	$ 689	10.8%
Hong Kong	$ 99	$ 125	$ 142	$ 136	$ 169	14.2%
Singapore*	$ 800	$1,049	$ 1,306	$ 1,031	$ 1,177	10.1%
China	$ 50	$ 67	$ 89	$ 120	$ 160	33.7%
Japan	$4,682	$6,667	$11,058	$10,180	$13,821	31.1%

*Production includes fab, assembly, and test by native manufacturers, and also contract assembly and test.

Source: Dataquest
June 1987

Table 8

ASIAN SEMICONDUCTOR
EXPORTS AND IMPORTS
(Millions of U.S Dollars)

	1982	1983	1984	1985	1986	CAGR 1982-1986
Exports						
South Korea	$ 624	$ 857	$1,291	$1,062	$1,381	22.0%
Taiwan	$ 388	$ 438	$ 640	$ 568	$ 682	15.1%
Hong Kong	$ 217	$ 212	$ 256	$ 213	$ 232	1.7%
Japan	$1,158	$1,813	$3,303	$2,457	$3,219	29.1%
Imports						
South Korea	$ 130	$ 234	$ 336	$ 341	$ 477	38.3%
Taiwan	$ 309	$ 387	$ 607	$ 536	$ 697	22.6%
Hong Kong	$ 596	$ 972	$1,468	$1,306	$1,568	27.3%
Japan	$ 569	$ 718	$1,032	$ 708	$ 854	10.7%

Source: Dataquest
June 1987

Again, each side of the Pacific Rim has too much at stake to ignore the grievances of its trading partners. In matters such as this, it is normal for opposing political forces to engage in posturing. But the rhetoric we are hearing these days has probably more to do with the short-run than the long-run outcome. The situation will probably evolve so that each side (of the Pacific Rim) realizes its comparative advantages in a dynamic setting:

- United States: Innovation/marketing/specialty manufacturing

- Japan: Manufacturing of relatively high-value semiconductor and electronics commodities

- Asian NICs: Manufacturing of relatively low-value semiconductor and electronics commodities

Social and Industrial Culture and Government

For 35 years, ending after World War II, the Japanese occupied Korea. Understandably, this has resulted in Korean animosity toward the Japanese. The South Korean electronics industry would thus seem to be positioned not only economically, but also culturally, to seize some of the U.S. market from Japan.

Also representative of South Korea's commitment to competing with the Japanese for electronics and semiconductor world market share are some of their recent changes in industrial culture. Gold Star recently adopted a Japanese style of business organization where broad product lines (e.g., consumer products, communications and computer equipment, electronic devices and industrial systems) are situated relatively high up in the organization. Also, Gold Star's strategic planning, along with R&D and new business, are also located at the sectoral level instead of the division level.

In April 1986, the South Korean government launched the Korean Semiconductor Cooperative Research Project to foster development of semiconductor equipment and materials. Evidence of other government planning and support in Asia can be seen in Taiwan with the government-established, science-based industrial park at Hsinchu. Such government direction, intervention, and involvement should go a considerable length in preserving the short-run gains these nations achieve during the trade war, due to the tremendous resources that they can use to finance long-term/long-payback investments.

SUMMARY

The recent rift in trade relations between the United States and Japan, combined with the considerable appreciation of the yen against the dollar and other Asian currencies, should enable the Asian electronics industry, and the South Korean industry in particular, to capture some of the U.S. market from Japan. In the long run, market forces and mutual self-interest are probably strong enough to prevent the Asians from retaining superlative short-run gains. In the long run, the international product cycle will probably evolve so that each partner achieves its own comparative advantage.

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Research Newsletter

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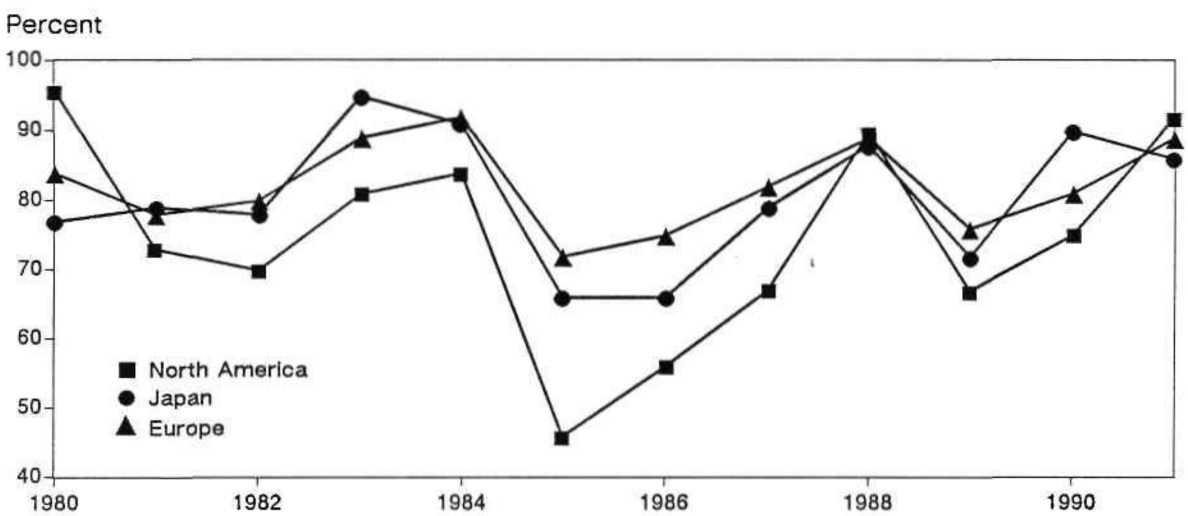
SECOND QUARTER PRICE UPDATE: RISING PRICES LEVEL OFF

SUMMARY

Dataquest's latest price survey indicates that since our last review, prices have leveled off from their prior downward trend. The anticipated absorption of available manufacturing capacity is well under way. Overall lead times have stretched considerably and are expected to continue to remain at the current levels through the third quarter of this year. The worldwide capacity utilization graph in Figure 1 illustrates how this trend of lengthening lead times will continue through 1988. The close communication between buyers and vendors emphasized during the past two years is still required in order to ensure consistent, reliable product supplies.

Figure 1

ESTIMATED CAPACITY UTILIZATION



Source: Dataquest
June 1987

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U.S.-JAPAN SEMICONDUCTOR TRADE ARRANGEMENT STATUS

The status of the U.S.-Japan Semiconductor Trade Arrangement is currently in turmoil as combinations of Japanese shipment controls and retaliatory trade sanctions taint trade relations between the two countries. In order to better understand the current situation, it is useful to see the chronology of the agreement in retrospect. Below are the key dates that led to the embattled pact:

- July 1985--Micron Technology charges that Japanese companies are dumping 64K DRAM devices.

- October 1985--Intel and AMD charge that Japanese companies are dumping all EPROM devices.

- December 1985--The U.S. government charges that Japanese companies are dumping 256K and 1 megabit DRAM devices. The ITC announces preliminary dumping penalties for 64K DRAMs.

- March 1986--The ITC announces preliminary dumping penalties for all EPROMs and 256K and 1 megabit DRAMs.

- April 1986--Final dumping penalties are announced for 64K DRAMs, effective May 1986.

- August 1986--The U.S.-Japan trade agreement is announced.

- September 1986--The trade agreement is signed.

- October 1986--The U.S. Department of Commerce (DOC) makes its first listing of Foreign Market Values (FMVs) for all EPROMs and 256K and 1 megabit DRAMs for the third quarter of 1986.

- November 1986--The DOC complains of continued dumping of unsanctioned semiconductor devices in the United States and the rest of the world.

- December 1986--The FMVs are released for the first quarter of 1987.

- January 1987--MITI announces first quarter production cutbacks in DRAMs and EPROMs in order to comply with the trade agreement.

- February 1987--The DOC files a complaint with Japan concerning the continued dumping of unsanctioned devices in non-U.S. markets.

- March 1987--MITI announces second quarter production cutbacks in addition to prior cutbacks made in DRAMs and EPROMs, resulting in a total reduction of 32 percent from fourth quarter 1986 levels.

- April 1987--The DOC imposes economic sanctions on Japan of $300 million on nonsemiconductor products in retaliation for noncompliance with the trade agreement.

- June 1987--The DOC establishes a partial removal (21 percent) of sanctions as a symbolic gesture acknowledging the improvement of price controls by MITI.

- June 1987--MITI initiates a proposal to Japanese producers to increase memory production 10 percent, to become effective in the third quarter, if approved.

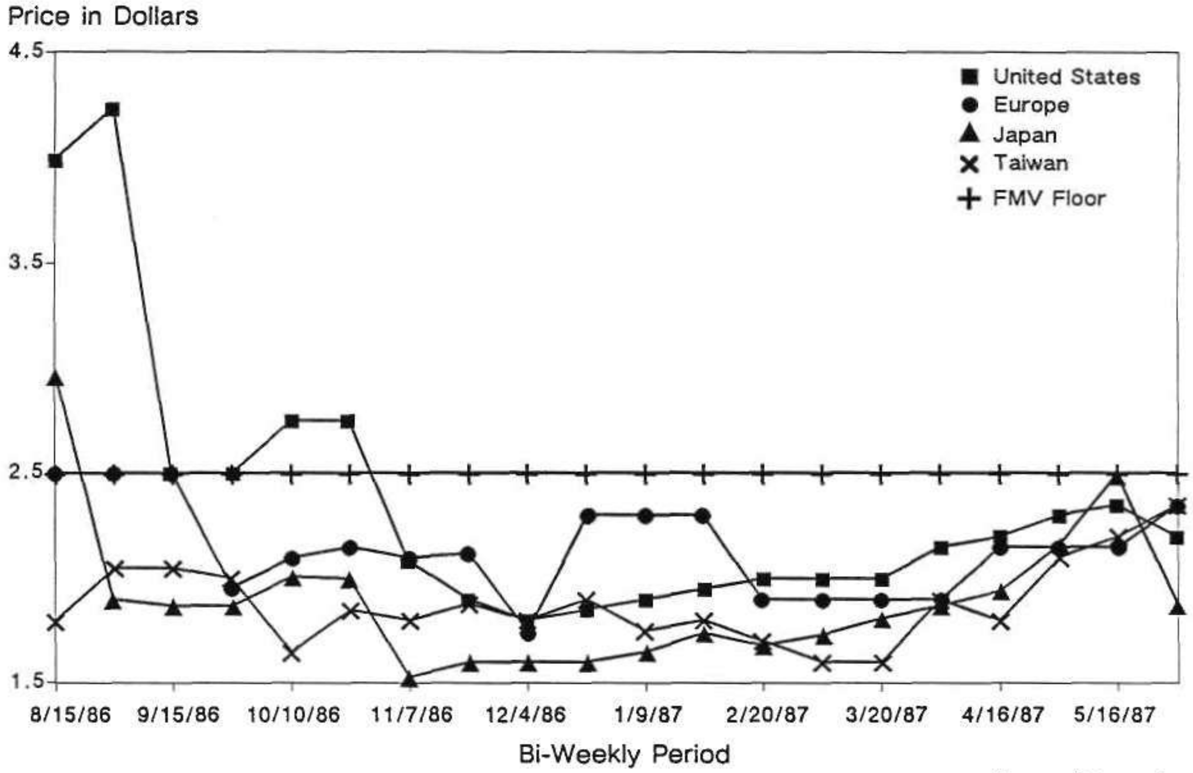
FMV RATIONALE

The idea behind the FMV concept was to provide a reasonable price based on cost to a market that was determined to have been damaged by predatory marketing practices. Although precautions were taken to prevent multiple tiered pricing in different regions of the world, the adage, "where there is a will there is a way," prevailed. Gray markets quickly developed in the Far East outside of Japan and even within the United States as FMVs proved to be way out of synch with market dynamics, as shown in Figure 2.

As attention focused on the uncontrolled gray markets, various methods of control were tried by MITI. Requests, lowering of export license yen levels, and finally administrative guidance demanding lower production levels succeeded in drying up most of the gray market memory sales. The result of these actions has temporarily raised DRAM and EPROM prices worldwide (including Japan) as the forces of supply and demand work on an artificially constrained supply line.

Figure 2

256K DRAM REGIONAL PRICING



Source: Dataquest
June 1987

IMPACT OF PRODUCTION CUTS

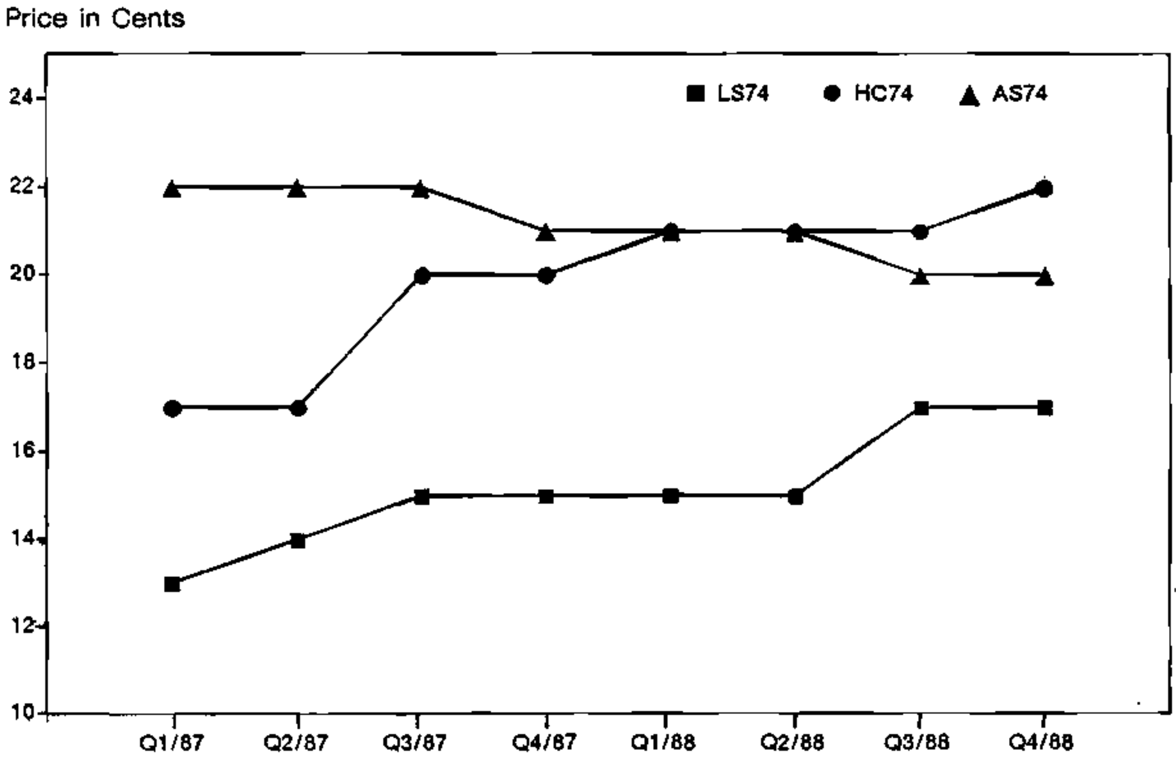
The production cuts mandated by MITI have been heard to be, in reality, shipment cuts. Many major Japanese manufacturers are still running wafers through their fab lines and are stockpiling wafers in inventory for quick shipment once trade tensions ease. The current price increases in the market can be seen as a visible response to the trade agreement and as a show of good faith by MITI. In the realpolitik of the world economy, the removal of trade sanctions and improved access to Japanese markets should resolve the current shipment allocation situation. Trade tensions should improve over the next two quarters as market prices for these key commodity ICs impress upon the agreement administrators that intervention in volatile markets such as the semiconductor market is, at best, a stopgap measure.

LOGIC TRENDS

Figure 3 shows the continuing trend of stable to rising prices that began early in the second quarter of this year. Lead times for these parts have increased dramatically since our last review, with averages ranging from 12 to 15 weeks. Surface-mount packages are demanding price premiums (up to 30 percent) and have an additional average lead time of three to four weeks above their DIP counterparts. This trend is expected to continue through the end of the year as capacity becomes utilized and surface-mount testers slowly come on stream.

Figure 3

U.S. STANDARD LOGIC PRICE TRENDS



Source: Dataquest
June 1987

MEMORY TRENDS

DRAM and EPROM memory prices have risen in direct response to the Japanese shipment reductions that began to be felt late in the first quarter. Market forces have made FMV pricing in some cases a bargain. Corresponding longer lead times for these affected parts range from 8 to 14 weeks, depending on density. Surface-mount packages and high-speed parts are experiencing price and lead-time premiums up to 50 percent more than their slower DIP relatives. Proposed increases of DRAM shipments from Japan will, if approved, keep prices from rising at their current rate. By the fourth quarter, prices are expected to again resume their downward pattern. One-megabit DRAM pricing continues to remain above or at official FMV levels. As production increases for this part, its prices are expected to gradually decline. The 5X crossover is still expected to occur during the fourth quarter of this year.

Other memory device prices have firmed as demand forces price declines to slow. SRAMs and EEPROMs, in particular, have shown price firming with lead times averaging a stable six to eight weeks.

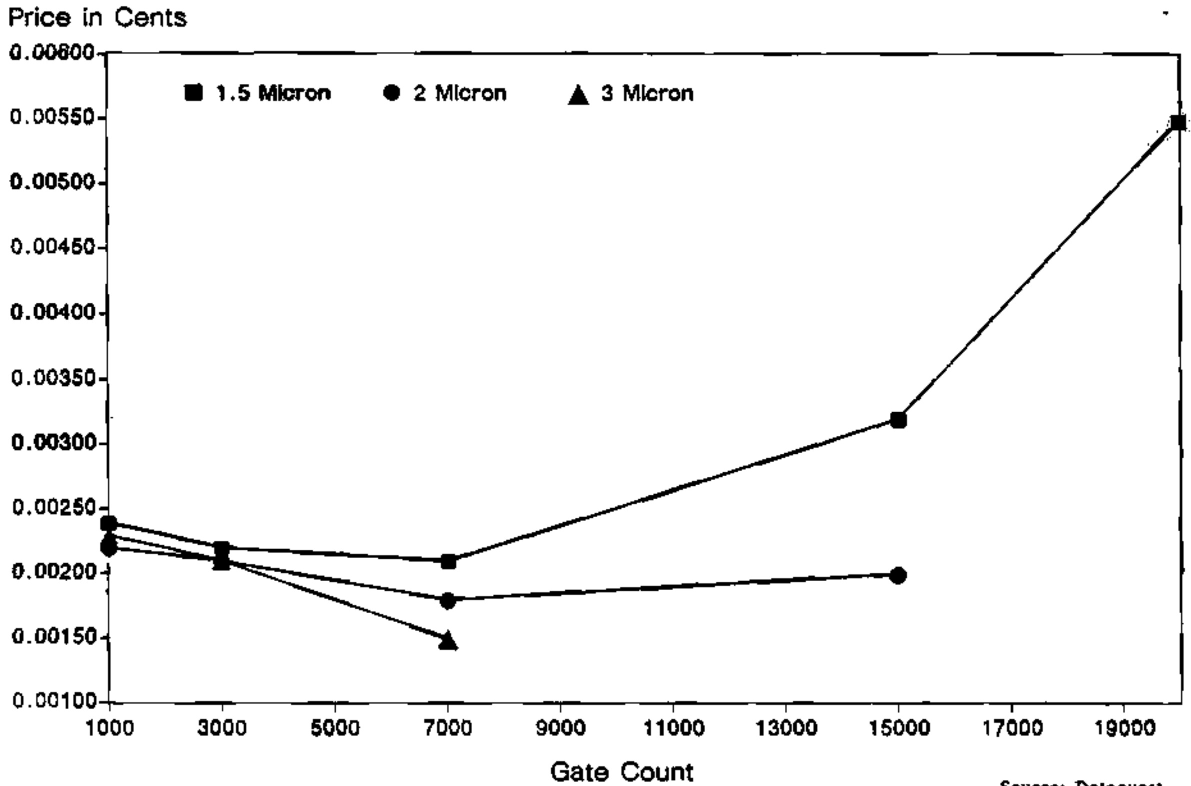
ASIC TRENDS

Figure 4 illustrates that the price per gate crossover has occurred for the 2-micron and 3-micron CMOS gate arrays in all densities except for the 5K gate devices. This reflects the maturity of the 2-micron process as it surpasses the six-year-old 3-micron technology in unit volume and in speed/size efficiencies. Price per gate for the 1.5-micron technology continues to put pressure on the 2-micron devices and remains 8 to 12 percent above comparable 2-micron designs. Our latest survey highlighted that, in many instances where there was a lower-than-average price per gate, the associated non-recurring engineering (NRE) charges were higher than that of companies where a higher-than-average cost per gate existed. It is important to combine the total of both NRE charges and cost per gate when analyzing ASIC alternatives.

Cell-based design and programmable logic device (PLD) pricing remained fairly stable when compared with our last survey. However, lead times for PLDs have stretched to 6 to 9 weeks for TTL parts and 6 to 12 weeks for CMOS devices.

Figure 4

1987 GATE ARRAY PRICE TRENDS
(Die Paid per Gate)



Source: Dataquest
June 1987

DATAQUEST OUTLOOK AND RECOMMENDATIONS

Current overall price trends continue to show firming as a result of the continuing growth in the data processing and electronic instrument markets. Price reductions have predictably slowed and lead times lengthened directly in proportion to the revival of business.

The current shipment reductions of Japanese memories are a direct result of the August 1986 U.S.-Japan Semiconductor Trade Arrangement. Supply of these parts should come into balance with demand as trade imbalances are rectified over the next six months. The present increases in hiring and the corresponding delay in raw material delivery due to increased demand will provide increased production capabilities by mid-third quarter. As volume increases to meet the sustained demand, prices for commodity semiconductors will moderate by the end of this year.

The continued utilization of manufacturing capacity combined with selected cutbacks in memory supply have accelerated the price-flattening, lead-time stretching trend that began late last year. It appears that the buyer's market of the past 2.5 years has been replaced by a seller's market that desires controlled growth over immediate short-term gains. Existing long-term contracts that took advantage of attractive pricing earlier in the year should be honored, acknowledging the fact that renewal contracts will reflect higher prices because of market conditions. Long-term procurement strategies that incorporate close communications with vendors should obviate large swings in prices and lead times. Accurate forecasting and constant communication between buyers and vendors will allow for the most efficient use of resources in the current business climate.

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CAPITAL SPENDING FORECAST: SLOWER BUT STEADIER GROWTH

INTRODUCTION

The capital equipment industry has just experienced its worst downturn in history. In 1986, worldwide capital spending, including captive spending, declined 30 percent. Dataquest believes that the capital equipment industry can now look forward to growth in four out of the next five years. This growth, however, will not be as strong as it has been in the past. We believe that future growth will be slower for two reasons: first, the growth of semiconductor consumption and production will be slower; second, a dollar's worth of capital equipment will be more productive than it has been in the past.

1986: MARKET CRASH

Japan's capital expenditures fell from ¥793 billion in 1985 to ¥293 billion in 1986, a 63 percent drop during calendar 1986. Expressed in dollars, the decline, although severe, was not quite as precipitous. The 1985 figure of $3.3 billion dropped to $1.7 billion in 1986, or 47 percent.

This severe decline in Japanese capital spending is due to major shocks that have hit the Japanese economy in general and the semiconductor industry in particular. These changes include:

- Sluggish exports due to trade friction with Japan's leading trading partners, including the United States and Europe
- Sharply reduced profits and even some layoffs

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- Excess capacity and declining domestic prices caused by growing competition from new entrants into the commodity DRAM market, especially from Pacific Rim countries

- The yen shock, which has raised production costs by more than 50 percent within the last year

Spending by merchant semiconductor manufacturers in North America also experienced a severe decline, from $2.3 billion in 1985 to $1.6 billion in 1986, a full 28 percent.

Capital spending by captive semiconductor manufacturers also fell in 1986, from $1.0 billion in 1985 to $0.9 billion in 1986, or 12 percent.

Europe and the rest of the world (ROW) were the two 1986 capital spending bright spots. Measured in dollars, spending in Europe increased 12 percent, from $600 million in 1985 to $670 million in 1986. Many equipment companies have reported sales either even with 1985 or higher. However, measured in local currency units, capital spending, even in Europe, experienced an 11 percent decline in 1986.

Spending in ROW (especially in Korea, Taiwan, Hong Kong, Thailand, and Singapore) was the only unalloyed bright spot in 1986; it grew 25 percent. However, ROW represented only 5 percent of the market for property, plant, and equipment (PPE) in 1986.

Figure 1 summarizes the 1986 market for capital spending in dollars. On a worldwide basis, capital spending declined 30 percent--from 1985's $7.5 billion to $5.3 billion in 1986.

1987 AND BEYOND: THE FORECAST

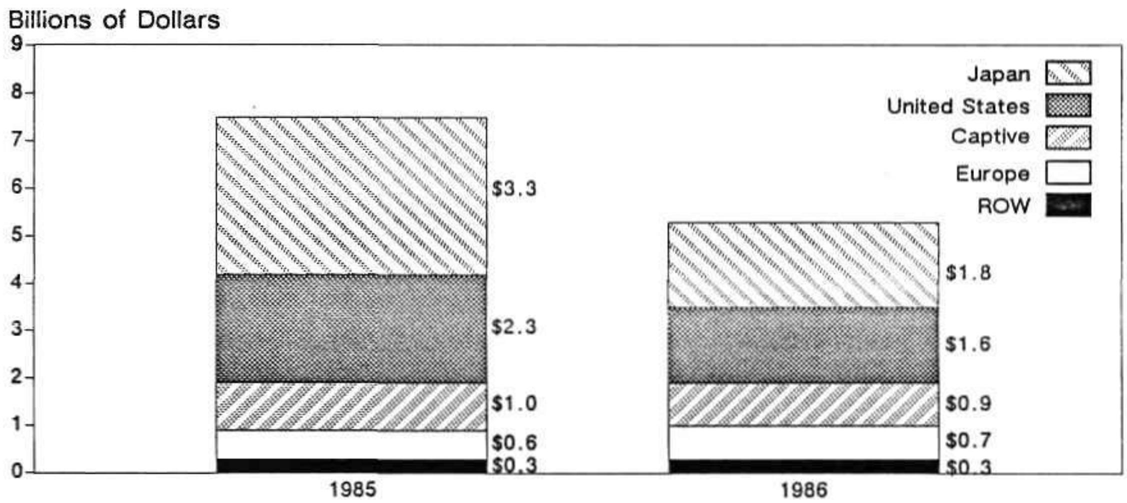
Except in Japan, we expect 1987 to be a year of recovery for the capital equipment industry. We look forward to a 10 percent increase in capital spending worldwide. The main force behind this increase is the continuing recovery of the semiconductor industry itself. Semiconductor manufacturers contacted by Dataquest in April and May were markedly more confident about their business than they were in January. Semiconductor companies are firm about their capital spending plans and in some cases have increased their plans markedly since the first of the year. We believe that semiconductor production will increase 10 percent worldwide in 1987.

When measured in dollars, capital spending in Japan will decline another 4 percent, to $1.7 billion. When measured in yen, the decline sounds even more painful: 11 percent. The reasons for this downward trend are the continuing uncertainty about exchange rates, overcapacity, low or nonexistent profit levels, and continuing trade friction.

Table 1 presents a regional breakdown of capital spending in 1987 versus 1986.

Figure 1

MARKET CRASH



Source: Dataquest
June 1987

Table 1

ESTIMATED REGIONAL CAPITAL SPENDING
(Millions of Dollars)

	1986	1987	Percent Change
North America	$1,640	$1,812	10%
Japan	1,754	1,688	(4%)
Europe	670	764	14%
ROW	275	406	48%
Captive	920	1,104	20%
Total	$5,260	$5,774	10%

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

Source: Dataquest
June 1987

1987 and Beyond: Highlights

As semiconductor consumption and production continue to expand in 1988, capacity utilization levels will rise. We therefore expect capital spending, including Japan's, to increase again in 1988. However, since we believe that semiconductor consumption and production will not grow in 1989, we expect a pause in capital spending growth that year. After 1989, however, we expect a renewed growth in capital spending (see Table 2). Also, after 1989, we expect a significant proportion of capital spending to be technology driven as a new generation of devices such as the 4Mb DRAM begins to go into production.

European capital spending will reach $1.7 billion by 1992, which represents a compound annual growth rate (CAGR) of 17 percent between 1986 and 1992.

Table 2

ESTIMATED CAPITAL SPENDING

	1982	1983	1984	1985	1986
North America	$1,212	$1,452	$3,051	$2,291	$1,640
Japan	921	1,698	3,578	3,332	1,754
Europe	315	350	630	600	670
ROW	45	91	201	220	275
Captive	501	542	965	1,045	920
Worldwide Capital Spending	$2,994	$4,133	$8,424	$7,488	$5,260
Percent Change		38%	104%	(11%)	(30%)

	1987	1988	1989	1990	1991	1992
North America	$1,812	$2,428	$2,292	$2,727	$ 3,436	$ 4,285
Japan	1,688	2,026	2,330	3,495	4,893	6,543
Europe	764	953	965	1,125	1,405	1,728
ROW	406	606	648	810	969	1,135
Captive	1,104	1,309	1,244	1,294	1,527	1,852
Worldwide Capital Spending	$5,774	$7,322	$7,478	$9,451	$12,230	$15,543
Percent Change	10%	27%	2%	26%	29%	27%

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

Source: Dataquest
June 1987

ROW capital spending will grow at a CAGR of 27 percent between 1986 and 1992, to $1.1 billion.

Captive manufacturers such as IBM and AT&T are a major market for semiconductor equipment. Captives accounted for 35 percent of total North American capital spending in 1986. We expect spending by the captives to increase 20 percent in 1987 and to grow to $1.8 billion in 1992.

Merchant capital spending in North America will grow at a slower rate than in the past--a 17 percent CAGR from 1986 to 1992. Because of this slower growth rate and the severity of the recent decline in capital spending, merchant capital spending will not reach its 1984 level of over $3 billion again until 1991.

Individual company capital spending in North America is shown in Table 3.

Table 3

NORTH AMERICAN COMPANY CAPITAL SPENDING

	1975	1976	1977	1978	1979	1980	1981
AMD	$ 1	$ 6	$ 10	$ 20	$ 39	$ 49	$ 58
Analog Devices	2	4	7	12	10	19	16
Fairchild	20	36	15	23	58	83	140
General Electric							
Harris						45	45
Intel	11	32	46	104	97	156	157
Thomson-Mostek	3	10	24	19	42	85	98
Motorola	21	33	43	72	159	177	184
National	17	26	31	51	84	116	105
Others	56	94	105	177	333	318	285
Philips-Signetics	4	10	19				
Texas Instruments	35	62	88	122	251	300	145
Subtotal of Domestic Company Spending	$170	$312	$388	$599	$1,073	$1,348	$1,233
Non-U.S.-Owned Company Spending in United States							
NEC	-	-	-	-	-	-	-
Philips-Signetics	-	-	-	$ 40	$ 50	$ 90	$ 115
Siemens	-	-	-	-	-	-	-
Thomson-Mostek	-	-	-	-	-	-	-
Total North American Capital Spending	$170	$312	$388	$639	$1,123	$1,438	$1,348
Percent Change		84%	24%	65%	76%	28%	(6%)

(Continued)

Table 3 (Continued)

NORTH AMERICAN COMPANY CAPITAL SPENDING

	1982	1983	1984	1985	1986	1987
AMD	$ 67	$ 111	$ 237	$ 172	$ 55	$ 120
Analog Devices	19	24	58	62	37	50
Fairchild	156	125	195	135	135	68
General Electric		64	107	81	50	50
Harris	35	25	50	50	40	30
Intel	138	146	388	214	150	225
Thomson-Mostek	47	78	123			
Motorola	160	174	412	330	250	338
National	82	120	300	184	117	100
Others	311	293	567	703	494	451
Philips-Signetics						
Texas Instruments	140	232	472	281	213	230
Subtotal of Domestic Company Spending	$1,155	$1,392	$2,908	$2,213	$1,541	$1,660
Non-U.S.-Owned Company Spending in United States						
NEC					$ 10	$ 12
Philips-Signetics	$ 55	$ 58	$ 133	$ 50	60	100
Siemens					20	15
Thomson-Mostek				39	9	25
Total North American Capital Spending	$1,210	$1,450	$3,041	$2,302	$1,640	$1,812
Percent Change	(10%)	20%	110%	(24%)	(29%)	(11%)

Source: Dataquest
June 1987

A Burst of Spending in Japan after 1987

We expect Japanese capital spending to recover somewhat in 1988, increasing from $1.69 billion in 1987 to $2.0 billion in 1988, or 20 percent. After 1988, we expect Japanese capital spending to increase at a rate much faster than the worldwide average. This is because the $6.9 billion of capital put on-stream in 1984 and 1985 will be nearing the end of its productive life and will have to be replaced. This 1984-1985 equipment will represent more than 50 percent of the Japanese installed base through the remainder of this decade.

As a consequence of the aging of a significant part of the Japanese installed base, we expect Japanese capital spending to increase 15 percent in 1989 when the worldwide market for capital goods will be flat; we also expect that in 1990 and 1991, Japanese capital spending will increase by 50 percent and 40 percent, respectively.

Table 4 shows individual Japanese company spending on a calendar year basis.

Table 4

JAPANESE MERCHANT COMPANY CAPITAL SPENDING
(Calendar Years, Millions of Dollars)

	1976	1977	1978	1979	1980	1981
Fuji Electric	0	0	0	0	0	0
Fujitsu	$ 3	$ 22	$ 48	$ 64	$110	$145
Hitachi	20	22	43	59	93	149
Japan Semiconductor	0	0	0	0	0	0
Matsushita	10	11	19	41	88	86
Mitsubishi	17	22	19	41	35	59
NEC	34	37	67	105	132	172
NJRC	0	0	0	0	0	0
NMB	0	0	0	0	0	0
Oki	10	15	10	14	53	54
Rohm	0	0	0	0	0	0
Sanken Electric	0	0	0	0	0	0
Sanyo	7	7	7	18	35	54
Sharp	0	0	7	37	37	43
Shindengen	0	0	0	0	0	0
Seiko Epson	0	0	0	0	0	0
Sony	0	0	0	0	0	0
Toshiba	14	19	24	37	48	72
Others	0	0	0	0	0	0
Total	$115	$156	$242	$416	$632	$834

(Continued)

Table 4 (Continued)

JAPANESE MERCHANT COMPANY CAPITAL SPENDING
(Calendar Years, Millions of Dollars)

	1982	1983	1984	1985	1986
Fuji Electric	$ 16	$ 26	$ 51	$ 50	$ 30
Fujitsu	141	226	485	303	96
Hitachi	145	264	506	387	132
Japan Semiconductor	0	0	0	0	30
Matsushita	36	89	371	366	144
Mitsubishi	80	132	274	261	120
NEC	169	247	544	517	180
NJRC	8	9	17	21	30
NMB	0	0	59	59	0
Oki	44	47	110	109	60
Rohm	8	13	25	38	48
Sanken Electric	8	13	25	25	24
Sanyo	40	51	135	197	108
Sharp	32	68	110	151	132
Shindengen	4	4	13	13	18
Seiko Epson	20	38	76	34	30
Sony	20	38	59	151	96
Toshiba	113	366	574	517	389
Others	36	68	143	134	90
Total	$921	$1,698	$3,578	$3,332	$1,754

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

Source: Dataquest
June 1987

A SLOWER LONG-TERM GROWTH

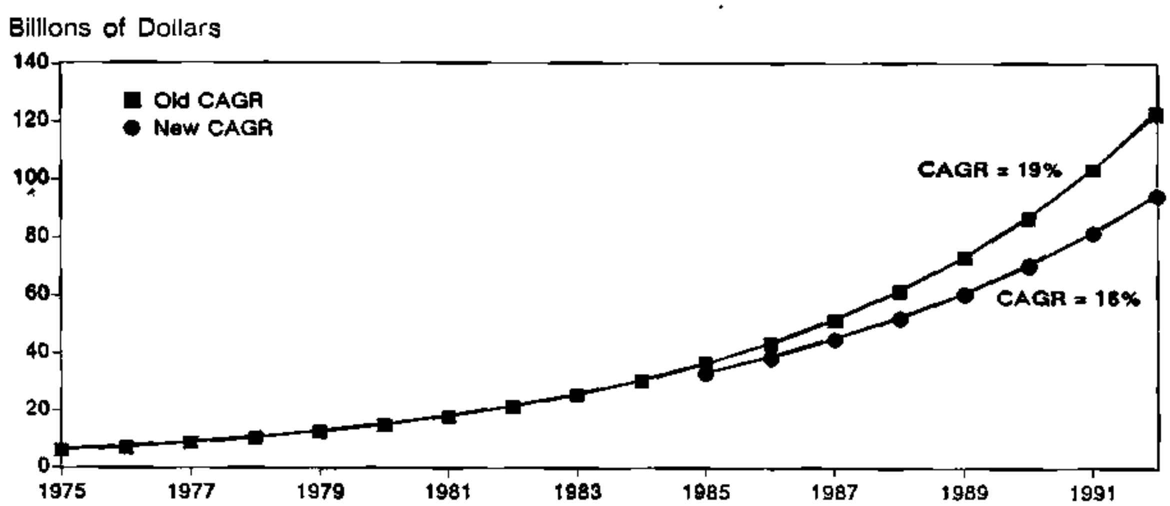
As shown in Table 2, we expect healthy growth during four out of the next five years. This growth, however, will not be as robust as it has been in the past. For the period from 1985 to 1992, the worldwide CAGR is 11 percent; for the period from 1980 to 1985 it was 27 percent.

The CAGR of capital spending has slowed down for two reasons: first, the CAGR of the semiconductor industry itself has slowed; second, the productivity of capital has begun to increase.

From 1975 to 1985, worldwide merchant semiconductor production has grown at a 19 percent CAGR. Dataquest now expects semiconductor production to grow at a slower rate of 16 percent. This new, lower, long-term growth rate is due to the absence of a new "hoola-hoop" such as the PC to drive the industry as it did in 1982 through 1984. It is also due to the success of the industry. Because semiconductors are now found throughout the economy, they will increasingly be influenced by the secular trends of the economy. The effect of this new, slower growth rate will be that the market for semiconductors will be $28 billion less in 1992 than it would have been (see Figure 2). For equipment makers this means $5 billion fewer revenue dollars in 1992 than if the CAGR had remained constant.

Figure 2

A SLOWER WORLDWIDE MERCHANT CAGR
(The Old and the New)

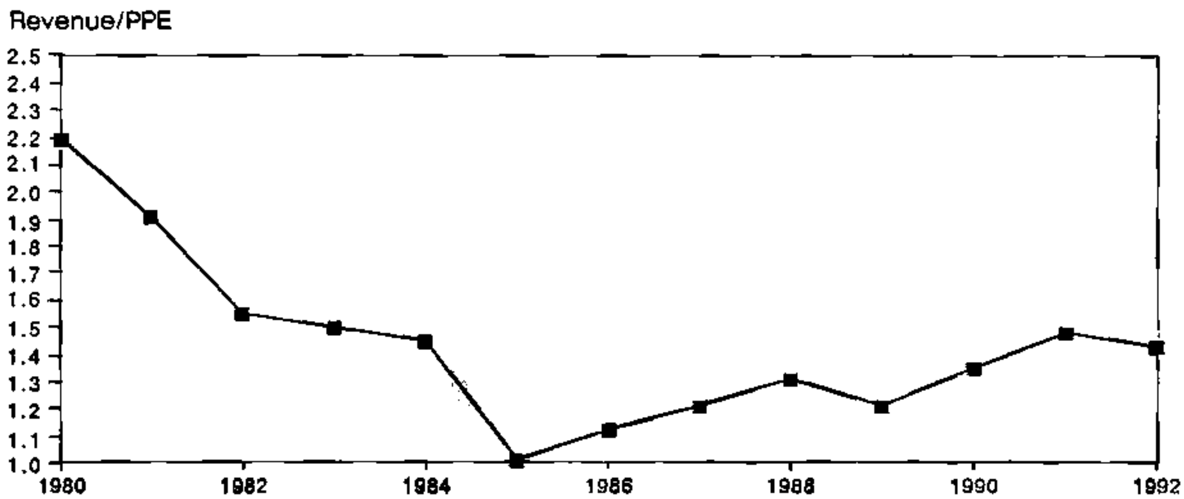


Source: Dataquest
June 1987

As mentioned above, the second reason for the slowdown in the capital spending CAGR is the increasing productivity of capital. Capital productivity is the amount of revenue that is generated with a given installed PPE base. Historically, this ratio has declined (see Figure 3). We believe, however, that capital productivity has begun to rise and will continue to do so. There are several reasons for this. Computer-integrated manufacturing (CIM) will allow manufacturers to schedule many different product mixes and maintain line balance while increasing equipment utilization. (We estimate that equipment utilization is presently in the neighborhood of 40 percent.) Manufacturers will increase their yields because automation will remove people from clean rooms. Lower particulate from semiconductor equipment and materials will also increase yields.

Figure 3

REVENUE/PPE
WORLDWIDE INSTALLED BASE

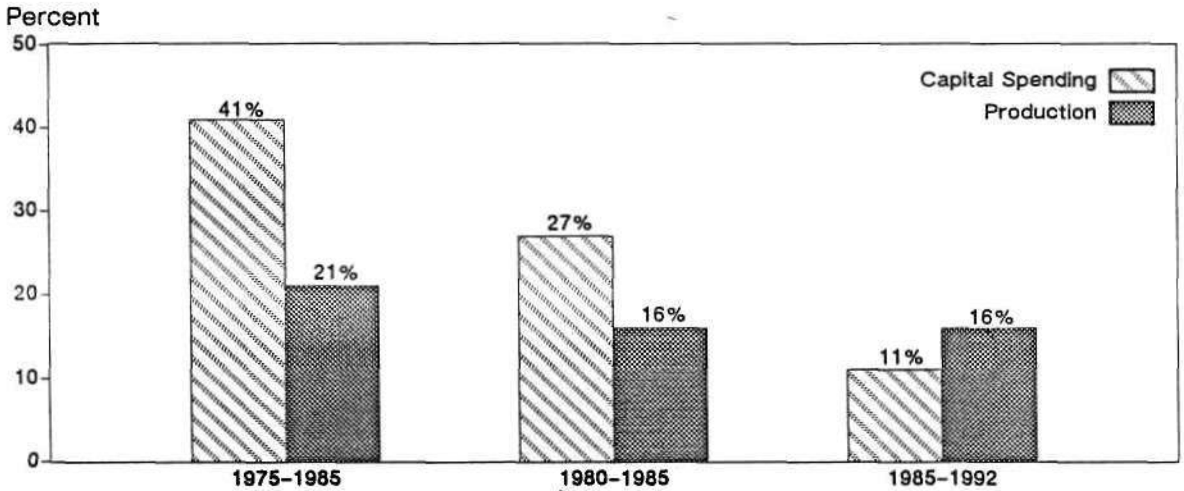


Source: Dataquest
June 1987

Figure 4 shows the effects of both the slowdown of semiconductor production and of increasing capital productivity. For the first period, from 1975 to 1985, worldwide capital spending grew at a CAGR of 41 percent; worldwide semiconductor production, including captives, grew at a CAGR of 21 percent. From 1980 to 1985, however, both capital spending and production CAGRs had fallen; the CAGR of capital spending fell more. From 1985 to 1992, we expect that the capital spending CAGR will fall below that of semiconductor production. Growth will occur, but it will be slower than it has been in the past.

Figure 4

DECLINING CAGR
CAPITAL SPENDING VERSUS PRODUCTION



Source: Dataquest
June 1987

CONCLUSION

Although growth will be slower for the capital equipment industry than it has been in the past, there will be growth--and that is an improvement over the last two years. Moreover, the growth will be relatively sustained: we expect healthy growth in four out of the next five years. Semiconductor manufacturers will spend first to increase capacity and then to introduce new manufacturing technology. We expect that the CAGR of the semiconductor equipment industry from 1985 to 1992 will be 11 percent, about four times the growth rate of the U.S. economy, and almost 50 percent higher than the growth rate for the electronics industry in the United States. Although less so than in the past, the semiconductor capital equipment industry is still a growth industry.

Mark Giudici
George Burns

Dataquest
a company of The Dun & Bradstreet Corporation

Research Newsletter

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DATAQUEST'S FORECAST FOR BUSINESS COMPUTER SYSTEMS: MODERATE GROWTH FOR 1987 THROUGH 1991

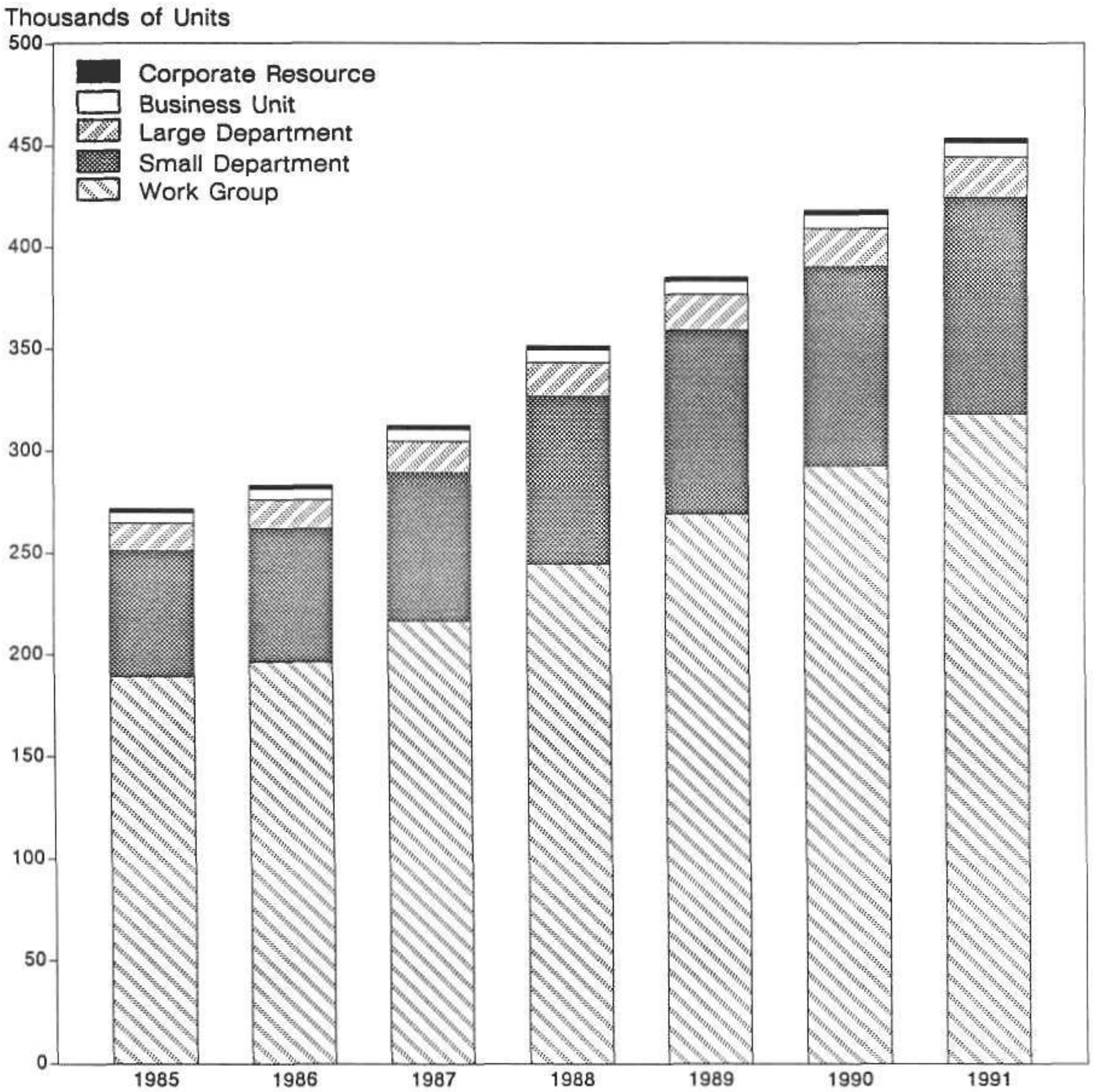
SUMMARY

After lackluster revenue growth in 1985 and 1986, the business computer systems industry should experience a moderate improvement in 1987. Dataquest forecasts that U.S. business computer industry revenue will grow 4.5 percent in the coming year, with a compound annual growth rate (CAGR) of 4.8 percent over the next five years (1987-1991). Figure 1 illustrates growth for unit shipments, and Figure 2 shows the dollar value of those shipments. A detailed numerical presentation of both shipments and dollars for actual performance from 1982 through 1986 and forecast performance for 1987 through 1991 is shown in Table 1. The U.S. market for multiuser business systems in 1986 totaled approximately $19 billion. We expect revenue to reach $24 billion by 1991.

Dataquest Incorporated, 1290 Ridder Park Drive, San Jose, CA 95131-2398, (408) 971-9000, Telex 171973

Figure 1

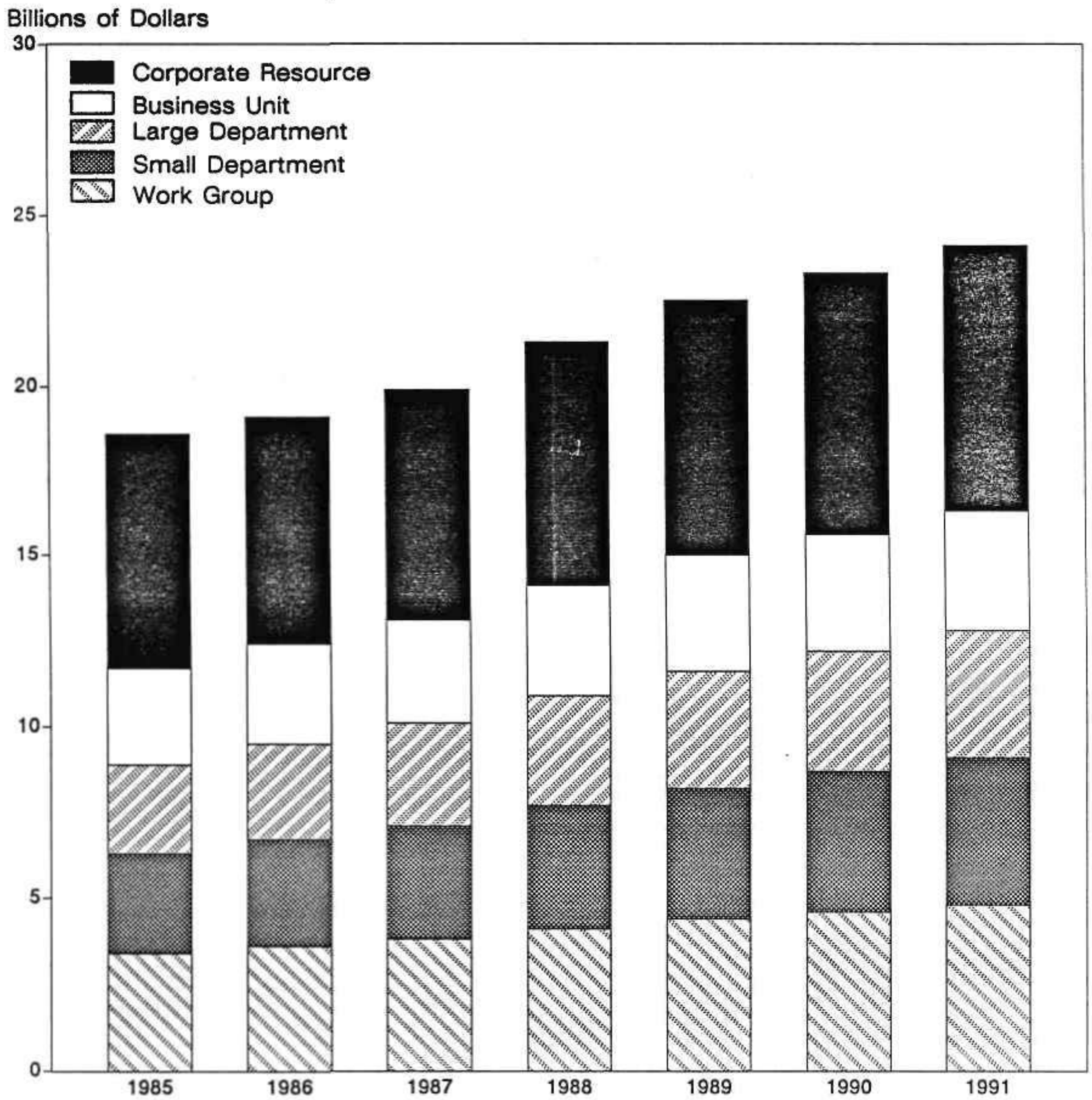
U.S. BUSINESS COMPUTER SYSTEMS
FORECAST UNIT SHIPMENTS



Source: Dataquest
June 1987

Figure 2

U.S. BUSINESS COMPUTER SYSTEMS
FORECAST UNIT SHIPMENT VALUE



Source: Dataquest
June 1987

Table 1

U.S. BUSINESS COMPUTER SYSTEMS
ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast					CAGR	CAGR
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-1986	1987-1991
Annual Shipments (K Units)	128.6	176.8	236.7	271.8	283.4	312.4	351.2	385.6	418.4	454.0	21.8%	9.8%
Average Selling Price ($K per Unit)	$103.2	$88.9	$76.3	$68.6	$67.3	$63.8	$60.7	$58.2	$55.5	$53.0	(10.1%)	(4.6%)
Total End-User If-Sold Revenue ($B)	$ 13.3	$15.7	$18.0	$18.6	$19.1	$19.9	$21.3	$22.4	$23.2	$24.0	9.5%	4.8%
Revenue Growth	26.7%	18.5%	14.8%	3.3%	2.3%	4.5%	7.0%	5.2%	3.5%	3.5%		
Retirements from Installed Base (K Units)	21.8	45.3	61.8	88.9	121.1	166.8	221.9	252.8	278.5	318.1	53.6%	17.5%
Year-End Installed Base (K Units)	365.2	496.7	671.6	854.6	1,016.8	1,162.4	1,291.7	1,424.6	1,564.4	1,700.3	29.2%	10.0%
Installed Base Growth	41.3%	36.0%	35.2%	27.2%	19.0%	14.3%	11.1%	10.3%	9.8%	8.7%		

Source: Dataquest
June 1987

KEY FACTORS INFLUENCING GROWTH IN MARKET SEGMENTS

As Figures 1 and 2 illustrate, the five market segments of the U.S. business computer system industry: corporate resource, business unit, large department, small department, and work group, will grow at different rates. The higher growth-rate areas are work group and departmental systems. On a segment-by-segment basis, the following sections detail the key factors behind Dataquest's growth projections for 1987 and the successive years through 1991.

Corporate Resource Segment

Table 2 shows the actual and forecast performance for the corporate resource segment, where the largest mainframes are found. After the continued decline in shipments experienced in 1985 and 1986, Dataquest expects 1987 to show relatively flat shipments and a slight gain in revenue due to an abundance of new high-end systems sold by multiple vendors. These systems will be installed during 1987. The following factors are key to this forecast:

- The further acceptance of the expanding 3090 family of IBM products, the XL Series from NAS, and the 5890 family from Amdahl will fuel enhanced revenue while maintaining flat shipment growth.

- Consolidation occurred in 1986 with the mergers of major corporate resource vendors: Unisys (Burroughs and Sperry) and Group Bull (Bull, Honeywell, and NEC). Both new entities (as well as the other corporate resource vendors, CDC and NCR) must prove themselves capable of maintaining market share from encroachment by IBM and the plug-compatible manufacturers (PCMs).

- Dataquest believes that the mainframe market is mature, with small incremental growth potential for revenue throughout the decade due to much higher cost per mainframe mips versus midrange or PC mips.

Business Unit Segment

For 1987, the business unit segment revenue is expected to grow 4.2 percent, as seen in Table 3. The reasons for this include:

- The traditional minicomputer vendors (i.e., Digital Equipment, Hewlett-Packard, IBM, Prime, and Tandem) will continue to dominate and fuel moderate growth with new and existing products.

- Dataquest believes the business unit segment is also a mature market, with only moderate growth forecast for the rest of the decade. As with corporate resource systems, this segment will also suffer as more computing is pushed toward the end user where per mip and communications costs are lower.

Table 2

U.S. CORPORATE RESOURCE BUSINESS COMPUTER SYSTEMS
ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast					CAGR	CAGR
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-1986	1987-1991
Annual Shipments (K Units)	1.8	2.0	2.1	2.0	1.9	2.0	2.1	2.2	2.3	2.3	1.4%	4.4%
Average Selling Price ($M per Unit)	$3.1	$3.3	$3.5	$3.5	$3.5	$3.5	$3.4	$3.4	$3.4	$3.3	3.0%	(1.0%)
Total End-User If-Sold Revenue ($B)	$5.7	$6.5	$7.1	$6.9	$6.7	$6.8	$7.2	$7.5	$7.7	$7.8	4.5%	3.3%
Revenue Growth	35.4%	14.0%	10.1%	(3.2%)	(2.1%)	1.5%	5.3%	4.0%	2.0%	2.0%		
Retirements from Installed Base (K Units)	0.7	0.8	0.8	0.8	0.9	1.1	1.4	1.8	2.0	2.1	5.5%	17.7%
Year-End Installed Base (K Units)	9.8	10.9	12.2	13.4	14.4	15.3	16.0	16.4	16.7	16.9	10.2%	2.6%
Installed Base Growth	12.6%	12.2%	11.3%	9.7%	7.7%	6.1%	4.7%	2.4%	1.8%	1.4%		

Source: Dataquest
June 1987

Table 3

U.S. BUSINESS UNIT BUSINESS COMPUTER SYSTEMS
ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast					CAGR	CAGR
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-1986	1987-1991
Annual Shipments (K Units)	4.1	4.5	5.0	5.3	5.4	5.7	6.2	6.5	6.8	7.0	7.1%	5.1%
Average Selling Price ($K per Unit)	$651.9	$618.2	$574.3	$523.7	$528.8	$523.6	$518.3	$513.1	$507.9	$502.8	(5.1%)	(1.0%)
Total End-User If-Sold Revenue ($B)	$ 2.7	$ 2.8	$ 2.9	$ 2.8	$ 2.9	$ 3.0	$ 3.2	$ 3.4	$ 3.4	$ 3.5	1.7%	4.0%
Revenue Growth	9.9%	4.2%	2.2%	(2.5%)	2.9%	4.2%	6.6%	5.0%	2.3%	2.3%		
Retirements from Installed Base (K Units)	0.9	1.2	1.8	2.7	3.2	3.7	4.1	5.0	5.3	5.4	36.9%	10.3%
Year-End Installed Base (K Units)	34.3	37.7	40.9	43.6	45.8	47.8	49.9	51.5	52.9	54.4	7.5%	3.3%
Installed Base Growth	10.3%	9.7%	8.5%	6.6%	5.1%	4.5%	4.3%	3.2%	2.8%	2.9%		

Source: Dataquest
June 1987

Large Department Segment

After an encouraging turnaround from flat revenue in 1985 to an increase of 5.1 percent in 1986, the large department segment is forecast to grow 6.8 percent in 1987 (see Table 4). The main forces influencing this segment are:

- Expected volume shipment of the IBM 9370 Series in the third quarter of 1987 for IBM's 9370 Series will be a positive growth factor.

- As networking schemes and departmental computing applications software are made more available during 1987, increased segment growth will result.

Small Department Segment

The emergence of powerful 68020-based systems is fueling an expected 7.8 percent growth rate in 1987's small department revenue (see Table 5). Additional key forces contributing to this segment forecast are:

- Many of the traditional minicomputer vendors are downsizing their products to attack this growth segment, with products such as Digital Equipment's MicroVAX II, IBM's 9370, and Tandem's CLX. These companies are faced with developing new distribution channels for their products, typically through third-party resellers. Through these resellers, the companies are penetrating markets beyond the Fortune 500 and expanding overall volume.

- Some of the work group vendors, such as Altos and Convergent Technologies, are growing their product lines beyond the work group market and are making a stronger showing in the departmental markets.

- Similar to the large department segment, the major industry trend toward distributed computing promotes continued development in this segment.

Table 4

U.S. LARGE DEPARTMENT BUSINESS COMPUTER SYSTEMS
ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast					CAGR	CAGR
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-1986	1987-1991
Annual Shipments (K Units)	12.1	14.1	14.5	13.6	14.1	15.2	16.5	17.6	18.6	19.7	3.9%	6.7%
Average Selling Price ($K per Unit)	$173.5	$178.5	$182.3	$194.4	$196.7	$194.7	$192.8	$190.8	$188.9	$186.3	3.2%	(1.1%)
Total End-User If-Sold Revenue ($B)	$ 2.1	$ 2.5	$ 2.7	$ 2.6	$ 2.8	$ 3.0	$ 3.2	$ 3.4	$ 3.5	$ 3.7	7.2%	5.5%
Revenue Growth	31.3%	20.0%	5.2%	(0.4%)	5.1%	6.8%	7.2%	5.8%	4.5%	4.5%		
Retirements from Installed Base (K Units)	2.1	3.5	5.3	7.6	9.4	11.0	13.5	14.1	15.9	17.2	45.5%	11.8%
Year-End Installed Base (K Units)	41.2	51.8	61.1	67.0	71.7	76.0	78.9	82.5	85.1	87.7	14.9%	3.7%
Installed Base Growth	32.1%	25.8%	17.8%	9.8%	7.0%	5.9%	3.9%	4.4%	3.3%	3.0%		

Source: Dataquest
June 1987

Table 5

U.S. SMALL DEPARTMENT BUSINESS COMPUTER SYSTEMS
ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast					CAGR	CAGR
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-1986	1987-1991
Annual Shipments (K Units)	26.4	32.1	44.1	62.0	65.6	72.9	82.0	90.3	98.3	107.0	25.5%	10.1%
Average Selling Price ($K per Unit)	$51.5	$53.3	$51.0	$46.4	$46.7	$45.3	$43.9	$42.6	$41.3	$40.1	(2.4%)	(3.0%)
Total End-User If-Sold Revenue ($B)	$ 1.4	$ 1.7	$ 2.3	$ 2.9	$ 3.1	$ 3.3	$ 3.6	$ 3.8	$ 4.1	$ 4.3	22.5%	6.8%
Revenue Growth	7.1%	25.7%	31.6%	28.0%	6.4%	7.8%	9.1%	6.8%	5.6%	5.6%		
Retirements from Installed Base (K Units)	5.4	10.3	15.3	20.7	23.5	26.9	32.0	43.0	59.0	76.9	44.4%	30.0%
Year-End Installed Base (K Units)	91.9	113.7	142.6	184.0	226.1	272.1	322.2	369.5	408.9	439.0	25.2%	12.7%
Installed Base Growth	29.7%	23.7%	25.4%	29.0%	22.9%	20.4%	18.4%	14.7%	10.6%	7.4%		

Source: Dataquest
June 1987

Work Group Segment

Work group revenue is forecast to grow 5.9 percent in 1987 (see Table 6). Also a growth segment for business computers, the work group market will be influenced markedly by the powerful 32-bit microprocessors during the coming years. Principal reasons for the forecast are:

- Market entry by traditional minicomputer vendors--such as IBM's Personal System/2, Model 80, and Digital Equipment's MicroVAX 2000--will expand Fortune 1000 penetration, which to date has been minimal.

- IBM ATs and AT-compatibles running the Xenix operating system flooded the low end of the market in 1986 and produced a new price/performance point for entry systems bringing new users into the computer marketplace.

- The capability of running multiple operating systems, principally UNIX and MS-DOS, will be a positive growth factor. This capability is beginning to emerge during 1987 in the new 80386-based systems. We believe Motorola's 68000 series of micro-processors will offer this capability in the near future.

- Progress has been made to converge on one UNIX standard (e.g., the Microsoft-AT&T agreement to codevelop a POSIX-compliant offering that will replace Microsoft's Xenix and bear the UNIX name). This will reduce confusion and maintenance costs for the market. A second benefit will be expansion of the application software base.

- A factor inhibiting work group system growth is the competition coming from the improving technology and decreasing costs of PC LANs.

Table 6

U.S. WORK GROUP BUSINESS COMPUTER SYSTEMS ACTUAL AND FORECAST SHIPMENTS AND VALUE

	Actual					Forecast						
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	CAGR 1982-1986	CAGR 1987-1991
Annual Shipments (K Units)	84.1	124.1	170.9	188.9	196.3	216.5	244.5	268.9	292.4	318.0	23.6%	10.1%
Average Selling Price ($K per Unit)	$17.2	$17.9	$18.5	$18.2	$18.4	$17.6	$16.9	$16.2	$15.6	$15.0	1.6%	(4.0%)
Total End-User If-Sold Revenue ($B)	$ 1.4	$ 2.2	$ 3.2	$ 3.4	$ 3.6	$ 3.8	$ 4.1	$ 4.4	$ 4.6	$ 4.8	25.6%	5.7%
Revenue Growth	50.6%	53.6%	42.4%	8.7%	4.8%	5.9%	8.4%	5.6%	4.4%	4.4%		
Retirements from Installed Base (K Units)	12.6	29.5	38.6	57.2	84.1	124.1	170.9	188.9	196.3	216.5	60.7%	14.9%
Year-End Installed Base (K Units)	188.2	282.7	415.1	546.8	658.9	751.3	824.8	904.9	1,001.0	1,102.5	36.8%	10.1%
Installed Base Growth	61.3%	50.3%	46.8%	31.7%	20.5%	14.0%	9.8%	9.7%	10.6%	10.1%		

Source: Dataquest
June 1987

OVERALL MARKET FORCES

Dataquest expects data processing budgets to grow 4 to 5 percent in 1987. A major portion of the budget increase will be spent on networking and application software, leaving little room for systems hardware growth. Incremental growth will come, to a large degree, from increased market penetration of companies outside the Fortune 1000.

Dataquest's forecasts were made under the assumption that the U.S. economy will continue the stability shown during the past few years and will exhibit moderate growth in 1987. We expect that tax laws passed in 1986 will have a negligible effect on this market.

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Mark Guidici
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Dataquest
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The Dun & Bradstreet Corporation

Research *Bulletin*

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**TOSHIBA'S EMERGING ASIC STRATEGY:
GOING FOR THE TOP**

In a major bid to become the world's largest ASIC vendor, Toshiba is actively building alliances with CAD makers, design houses, and other major semiconductor makers. During the last two years, Toshiba has signed the following ASIC agreements:

- LSI Logic and Sun Microsystems are partners in Toshiba's "Sea of Gates" strategy, with LSI Logic (deal signed in October 1985) supplying its design software and Sun providing CAD workstations (October 1985).

- General Electric and Siemens are working with Toshiba to develop a common standard cell library using Toshiba's CMOS process (August 1986).

- Toshiba just signed a three-year contract with SDA Systems, a venture-backed CAD startup with equity funding from National, Harris, GE, and Ericsson, to develop ASIC design software (May 1987).

- Chips and Technologies, which is teamed up with Kyocera, ASCII, and Mitsui, is a bipolar and CMOS array subcontractor. Recently, Dr. Kaichiro Odagawa, a long-time Toshiba director, became LSI Design director for Kyocera, which is pushing into ASICs (August 1986).

- Toshiba is developing a super smart card for Visa International using its CMOS standard cell library (November 1985).

- Toshiba is also developing, producing, and marketing Laser Path's gate arrays (March 1986).

As shown in Table 1, Toshiba is the sixth largest ASIC vendor worldwide, with revenue of $132.6 million in 1986 (excluding full custom). Currently, it is building a large design center with 100 design rooms in Kawasaki City. By teaming up with other companies (see Figure 1), Toshiba hopes to parlay its strengths to become a top player in the fast-growing ASIC market. As the competition intensifies, Dataquest believes other ASIC vendors will follow suit to leverage their research and marketing strengths.

Penny Sur
Sheridan Tatsuno

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Table 1

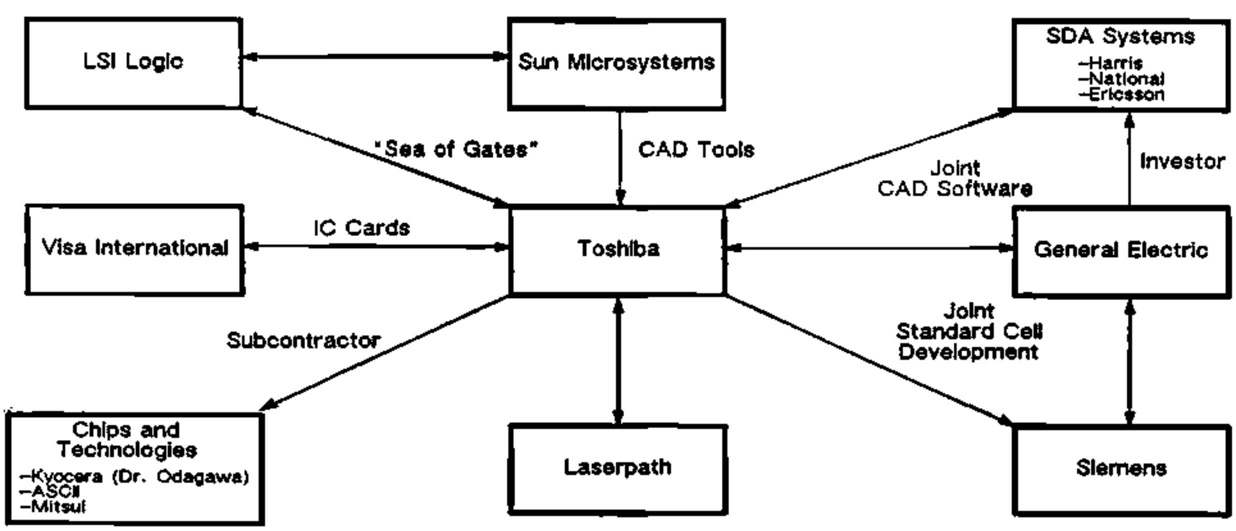
TOP 10 ASIC VENDORS WORLDWIDE IN 1986
(Millions of Dollars)

	Company	1986	1985	Percent Growth
1.	Fujitsu	$ 359.2	$ 251.2	43.0%
2.	LSI Logic	194.3	140.0	38.9%
3.	AT&T	183.1	144.4	26.8%
4.	MMI/AMD	176.7	148.1	19.3%
5.	NEC	151.2	97.0	55.9%
6.	Toshiba	132.6	52.5	152.3%
7.	Texas Instruments	99.7	71.2	40.0%
8.	Motorola	94.7	78.3	20.9%
9.	Hitachi	78.8	58.1	35.6%
10.	Signetics	76.0	73.3	3.7%
	Top 10 Vendors	$1,546.3	$1,114.1	38.8%

Source: Dataquest
May 1987

Figure 1

TOSHIBA'S EMERGING ASIC STRATEGY



Source: Dataquest
May 1987

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THOMSON-SGS MERGER

The French Group, Thomson, and the Italian Group, STET, have received approval from their respective governments to go ahead with plans to merge the microchip activities of their subsidiaries, Thomson Semiconducteurs and SGS Semiconductors. The merger will involve the creation of a Netherlands-based company, owned 50 percent by Thomson-CSF and 50 percent by STET. The executive vice president of Thomson-CSF, Henri Starck, is to be appointed Chairman of the new company, while Pasquale Pistorio, managing director of SGS Micro Elettronica, will be chief executive officer. The new company will consolidate activities in Europe, North America, and Asia, serving international markets and generating revenue of more than $800 million.

DATAQUEST ANALYSIS

Thomson achieved worldwide revenue of $436 million in 1986, which put it just ahead of SGS at $370 million. Thomson ranked seventeenth worldwide in 1986, while SGS was twentieth. The Thomson-SGS combination will rank eleventh worldwide and will be Europe's second-largest semiconductor concern. An analysis of each company's 1986 sales breakdown by product, end-use segment, and geographic sales territory is detailed in Tables 1, 2, and 3, respectively. The two companies are of similar size and both have embarked on radical, often pragmatic, recovery plans since the early 1920s. Their increased focus on global marketing and internationalization, manufacturing efficiency, and customer service has allowed them to significantly outpace the world market growth in recent years despite two significant industry recessions.

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Dataquest believes that this merger is a very positive event for the European semiconductor industry and for each company, both collectively and individually. It will virtually guarantee their place among the world leaders in the 1990s, enabling them to reach their 3 percent worldwide market share goal today, this being considered the critical mass for survival in the global marketplace. It currently places them number 11 worldwide, just behind National Semiconductor and ahead of AMD, with a combined product range that is remarkably complementary. Without doubt, their combined resources mean the emergence of a new powerful force in the world semiconductor market.

Penny Sur
Byron Harding

Table 1

ESTIMATED 1986 SALES REVENUE BY PRODUCT
(Percent Based on U.S. Dollars)

Product	SGS	Thomson
MOS	29%	48%
Bipolar	50	20
Discrete	21	32
Total	100%	100%

Source: Dataquest
May 1987

Table 2

ESTIMATED 1986 SALES REVENUE BY END USE SEGMENT
(Percent Based on U.S. Dollars)

Segment	SGS	Thomson
Computer	16%	17%
Consumer (Including Transportation)	41	25
Industrial	26	25
Govt./Military	0	10
Telecommunications	17	23
Total	100%	100%

Source: Dataquest
May 1987

Table 3

ESTIMATED 1986 SALES REVENUE BY GEOGRAPHIC REGION
(Percent Based on U.S. Dollars)

Region	SGS	Thomson
Asia	16%	13%
Europe	65	63
North America	19	24
Total	100%	100%

Source: Dataquest
May 1987

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Research Newsletter

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JAPANESE SEMICONDUCTOR MARKET: FIRST-QUARTER 1987 UPDATE

SUMMARY

As a result of actual fourth-quarter 1986 results for Japanese semiconductor consumption, we have updated our quarterly forecasts for 1987 and 1988. In yen terms, we still foresee slow growth in the first half of 1987, picking up in the second half of the year. Total semiconductor quarterly growth rates (in yen) for 1987 remain the same as in our January 1987 forecast.

The yen-to-dollar exchange rate still remains a thorny issue when forecasting the Japanese semiconductor market. Figure 1 shows the yen-per-dollar exchange rate from January 1984 through the middle of March 1987. The yen appeared to have stabilized against the dollar as a result of the "Group of Seven" meeting on February 28, but the dollar subsequently fell to a new postwar low against the yen. In the wake of the March 27 announcement of U.S. trade sanctions against Japan, the dollar has continued its downward path against the yen. Prior to this announcement, world opinion was that the dollar was already low enough. We believe that Japanese semiconductor consumption cannot recover this year if the dollar falls much lower; we believe that it will stabilize again over the next couple of months. Our forecast is based on a yen-per-dollar exchange rate of 154.

In order to support our forecast growth, the Japanese electronics industry must retain some semblance of health. The Japanese electronics products selected by the Reagan administration for 100 percent tariffs amount to approximately $1.2 billion of end products imported into the United States, most of which contain some amount of semiconductors. However, the semiconductor content of these products totals around 8 to 10 percent, or $96 million to $120 million worth of semiconductors. Therefore, we do not believe that the U.S. sanctions will have a major effect on semiconductor consumption in Japan.

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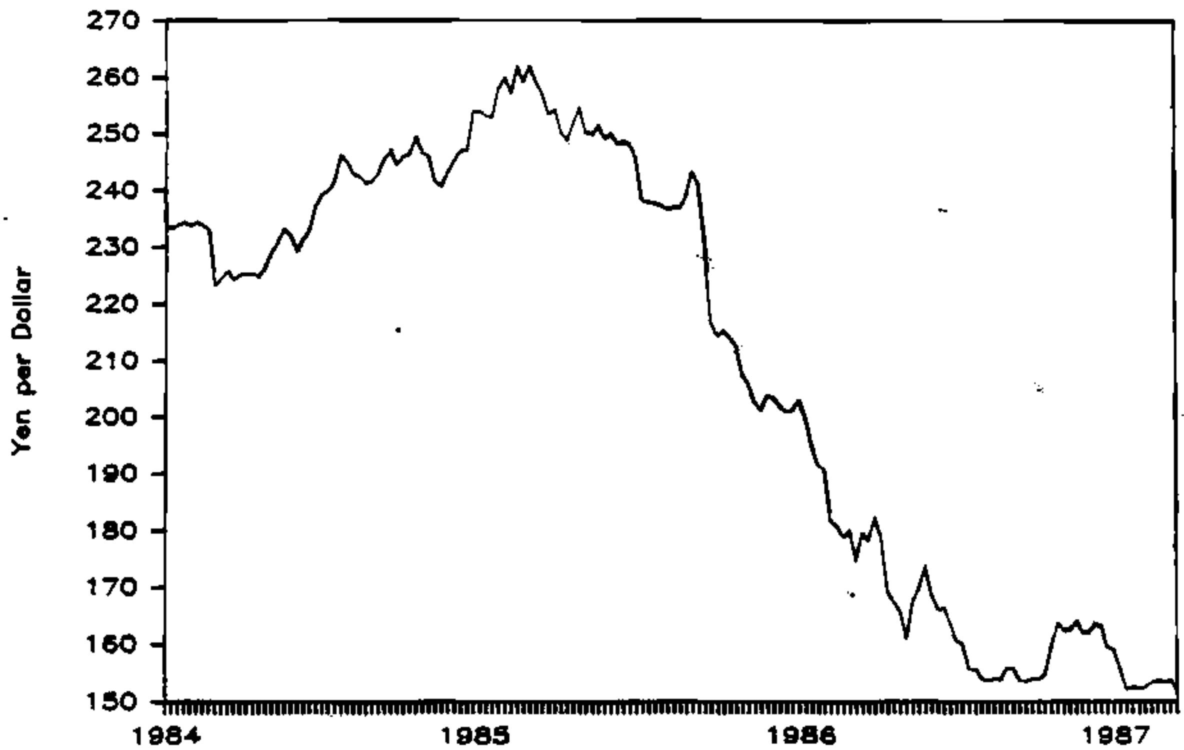
Figure 1

YEN-PER-U.S. DOLLAR EXCHANGE RATE



Source: Far Eastern Economic Review
Dataquest
May 1987

FORECAST

The Japanese semiconductor market became the world's largest in 1986, at ¥2,068.6 billion ($12,356 million). The market grew only 1.0 percent in yen, but because of severe yen appreciation, dollar growth was 43.7 percent.

We expect 1987 to be healthier than 1986 as Japan continues to adjust to the high yen through the first two quarters of the year. Third quarter 1987 should show strong growth of almost 6 percent. We forecast total 1987 growth to be 6.0 percent in yen (15.2 percent in dollars). Linear ICs, discretes, and optoelectronics will continue to be the hardest-hit product areas as the shift to offshore production of consumer electronics equipment continues for at least the first half of 1987.

The year 1988 should be a much stronger year, with yen growth of 17.5 percent (also 17.5 percent in dollars). We expect most product lines to do well in 1988, as most shifts of end products to offshore production will have occurred in 1986 and 1987.

Although competitive pricing pressure still exists in Japan as manufacturers strive to cut production costs of equipment destined for the U.S. market, MITI's move to cut production of DRAMs and EPROMs in the first two quarters of 1987 has had the immediate effect of raising the prices of these products in Japan. We have also heard of some supply shortages, particularly of 256K DRAMs.

Tables 1 through 4 show our quarterly forecast of the Japanese semiconductor market size and growth, in yen and dollars, from 1986 through 1988.

Figures 2 and 3 graphically depict the differences between the forecast in yen and the forecast in dollars.

DATAQUEST CONCLUSIONS

Over the next couple of years, we do not foresee the emergence of large new semiconductor application markets (such as VCRs and PCs), which in the past have been the driving force of semiconductor market growth. In real (i.e., yen) terms, we expect the Japanese semiconductor market to grow more slowly than the U.S. market in 1987 and 1988. These are very traumatic times for Japan, as the country struggles with a historically high unemployment rate (3 percent in January), announcements of layoffs in "sunset" industries (19,000 people at Nippon Steel alone), an appreciated yen that has caused profits of all the industrial giants to plummet, and escalating trade tension with the United States. The Reagan administration's announcement of retaliation against Japanese companies for noncompliance with the U.S.-Japan Semiconductor Trade Arrangement is clearly the first round in a trade war that could have serious implications for both the United States and Japan.

Mark Giudici
Patricia S. Cox

Table 1

JAPANESE SEMICONDUCTOR CONSUMPTION
(Percent Change in Terms of Yen)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	1.1%	1.4%	4.4%	(3.2%)	1.0%
Total IC	2.3%	1.9%	4.9%	(3.5%)	1.5%
Bipolar Digital	(1.0%)	6.3%	0.9%	(3.4%)	(4.5%)
Memory	0	3.1%	0	0	(12.4%)
Logic	(1.1%)	6.8%	1.0%	(3.9%)	(3.3%)
MOS	5.2%	0.7%	7.6%	(1.5%	1.6%
Memory	1.9%	2.3%	2.4%	8.0%	(11.1%)
Micro Device	6.7%	(5.9%)	10.2%	(7.5%)	16.8%
Logic	7.1%	5.0%	10.1%	(4.6%)	4.1%
Linear	(1.0%)	1.9%	2.3%	(7.1%)	4.1%
Discrete	(4.1%)	(0.1%)	4.0%	(0.8%)	(3.4%)
Optoelectronic	2.7%	(0.6%)	(1.0%)	(5.9%)	9.1%
	Q1/87	**Q2/87**	**Q3/87**	**Q4/87**	**1987**
Total Semiconductor	1.1%	2.0%	5.9%	3.0%	6.0%
Total IC	1.2%	2.4%	7.6%	2.9%	8.0%
Bipolar Digital	3.5%	1.1%	5.0%	0.5%	6.4%
Memory	4.5%	2.9%	11.3%	0	13.7%
Logic	3.4%	0.8%	4.0%	0.6%	5.4%
MOS	3.8%	3.4%	10.2%	3.9%	16.2%
Memory	4.2%	1.6%	11.4%	4.6%	21.6%
Micro Device	4.3%	5.9%	12.4%	5.9%	14.6%
Logic	3.1%	3.0%	7.5%	1.7%	12.6%
Linear	(4.8%)	1.1%	3.4%	1.9%	(5.7%)
Discrete	(2.1%)	(0.4%)	2.0%	1.2%	0.2%
Optoelectronic	(0.7%)	(0.4%)	6.0%	4.0%	(2.2%)
	Q1/88	**Q2/88**	**Q3/88**	**Q4/88**	**1988**
Total Semiconductor	2.3%	6.6%	7.2%	4.8%	17.5%
Total IC	2.8%	5.0%	7.4%	3.6%	18.9%
Bipolar Digital	2.9%	7.8%	9.2%	6.1%	19.4%
Memory	1.3%	3.8%	6.0%	3.4%	14.8%
Logic	3.1%	8.4%	9.7%	6.5%	20.1%
MOS	3.4%	5.3%	8.8%	4.0%	23.4%
Memory	5.4%	7.6%	11.7%	5.6%	31.0%
Micro Device	2.4%	3.0%	7.0%	3.0%	22.1%
Logic	2.4%	5.0%	7.2%	3.0%	17.2%
Linear	1.2%	3.0%	3.2%	1.5%	9.1%
Discrete	1.5%	4.0%	5.6%	2.3%	10.1%
Optoelectronic	5.5%	4.3%	6.1%	1.4%	19.2%

Source: Dataquest
May 1987

Exchange Rate (¥/US$)	154	154	154	154	154

Source: Dataquest
May 1987

Table 2

JAPANESE SEMICONDUCTOR CONSUMPTION
(Billions of Yen)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	¥504.9	¥511.8	¥534.4	¥517.5	¥2,068.6
Total IC	¥385.6	¥392.8	¥412.2	¥397.8	¥1,588.4
Bipolar Digital	¥ 52.1	¥ 55.4	¥ 55.9	¥ 54.0	¥ 217.4
Memory	6.4	6.6	6.6	6.6	26.2
Logic	45.7	48.8	49.3	47.4	191.2
MOS	¥209.8	¥211.3	¥227.3	¥224.0	¥ 872.4
Memory	68.8	70.4	72.1	77.9	289.2
Micro Device	65.6	61.7	68.0	62.9	258.2
Logic	75.4	79.2	87.2	83.2	325.0
Linear	¥123.7	¥126.1	¥129.0	¥119.8	¥ 498.6
Discrete	¥ 88.5	¥ 88.4	¥ 91.9	¥ 91.2	¥ 360.0
Optoelectronic	¥ 30.8	¥ 30.6	¥ 30.3	¥ 28.5	¥ 120.2
Exchange Rate (¥/US$)	188.0	170.0	156.0	160.0	167.0
	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	¥520.1	¥529.3	¥564.1	¥579.4	¥2,192.9
Total IC	¥402.5	¥412.2	¥443.5	¥456.5	¥1,714.7
Bipolar Digital	¥ 55.9	¥ 56.5	¥ 59.3	¥ 59.6	¥ 231.3
Memory	6.9	7.1	7.9	7.9	29.8
Logic	49.0	49.4	51.4	51.7	201.5
MOS	¥232.6	¥240.4	¥265.0	¥275.4	¥1,013.4
Memory	81.2	82.5	91.9	96.1	351.7
Micro Device	65.6	69.5	78.1	82.7	295.9
Logic	85.8	88.4	95.0	96.6	365.8
Linear	¥114.0	¥115.3	¥119.2	¥121.5	¥ 470.0
Discrete	¥ 89.3	¥ 88.9	¥ 90.7	¥ 91.8	¥ 360.7
Optoelectronic	¥ 28.3	¥ 28.2	¥ 29.9	¥ 31.1	¥ 117.5
Exchange Rate (¥/US$)	154.0	154.0	154.0	154.0	154.0
	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	¥595.1	623.8	667.9	690	¥2,576.8
Total IC	¥469.1	¥492.7	¥529.3	¥548.5	¥2,039.6
Bipolar Digital	¥ 61.3	¥ 66.1	¥ 72.2	¥ 76.6	¥ 276.2
Memory	8.0	8.3	8.8	9.1	34.2
Logic	53.3	57.8	63.4	67.5	242.0
MOS	¥284.9	¥300.0	¥326.4	¥339.3	¥1,250.6
Memory	101.3	109.0	121.8	128.6	460.7
Micro Device	84.7	87.2	93.3	96.1	361.3
Logic	98.9	103.8	111.3	114.6	428.6
Linear	¥122.9	¥126.6	¥130.7	¥132.6	¥ 512.8
Discrete	¥ 93.2	¥ 96.9	¥102.3	¥104.7	¥ 397.1
Optoelectronic	¥ 32.8	¥ 34.2	¥ 36.3	¥ 36.8	¥ 140.1
Exchange Rate (¥/US$)	154.0	154.0	154.0	154.0	154.0

Source: Dataquest
May 1987

Table 3

JAPANESE SEMICONDUCTOR CONSUMPTION
(Percent Change in Terms of Dollars)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	11.4%	12.1%	13.7%	(5.6%)	43.7%
Total IC	12.7%	12.7%	14.3%	(5.9%)	44.5%
Bipolar Digital	9.1%	17.7%	9.8%	(5.9%)	36.2%
Memory	9.7%	14.7%	7.7%	(2.4%)	24.8%
Logic	9.0%	18.1%	10.1%	(6.3%)	37.9%
MOS	15.9%	11.4%	17.2%	(3.9%)	45.1%
Memory	12.3%	13.1%	11.6%	5.4%	27.8%
Micro Device	17.5%	4.0%	20.1%	(9.9%)	64.6%
Logic	17.9%	16.2%	20.0%	(7.0%)	49.0%
Linear	9.0%	12.8%	11.5%	(9.4%)	47.4%
Discrete	5.6%	10.4%	13.3%	(3.2%)	37.3%
Optoelectronic	13.1%	9.8%	7.8%	(8.2%)	53.6%

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	4.4%	1.8%	6.6%	2.7%	15.2%
Total IC	5.1%	2.4%	7.6%	2.9%	17.3%
Bipolar Digital	7.7%	1.1%	4.9%	0.5%	15.7%
Memory	9.8%	2.2%	10.9%	0	23.7%
Logic	7.4%	0.9%	4.0%	0.6%	14.6%
MOS	7.9%	3.4%	10.2%	3.9%	26.2%
Memory	8.2%	1.7%	11.4%	4.5%	32.1%
Micro Device	8.4%	5.9%	12.4%	5.9%	24.7%
Logic	7.1%	3.1%	7.5%	1.6%	22.0%
Linear	(1.2%)	1.2%	3.3%	1.9%	2.6%
Discrete	1.8%	(0.5%)	2.1%	1.2%	8.9%
Optoelectronic	3.4%	(0.5%)	6.0%	4.1%	6.6%

	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	2.7%	4.8%	7.1%	3.3%	17.5%
Total IC	2.8%	5.0%	7.5%	3.6%	19.0%
Bipolar Digital	2.8%	7.8%	9.3%	6.0%	19.4%
Memory	2.0%	3.8%	5.6%	3.5%	15.0%
Logic	3.0%	8.4%	9.9%	6.3%	20.0%
MOS	3.5%	5.3%	8.8%	3.9%	23.4%
Memory	5.4%	7.6%	11.7%	5.6%	31.0%
Micro Device	2.4%	2.9%	7.1%	3.0%	22.1%
Logic	2.4%	5.0%	7.3%	2.9%	17.2%
Linear	1.1%	3.0%	3.3%	1.4%	9.1%
Discrete	1.5%	4.0%	5.6%	2.4%	10.1%
Optoelectronic	5.4%	4.2%	6.3%	1.3%	19.3%

Source: Dataquest
May 1987

Table 4

JAPANESE SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	$2,686	$3,011	$3,425	$3,234	$12,356
Total IC	$2,051	$2,311	$2,642	$2,486	$ 9,490
Bipolar Digital	$ 277	$ 326	$ 358	$ 337	$ 1,298
Memory	34	39	42	41	156
Logic	243	287	316	296	1,142
MOS	$1,116	$1,243	$1,457	$1,400	$ 5,216
Memory	366	414	462	487	1,729
Micro Device	349	363	436	393	1,541
Logic	401	466	559	520	1,946
Linear	$ 658	$ 742	$ 827	$ 749	$ 2,976
Discrete	$ 471	$ 520	$ 589	$ 570	$ 2,150
Optoelectronic	$ 164	$ 180	$ 194	$ 178	$ 716
Exchange Rate (¥/US$)	188	170	156	160	167

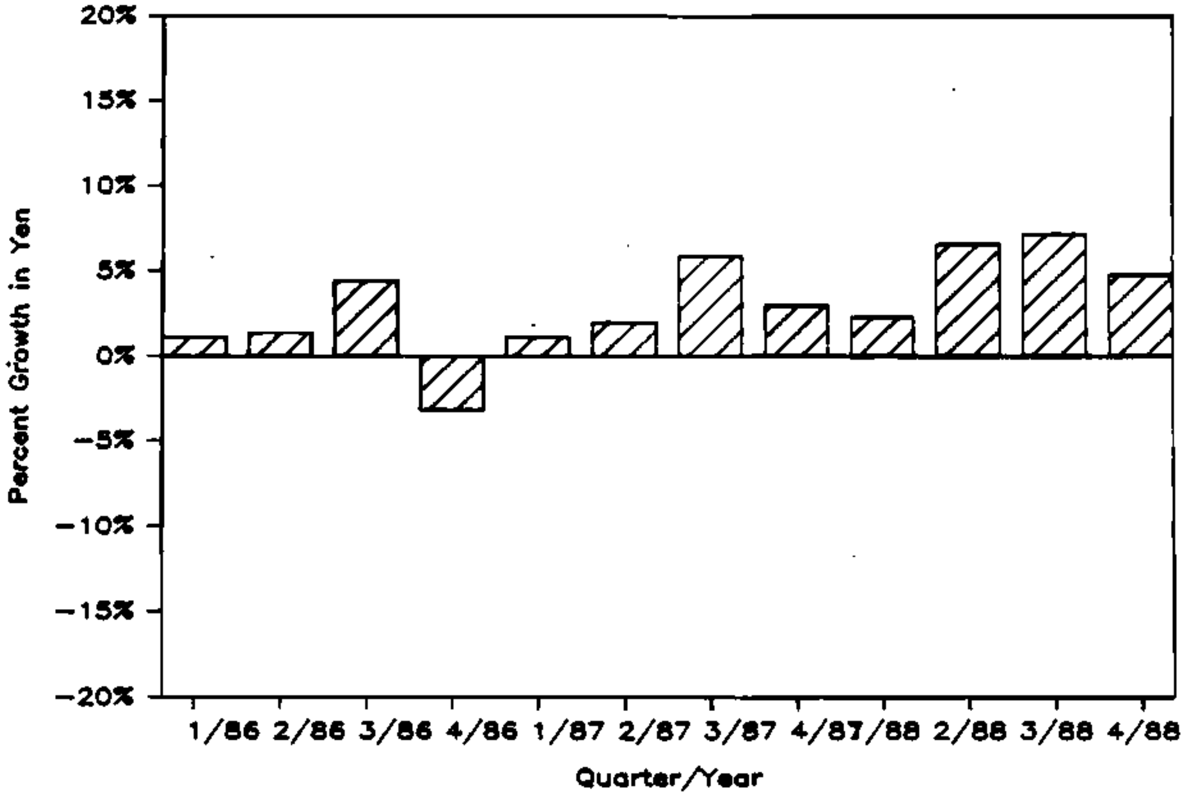
	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	$3,377	$3,437	$3,663	$3,762	$14,239
Total IC	$2,613	$2,677	$2,880	$2,964	$11,134
Bipolar Digital	$ 363	$ 367	$ 385	$ 387	$ 1,502
Memory	45	46	51	51	193
Logic	318	321	334	336	1,309
MOS	$1,510	$1,561	$1,721	$1,788	$ 6,580
Memory	527	536	597	624	2,284
Micro Device	426	451	507	537	1,921
Logic	557	574	617	627	2,375
Linear	$ 740	$ 749	$ 774	$ 789	$ 3,052
Discrete	$ 580	$ 577	$ 589	$ 596	$ 2,342
Optoelectronic	$ 184	$ 183	$ 194	$ 202	$ 763
Exchange Rate (¥/US$)	154	154	154	154	154

	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	$3,864	$4,050	$4,338	$4,480	$16,732
Total IC	$3,046	$3,199	$3,438	$3,561	$13,244
Bipolar Digital	$ 398	$ 429	$ 469	$ 497	$ 1,793
Memory	52	54	57	59	222
Logic	346	375	412	438	1,571
MOS	$1,850	$1,948	$2,120	$2,203	$ 8,121
Memory	658	708	791	835	2,992
Micro Device	550	566	606	624	2,346
Logic	642	674	723	744	2,783
Linear	$ 798	$ 822	$ 849	$ 861	$ 3,330
Discrete	$ 605	$ 629	$ 664	$ 680	$ 2,578
Optoelectronic	$ 213	$ 222	$ 236	$ 239	$ 910
Exchange Rate (¥/US$)	154	154	154	154	154

Source: Dataquest
May 1987

Figure 2

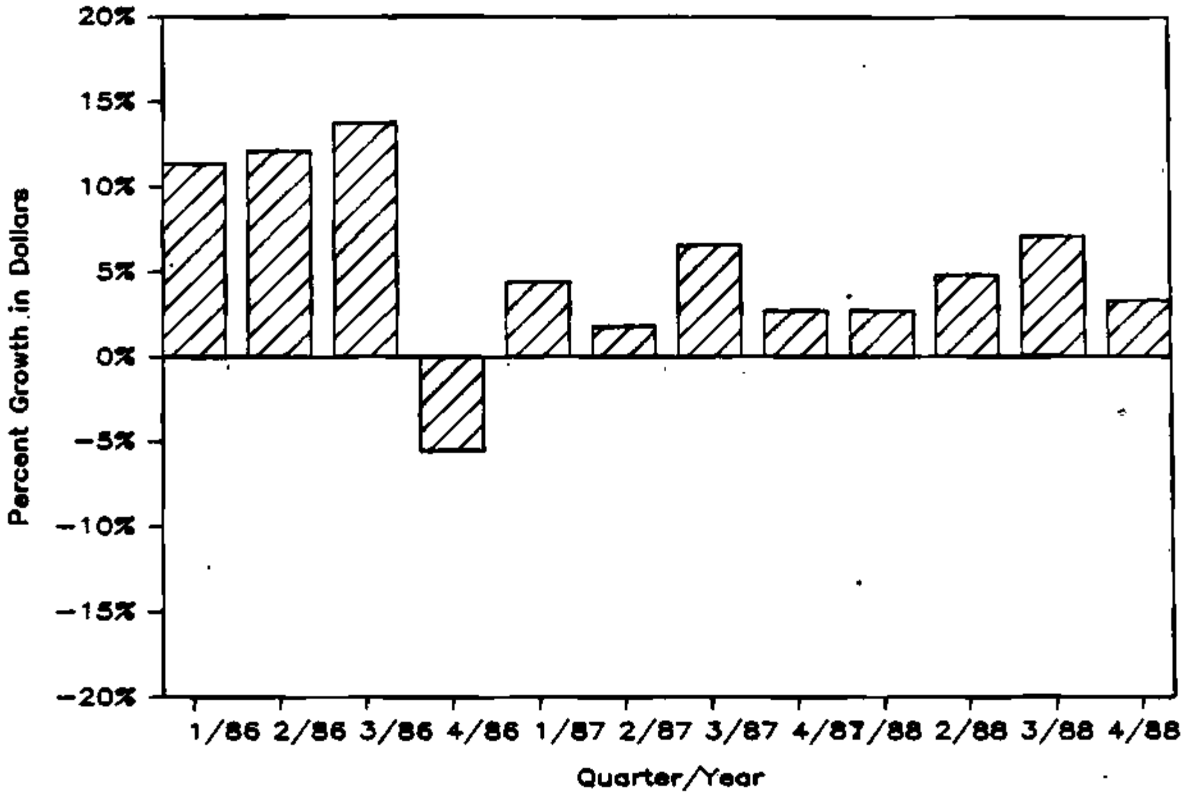
JAPANESE SEMICONDUCTOR MARKET
ESTIMATED QUARTER-TO-QUARTER GROWTH IN YEN



Source: Dataquest
May 1987

Figure 3

JAPANESE SEMICONDUCTOR MARKET
ESTIMATED QUARTER-TO-QUARTER GROWTH IN DOLLARS



Source: Dataquest
May 1987

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Research *Bulletin*

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LET THE MANUFACTURER AND BUYER BEWARE: LEAD-TIME CONCERN IS APPARENT IN FIRST MONTHLY PROCUREMENT SURVEY

Dataquest's Semiconductor Application Markets (SAM) service began its first monthly semiconductor procurement survey on May 1 to complement the annual procurement survey done each year. Several major electronic equipment companies have agreed to share with us, on a monthly basis, information regarding their semiconductor buying trends. Each month we will survey our team of respondents and report on tactical industry trends shaping the short-term industry outlook. This bulletin highlights the information gleaned from our first such survey.

Clearly, the single most important procurement issue facing buyers is lead times. Concern arose regarding obtaining DRAMs as well as regarding placing orders soon enough to avoid getting "left in the cold." One respondent was concerned that lead times would continue to stretch, and another respondent's major concern was to obtain lead time agreements with particular suppliers. The average lead time for new orders was nearly 12 weeks.

In general, most respondents said that semiconductor prices were remaining the same; increases mentioned were no more than 5 percent, seen in DRAMs and components purchased overseas. Most users are not having particular difficulty obtaining components in the quantities that they require; however, when difficulties were mentioned, they involved memory, standard logic, and linear devices.

Other information learned from the survey included the following:

- May billings were expected to be flat to slightly up.
- All buyers expected to place orders in May; they estimated that 6 percent of these orders would be placed with distributors.
- Target inventories were in alignment with actual inventory levels, with the average target and actual level being 33 days.

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- Last month, users rejected an average of 1.9 percent of components because they did not meet specification.

- Most companies were experiencing approximately the same rate of electronic equipment sales as at this time last year. No single application market area seemed to be experiencing either much higher or much lower sales activity.

We can only discern that the business cycle is once again in a state of flux, with many waiting to see if the upturn is here for good. Concern over lead times and availability is one indication that the market is tightening; in our annual survey, users projected that their purchases would increase nearly 14 percent in 1987. Next month's survey will be our first month-to-month comparison--we await the opportunity to plot a monthly course.

Mark Guidici
Anthea C. Stratigos

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Research Newsletter

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SILICON COMPILER COMPANIES MERGE--
SIGN OF METHODOLOGY TAKING OFF

INTRODUCTION

Silicon Compilers Incorporated (SCI) of San Jose, California, and Silicon Design Labs (SDL) of Liberty Corner, New Jersey, announced a merger of their companies. The resulting organization will be known as Silicon Compiler Systems (SCS), with corporate headquarters in San Jose, California. SCS, the combined company, would employ approximately 225 persons, and represent an estimated $23 million in 1986 sales, according to Dataquest's calculations (see Table 1).

Table 1

SELECTED COMPILATION COMPANIES
1986 REVENUE
(Millions of Dollars)

	1986 Revenue	
Company	Company	CAD Software
SDA	$ 7	$ 5
Seattle Silicon (Formerly SST)	$ 9	$ 6
Silicon Compilers Inc. (SCI)	$ 16	$12
Silicon Compiler Systems Corporation (SCS)*	$ 23	$18
Silicon Design Labs (SDL)	$ 7	$ 6
VLSI Technology, Inc. (VTI)	$114	$ 9

*Estimate based on consolidated revenue of SCI and SDL.

Source: Dataquest
May 1987

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SCS represents a challenging presence among companies addressing the market for automated IC design and a real boost to inroads already made by silicon compilation. The promise of the integrated company is to satisfy the market's pent-up demand for a common set of design tools--tools that provide both systems engineers and IC designers the means to capture and translate to each other their respective design expertise.

In this newsletter, Dataquest analyzes the impact this milestone announcement is likely to have on both the companies involved and the future of automated IC design tools.

DATAQUEST ANALYSIS

This merger contains a number of pluses for both companies. Now SCI and SDL have the flexibility to focus on integrating their individual technological strengths, rather than struggling to overcome their shortcomings. No longer will these companies have to dilute their resources by competing with each other.

SCI brings several advantages to the merger:

- A large installed base of more than 200 systems--SCI's users are largely systems engineers in the targeted industries of defense and aerospace. SDL, in contrast, had targeted IC designers in semiconductor houses. By anyone's count, there are orders-of-magnitude more systems engineers than IC designers on the planet.

- The Genesil front-end tool--This will be integrated with SDL's back-end Generator Development Tool (GDT). This integration will allow IC designers to enlarge or edit Genesil's function set and provide them with the ability to include process-specific design information. System engineers will benefit from greater architectural flexibility in design choices as a result of an expanding function set.

- An in-place European sales, support, and design center structure--SCI maintains locations in England, France, Germany, and the Netherlands.

- An extremely strong marketing and support infrastructure--SCI's marketing and customer support efforts have resulted in a relatively large and satisfied installed base.

SDL brings several strengths to the new relationship in addition to the GDT product:

- SDL provides a design language and simulation as well as the "L" circuit description language and a respectable simulation offering known as LSIM. (SDL markets LSIM either unbundled or bundled with GDT.)

- SDL is reported to maintain a very healthy cash position in reserves.

- SDL's installed base of tools in semiconductor houses are well accepted.

By addressing the needs of both the IC and systems designers, SCS' eventual product would provide a necessary linkage between IC design expertise and new ASIC designers. Also, the merger of the nonoverlapped user bases could serve to leverage sales in companies with high vertical integration. In this merger everybody's software runs on the same hardware platforms--Digital and Apollo workstations, another positive aspect of the move.

User Impact

What will designers at user companies face as a result of this new entity? One perspective indicates the following short-term limitations:

- There is no common user interface at this time.

- There are no guarantees of manufacturability for the end chip designs.

- It is not known which foundries will support the new tools.

- In most cases, the foundries will have to create the additional libraries of functions.

The other perspective indicates that in the longer term, the tools are theoretically compatible. However, as product evolution continues, complete integration must be the ultimate goal. We believe that with the financial strength and commitment to technology and methodology evident in these two organizations, that goal should be very achievable. At the point of complete compatibility, users will be closer to the ideal system for complete generation of unique functions and the integration of those functions into a device that can be parameterized.

DATAQUEST CONCLUSIONS

The market for silicon compilation has not experienced the instantaneous acceptance and success of EDA. The phenomenal growth of EDA's "little three"--Daisy, Mentor, and Valid has not been shared by the "silicon little three"--Seattle Silicon, SCI, and SDL. Two short years ago, the entire compilation market seemed to consist of only these three small companies preaching an esoteric methodology called "true silicon compilation." Success has been slow in coming, and only through real-life design successes. Only now can the electronic CAD/CAM marketplace begin even to distinguish between compilation products.

This merger serves to advance further acceptance of the compiler methodology and does not necessarily cut out either new entrants or the competition. The year 1986 marks a definite year of transition for ECAD companies. This is particularly true for vendors of automated IC design tools, with the revenue of SCI, SDA, SDL, and Seattle Silicon all at least doubling this past year. As if CAD tools from CAD vendors were not enough, ASIC houses like LSI Logic and VTI are both offering compilation tools based on their processes; another endorsement for the methodology.

Here is a merger that makes sound business and technological sense. Mergers of CAD companies are by nature different from merging manufacturing companies, for example. It is not a question of doubling output by doubling physical plant capacity, but of culturally and technologically meshing both products and people. SCI and SDL are of the same faith, even if not from the same locale and cultural backgound, and they've got a lot in common. These are both companies on the way up--not out. We view the SCI-SDL alliance as:

- A strategic move, based on the real strengths of each company without a great deal of overlap of technology, personnel, or customer accounts

- A good technological fit, based on a common underlying design methodology and the same hardware

Challenges to the marriage include the following:

- Geographical distance--The development groups integrating GDT and Genesil will be split between New Jersey and California. SDL's New Jersey facility will also continue to provide sales support and evolve the original SDL products, while SCI's R&D will remain centered in California. Integration is at the heart of the merger, and coordinating such a high-level integration at a continent's distance may prove difficult.

- Management and corporate cultural styles--SDL is coming out of the AT&T/Bell Labs ethos, while SCI is a blend of Silicon Valley with Cal Tech Pasadena. These are just very different mindsets.

- Development delays--Necessary future product evolution may be delayed during a protracted integration phase.

- Unprofitable design service business--We see a real risk in a CAD company running a design service business without a fab line behind it. Design services are notoriously unprofitable, even when coupled with manufacturing. The challenge here is either to create a profitable model for this type of business or phase it out.

The new Silicon Compiler Systems' primary challenge is to deliver the integrated data base and products. If this is not achieved, we are back to the same old story: tools that neither play nor talk with each other--not something the market will either want or tolerate.

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Research *Bulletin*

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IBM'S PERSONAL SYSTEM/2: DOORS ARE STILL OPEN FOR DRAM MERCHANT VENDORS

The introduction of the IBM Personal System/2 line of personal computers is certainly welcome news to semiconductor MOS memory manufacturers. However, the closeness of this announcement to press exposure on IBM's 4Mb DRAM has led to speculation that IBM intends to use only its internally produced DRAMs in the new computers. This newsletter addresses that issue.

PERSONAL SYSTEM/2 ON-BOARD DRAM REQUIREMENTS

At first glance, the speculation seems well founded. There are two single in-line modules (SIMs) attached to the motherboard through two 30-pin connectors. Each SIM has a 512Kx9 organization and contains six DRAMs. Dataquest believes that four of the DRAMs are 1Mb devices with 256Kx4 organizations and that two of the DRAMs are 256K devices with 256Kx1 organizations. Despite the proliferation of surface-mount devices everywhere else in the system, the DRAMs are in pin-grid array (PGA) packages.

The standard SIMs in the market are in 256Kx9 or 1Mbx9 organizations and hold DRAMs in surface-mount packages--plastic-leaded chip carriers (PLCCs) for 256K DRAMs and small-outline J-lead (SOJ) for 1Mb DRAMs.

DATAQUEST ANALYSIS

Dataquest believes that IBM's on-board main memory approach does not exclude external DRAM vendors. The economics dictate that having multiple sources of DRAMs ensures more competitive pricing and uninterrupted supply. Competition with other vendors also fosters efficiency and technological excellence in IBM's semiconductor operations.

Technically, the 512Kx9 SIM does not pose any barriers to other merchant market vendors. The 30-pin connector is standard and can be used for 256Kx9 and 1Mbx9 modules available in the market.

The SIM approach is not new. Many competing computer manufacturers use the same approach because of the inherent benefits: minimal board space use, ability to configure system memory in the late assembly stages, and field upgradability. Several vendors build SIMs, including Hitachi, NEC, Texas Instruments, and Toshiba.

The PGA package does not pose any barriers, since vendors can use surface-mount devices in their place. Dataquest believes that IBM has long been using PGA packages for other systems. It has become a fairly inexpensive package and its use in the new personal computer line leverages IBM's assembly capacity for this package. We believe that the use of surface-mount packages instead of PGAs would also be welcome by IBM.

SIMs using 256K DRAMs are experiencing long lead times because of the limited availability of PLCC packages and the turnaround time in mounting DRAMs on the SIM. At present, SIMs have lead times of as much as 12 weeks, which may extend to 16 weeks as 256K DRAMs become scarcer. The turnaround time for modules from Japan is averaging six to eight weeks. This situation may have contributed to IBM's decision to increase reliance on its internal operations.

Although the doors are open to other DRAM vendors, this SIM approach enhances the competitiveness of IBM's internal DRAM operations. IBM has been ahead in the development of 1Mb DRAMs and has now found an inexpensive approach to SIM production using a leveraged PGA package. Although IBM's sufficient capacity of PGA packages and 1Mb DRAMs could constrain the DRAM market, we do expect other DRAM merchant vendors to support IBM's new personal computer market.

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Research Newsletter

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ISSCC 87: SYSTEMS VIEWPOINT DOMINATES DISCUSSIONS AND PROCESS TECHNOLOGY TAKES ANOTHER STEP FORWARD

INTRODUCTION

The 34th annual International Solid State Circuits Conference (ISSCC) was held during the last week in February in New York City. Authors from 34 companies delivered 116 papers. Leading contributing companies were Hitachi with 15 papers, AT&T with 10, and Toshiba with 8. Authors from Japanese companies delivered 44 percent of the papers, including 68 percent of the memory papers. The Japanese papers also described impressive devices in consumer applications and high-speed circuitry.

In addition to the everpresent thrust toward finer lines, denser memories, and larger chips, the principal topics that distinguished this year's ISSCC are as follows:

- There were a large number of papers that discussed devices with massive processing capabilities (DSP, image processing, 32-bit RISC processors, and special purpose MPUs and accelerators).

- There was increased attention to practical chip-production issues: CAD and the efficient use of design resources, design verification methods, test problems, packaging issues, and device manufacturability.

- With the movement to systems-on-a-chip, independent chip makers appear to be getting an ever-smaller piece of the pie, as vertically integrated, well-financed systems houses apply their expertise and finances to increasingly expensive design undertakings.

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ISSCC PRESENTATION SCORECARD

With some qualifications, the mix of ISSCC papers can be a useful indicator of industry trends. As in previous issues of the Dataquest ISSCC newsletter, we have updated several tables showing the make-up of this year's session and several such trends.

Session Summary

Table 1 profiles the 22 regular ISSCC sessions and the 10 evening sessions. North American authors decreased from 53 percent to 43 percent of the total, while European authors increased from 10 percent to 13 percent, and Japanese authors increased from 37 percent to 44 percent of the total, compared to ISSCC 1986. This year there were a large number of papers from universities (20), some with co-authors from merchant or captive suppliers.

As expected, the technology employed continued to shift toward the use of CMOS. In the 1986 IC market, CMOS comprised about 23 percent of total IC sales, about equal to its percent of ISSCC papers just five years ago.

Trend by Country of Origin

Authors from Japanese companies continue to increase in number (up sharply from 1986), and they presented in many sessions where they were weaker in the past. Europeans were well represented across all sessions. Table 2 compares authorship of ISSCC papers for the last few years.

Leading Companies Presenting Papers

Table 3 lists the leading companies in terms of ISSCC presentations for the past three years. In 1987, among the leading seven companies were four Japanese: Fujitsu, Hitachi, Mitsubishi, and Toshiba. The leading large U.S. captives were: AT&T, Hewlett Packard, and IBM. NTT also was a significant contributor. The leading U.S. independents were General Electric with four papers, and Motorola and Texas Instruments with two each. For the first time in memory, Intel had no presentation, nor were there papers from several other U.S. majors: AMD, Fairchild, and Signetics. Harris Semiconductor and National Semiconductor supplied one paper each. There were, however, U.S. papers from several of the smaller start-ups from the most recent wave of venture activity: Anadigics, Crystal Semiconductor, Linear Technology, Microlinear, and SEEQ Technology.

Table 1

1987 ISSCC SESSION SUMMARY

Session Number	Topic	Number of Papers	Authorship: North America Merch.	Authorship: North America Captive	Authorship: Japan	Authorship: Europe	Technology Employed: MOS CMOS	Technology Employed: MOS NMOS	Technology Employed: MOS CCD	Bipolar	BICMOS	GaAs	Other
1	Megabit DRAMs	6		1	4	1	6						
2	32-bit Microprocessors	6	1	4	1		5	1					
3	Sampled-Data Analog Circuits	5	2	1	2		3					2	
4	High-Speed Circuit Technology	6	1	1	3	1	3			1	1		1
5	Opening of Conference												
6	Keynote Address												
7	Nonvolatile Memories	5	3		2		4	1					
8	Microprocessors-Design Methodology	5	1		2	2	5						
9	High-Speed A/D Converters	5		1	3	1				4		1	
10	Image Sensors & Processing Circuits	5		1	3	1		1	3				1
11	Fast Static RAMs	6			5	1	1			1	1	3	
12	Semi-Custom Array Design	5	1		4		3			1		1	
13	Digital Signal Processors	5	2	1	2		5						
14	Wideband Amplifiers	5	3	1		1		2		3			
15	High-Speed Signal Processing	6	1	1	3	1	3			2	1		
16	Microprocessors-Special Purpose	6	1	1	3	1	6						
17	Analog Techniques	7	2	3		2	4			1	1	1	
18	Test & Packaging	5	1	2	1	1	2	1		1			1
19	High-Density SRAMs	9	2	1	6		9						
20	Special-Purpose Accelerators	5	2	1	2		5						
	& DRAMs	4			4		3				1		
21	Telecommunication ICs	6	3		1	2	6						
22	VLSI Systems & Architectures	4	2	2			2		1				1
	Totals	116	28	22	51	15	75	6	4	14	5	8	4
				1985 Percent of Total:			52%	18%	5%	18%	0%	6%	1%
				1986 Percent of Total:			50%	16%	2%	20%	3%	4%	5%
				1987 Percent of Total:			65%	5%	3%	12%	4%	7%	3%

Wednesday Evening Informal Sessions

DRAM Cell Structures & Technologies
ASIS Architectures for the '90s
Next Generation IC Technology for Analog/Digital VLSI
Future Trends in Nonvolatile Memories
Directions in Smart Power ICs

Thursday Evening Informal Sessions

Digital ICs with Embedded Memory
Competing Technologies for High-Speed Digital Systems
Trends in Design Automation for Mixed Analog/Digital ASICs
Educating Future Chip Designers
Technologies for Broadband Networks

Source: 1987 ISSCC Digest of Technical Papers
Dataquest
April 1987

Table 2

ISSCC TECHNICAL PAPERS BY COUNTRY OF ORIGIN
(Percent)

Country	1981	1982	1983	1984	1985	1986	1987
Japan	25%	29%	42%	39%	45%	37%	44%
United States	61	66	50	51	43	53	43
Western Europe	14	5	8	10	12	10	13
Total	100%	100%	100%	100%	100%	100%	100%
Total Papers*	89	88	100	97	112	108	116

*Excluding panel sessions and keynote speakers

Source: Dataquest
April 1987

Table 3

LEADING SOURCES OF ISSCC PAPERS IN 1987
(Number of Papers)

Company	1987
Hitachi	15
AT&T Bell Laboratories	10
Toshiba	8
Fujitsu	6
Mitsubishi	6
Hewlett-Packard	5
IBM	5
NEC	5
NTT	5
Motorola	3
Sony	3
Others	45
Total	116

Source: Dataquest
April 1987

DOMINANT ARCHITECTURAL TREND--HIGH-THROUGHPUT PROCESSING CAPABILITY

One of the major themes of the 1987 ISSCC was evident in the efforts of circuit designers to dramatically increase the processing capabilities of the chips they design. These include chips that incorporate on-chip caches, pipelining, parallel processing capabilities, and RISC architectures. Chips are being made as large as is economically feasible, and every effort is made to avoid going off-chip for time-consuming operations.

A further set of papers sought the same goal through the design of dedicated special purpose accelerators. Mixed into several sessions were dedicated specialty memories that combine logic with standard memories to dramatically speed the delivery of data in special applications, especially video.

The conference made it clear that designers are increasingly oriented to producing chip systems that address and resolve the design problems of the systems houses, in silicon.

32-Bit Processors--RISC Architectures Overwhelm

Although the discussion of RISC architectures was an evening session in 1986, this year it emerged fully developed in the session dealing with 32-bit MPUs. Of the six papers presented, four used RISC-type architectures. The only exceptions were Digital's 32-bit MPU with on-chip caches and MMU, and Matsushita's chip. Digital's device used a minicomputer instruction set.

Each of the devices described typically put 115,000 to 172,000 transistors on a 8-10mm square die using 1.5um CMOS technology. However, one of the Hewlett Packard processors used NMOS technology, and the Matsushita 32-bit MPU used considerably more aggressive design rules (1.0um) to get 372,000 transistors on a 92.0 sq. mm die. All but the AT&T CRISP chip (C-Machine Rational Instruction Set Processor) were implemented in double-layer metal. The AT&T device used three layers of interconnect, one of metal and two of polysilicon.

Clock rates ranged from 8 MHz to 30 MHz, providing performance ratings of between 2 mips (average) and 20 mips (peak). Pipelining features varied, with different devices using three to five stages. Increased performance was also achieved through various on-chip instruction and data caches, ranging in size from 256 bytes (the Hewlett Packard RISC processor), to 13 Kbytes (on the AT&T CRISP chip). Only one device, the Hewlett Packard NMOS device, lacked an on-chip cache. Memory Management Units (MMUs), and Translation Lookaside Buffers provided virtual memory support. Power dissipation ranged from 500mW to 10W for HP's NMOS device. Other popular features included on-chip support to facilitate testing, as well as ease of interface to coprocessors or floating point processors.

Clearly marking the advantages of systems orientation was this session, where five of the six 32-bit processors presented were designed by either captive systems houses (AT&T, Digital, and HP), or vertically integrated merchant suppliers (Matsushita), all of whom have tremendous in-house systems expertise and systems perspective, not to mention financial resources (HP is the smallest at $6 billion in revenue per year). The only exception was a 32-bit RISC chip presented by the Stanford University Center for Integrated Systems.

Digital Signal Processors and Image Processors

Here also, CMOS processing dominated, with typical design rules down between 1.2 and 1.5um. Each of the papers in this session contained special features designed to address high-throughput applications.

As with several of the more general-purpose 32-bit MPUs, the 60ns DSP from AT&T-Bell Labs puts an instruction cache on-board.

Two papers (Toshiba and another from AT&T-Bell Labs) described devices aimed at speech processing, which came to the fore about five years ago and has slowly been giving way to silicon advances.

In the CCD imaging session, Sony described a CMOS image processor designed for application in VCRs.

Big Companies-Big Impact

As was the case in other system-chip application areas discussed above, independent semiconductor houses played only a small role in this session. No papers were presented by independents. The devices from big companies are often defined and designed in response to an in-house need in the final product--such as Sony's image processor or AT&T-Bell Labs' requirements for speech processing in telecom applications.

Furthermore, most of the papers offered by the systems houses that have significant semiconductor capability (AT&T-Bell labs, Hitachi, Toshiba, etc.), all had multiple authorship, with major participation from different parts of the company: often the R&D section, the IC design section, and the applications lab. This fact does not bode well for independent semiconductor houses as the trend advances to greater systems solutions--they are likely to lack the financial resources and the in-house breadth of talent and expertise to create such chips in a timely manner.

For example, for the 15 Hitachi papers presented, 12 were joint efforts involving one or more of the following arms of the Hitachi organization:

- Hitachi Central Research Labs--Tokyo, Japan
- Hitachi Consumer Products Research Center--Yokohama, Japan

- Hitachi Device Development Center--Tokyo, Japan
- Hitachi Kanagawa Works--Kanagawa, Japan
- Hitachi Ltd.--Tokyo, Japan
- Hitachi Musashi Works--Kodaira, Japan
- Hitachi Omika Works--Ibaraki-Ken, Japan
- Hitachi Research Lab--Ibaraki-Ken, Japan
- Hitachi Takasaki Works--Gunma, Japan
- Hitachi VLSI Engineering Corp.--Tokyo, Japan

While this is certainly a testimony to one company's organization of the research and product development effort, it also gives strong evidence to the fact that designing today's complex, applications-oriented chips is a multidisciplinary effort requiring tremendous resources.

Special-Purpose Microprocessors

The session of special-purpose microprocessors included six papers. Hitachi presented a paper on a microprocessor with 2 Kbytes of on-chip EEPROM, which makes provision for data security through an on-chip encryption key in ROM. The chip is aimed at what is termed the smart-card market and packaging on a card can be accomplished through TAB. Parallel processing is an area of considerable interest and two of the session papers described processors with highly parallel architectures, one from Brunel University, England, and the other from Digital. The Brunel chip aims at image-processing applications and the chip set from Digital would implement a massively parallel structure. The largest machine configuration could contain 8K processors and execute at 2.6 trillion 4-bit operations per second. Applications suited to this approach include simulation problems, AI, and image and data base processing, which typically are not well handled by serial processors. Two papers describing chips optimized for AI applications were presented. NTT Electrical Communications Labs described a 32-bit LISP processor with a microcoded interpreter-oriented architecture. By electing to leave most of the memory off of the chip, this chip contains 80K transistors. An impressive 553K transistor, 32-bit LISP processor from TI also implements a microcoded architecture. The compiler views the chip as stack oriented. Among other features of the device are hardware support for memory management, six on-chip RAMs, pipelining, and ROM for self test. The processor was designed for a 30ns clock cycle. The project was funded in part by DARPA. A paper from Toshiba dealt with a chip set for digital TV. In order to package the two devices totalling 195K transistors in plastic packaging, 1.5 micron CMOS technology was used.

High-Speed Circuit Technology and Special-Purpose Accelerators

These two sessions comprised 11 papers dealing with very high performance circuit elements, embodying a wide range of technologies to address many special-purpose functions. While these papers didn't have nearly the systems orientation as those discussed above, they were certainly as intent on high throughput, albeit in much more tightly focused applications.

Josephson junctions made their annual appearance in a paper from Fujitsu, Ltd., describing a 900-gate Josephson 16b ALU. At previous ISSCCs, Fujitsu had also designed and fabricated an 828-gate 16 x 16b multiplier, and a 112-gate 8b shift register, both using Josephson junction technology.

The staff at Hitachi Central Research Labs described a very impressive 48ps gate-delay ECL technology that utilized a proprietary Self-aligned Edge Contact Technology (SELECT). The device was impressive not only for its performance, but because this performance was obtained through the use of some critical device tolerances as fine as 0.1um.

In the Special-Purpose Accelerators Session, the devices described were impressive not only for their high performance in special applications, but for their advanced circuit and process technology.

The staff at NTT Electrical Communications Labs described a Pipeline Sorting Chip measuring 37 x 21mm. Non-zero yield was made possible through the use of a three-tier hierarchical redundancy scheme that nearly doubles the chip size, and through the use of liberal 3um design rules.

MOVING THE PERIPHERAL ISSUES ON-BOARD

Total Cost Management of the Design, Manufacturing, Test, and Maintenance of VLSI Chips

The same systems trend that is taking place in the silicon is also taking place throughout the industry in the design effort. The new "system" is total cost management. Issues that had traditionally been secondary design criteria, peripheral to the performance-optimization issue, are steadily being pulled into the design equation. This has shifted design considerations from device performance alone to bona fide "total cost" issues such as (1) efficient use of designers, (2) reduced time-to-market, (3) control of the exponentially increasing cost of testing, and (4) methods of ensuring higher reliability in a complex systems environment. The problems addressed by the designer now give much more consideration to these formerly peripheral issues. This trend was apparent in much of what was presented at this year's ISSCC, both directly and implicitly.

CAD Trends

It was also evident that many designers have attempted to design custom-capability chips using standard cell libraries or gate arrays. The goal then becomes to maximize chip performance and minimize design time (and the use of design resources) within the limits posed by a given set of standard cells or blocks.

In these presentations, attention is paid to gate density, gate utilization, design time/manpower, and, of course, chip performance. But, the first three criteria are being weighted more heavily than before.

In the CAD and chip-design area, the trends evident at the ISSCC itself understate the actual overall trend taking place in the industry. Nine years ago, the CAD-intensive Custom Integrated Circuits Conference came into being, in part driven by the special CAD interests of this area. Much of the growth in activity and interest in the design area is spilling over into the dramatic growth of that conference. The CAD discussions at ISSCC generally have revolved around issues of general interest to design, and not limited to ASICs.

Added Consideration Being Given to Testability

With complex logical functionality comes increased difficulty in testing, problems in high power output, and the need for high pin-count packaging. Session 13 at this year's ISSCC was devoted to testing and packaging issues, but a large number of the papers in other sessions also addressed these same problems in the context of their own chips.

In the 32-bit Microprocessor session, every design incorporated some level of on-chip testability. In the memory sessions this has been going on, in another manner, through the incorporation of redundant circuits and ECC, but those designs, too, were shown to reflect much more concern for the test problem.

It is only with memories and simple well-defined functional building blocks that the problems of packaging are minimized. High pin-counts (the 32-bit MPUs all had 160 pins or more) and high power dissipation are major concerns for high-speed, high-throughput processors.

This trend, too, tends to favor the vertically integrated chip manufacturers, especially IBM, which have always placed great emphasis on packaging and interconnection issues to improve system performance.

In the sessions dealing with high-performance devices, there were several instances where the device could not be fully tested at the highest clock rate for which it was designed, because of the unavailability of adequate test equipment.

Efficient Use of Design Resource--Keynote Address

Computer-aided design issues have been an important part of the ISSCC for many years, either directly in the session presentations, or in the informal evening sessions. This year's keynote address, by Robert Brodersen, of the University of California at Berkeley, discussed "IC Design in a Restructured Semiconductor Industry," which provided a good overview for the whole conference by discussing the shifting importance of circuit perfection and design time; complex, system-oriented chips and primitive building blocks; and designing for manufacturability and testability. His thesis is that great advances in price performance in the next generation of computers will result more from improved computer architectures than from improvements taking place at the device and circuit level. This will include, on the design side, reduced time to delivery, and increased ability to customize circuits through use of CAD tools. On the systems side, progress will result through the use of parallel-processing capabilities or pipeline architectures.

ADVANCES IN PROCESSING: CIRCUIT ELEMENTS AND INCREASING CIRCUIT DENSITY

As always, there were a host of papers dealing with basic advances in the fundamental processing capabilities of the state of the art. As is generally recognized, memory products, mainly DRAMs, as well as fast and slow SRAMs, lead the way. The 1987 ISSCC was no exception. A total of 35 papers and three of the special evening sessions focused on pushing back the current limits of fine-line processing (now 0.7um in DRAMs, and a remarkable 0.1um in one high-speed processor paper), density (NTT's 16Mb DRAM sets the new standard), and speed (5 SRAMs with access times under 5ns).

This performance is never free, however, and the apparent process complexity (e.g., mask steps) and the attendant problems coming from continual scaling, will certainly generate new problems for the next wave of circuit designers to solve.

Dynamic RAMs

There were 10 papers describing DRAMs, plus an evening session on DRAM cell structures and technology. As a technology, NMOS has disappeared entirely for the first time, being replaced by CMOS, and interestingly, a 35ns BICMOS DRAM was described by Hitachi.

NTT described a 16Mb DRAM, which was built using a 0.7um, n-well CMOS process. A trench capacitor was used, and the cell capacitance, at 70fF, was kept well above the low threshold at which soft-error problems begin to appear. Newly developed Error Correction Circuitry (ECC) was developed, and the chip incorporated 2Mb of parity bits along with the 16Mb for data. The die measures 147.8 sq. mm, and ran off a 3.3V power supply.

All of the 4Mb DRAMs used a vertical capacitor structure, using either a trench, stacked capacitor, or corrugated cell. Also, every supplier has built flexibility into the designs to allow production of x1 or x4 configurations through mask or bonding options. As in several of the sessions, designers of the 4Mb DRAMs are beginning to bring the supply voltage from 5V to 3.3V, though 4Mb will likely be a mixture of both. Table 4 gives several specs of the DRAMs described at this year's ISSCC.

Table 4

ISSCC DYNAMIC RAM SUMMARY

Company	Product	Features
Fujitsu	4Mb	7.5 sq. um cell, uses stacked capacitor cell
Hitachi	1Mb	BICMOS, 35ns access speed
Hitachi	4Mb	
IBM	4Mb	3.3V power, uses 1Mb litho tools
Matsushita	4Mb	8.0 sq. um cell
Mitsubishi	4Mb	
NTT	16Mb	2Mb ECC, 3.3V power, 4.9 sq. um cell
Oki	4Mb	Pseudostatic or virtually static mode
Siemens	4Mb	
Toshiba	4Mb	60ns access speed

Source: Dataquest
April 1987

Static RAMs

There were a total of 15 papers dealing with static RAMS, six of which could be classified as "high speed" (a concept increasingly relative and application dependent), and seven that emphasized high density. Two others described static RAMs with specialty cache-memory functions. Of these 15 papers, 10 were delivered by Japanese authors and five by U.S. or European authors. Of the high-speed devices, two were CMOS (one of which was BICMOS with ECL outputs), three were GaAs, and one was ECL.

There were two new and advanced variants that sought to produce a more compact SRAM cell to ease the transition to high densities. One of these was a 512Kx8 (4Mb) design that could be used as either a pseudo-static or virtually static RAM. Presented by Oki, this device appeared in the DRAM session because it was an SRAM that utilized a single-transistor DRAM storage cell.

The other, a small-celled 256K true SRAM, continues to use a 4-transistor cell, but solved some of the scaling problems associated with either the 6-transistor cell or the 4-transistor cell with poly-load resistors, through the use of a special circuit.

Various versions of the DRAM approach have been available since about 1980 from Hitachi, Intel, Mostek, National Semi, Toshiba, and Zilog, but have never made the impact they might have under the right market conditions, or if marketed differently. The scalable 4-Tx cell presented by Hitachi, however, being more in the tradition of the movement from 6-Tx to 4-Tx cell in 1977/78, appears to offer a significant incremental improvement over existing devices, without the drawbacks of earlier pseudostatic and virtually static RAMs.

Both of the versions presented in the 1987 ISSCC continue to resolve some of the user unfriendliness of earlier offerings, and may gain a substantial share of the high-density SRAM market.

True 1Mb SRAMs were presented by Hitachi, Mitsubishi, Sony, and Toshiba, all using the traditional cell structure and circuitry. These devices represent the new state of the art in high density SRAMs, and their principal device parameters are listed in Table 5.

Table 5

ISSCC 1MB SRAM SUMMARY

Company	Product	Features
Hitachi	128Kx8	42ns, 3-poly process
Mitsubishi	128Kx8	34ns, 3-poly process
Sony	128Kx8	35ns access
Toshiba	128Kx8	25ns

Source: Dataquest
April 1987

On the high-speed end of the spectrum, GaAs supplied half of the papers, including a 5ns 16K device from Mitsubishi LSI Research and Development Labs. At this year's ISSCC, NMOS, as a technology for high-speed SRAMs, was absent for the first time (see Table 6).

Table 6

ISSCC FAST SRAM SUMMARY

Company	Product	Speed	Features
Fujitsu	8Kx8	5ns	ECL
Fujitsu	49K Tag Memory		Twin-well CMOS
Hitachi	64Kx1	7ns	BICMOS with ECL outputs
Hitachi	4K	1ns	GaAs
Mitsubishi	4Kx4	5ns	GaAs
Philips Rsch	1K	2ns	GaAs

Source: Dataquest
April 1987

Nonvolatile Memory

There was one formal session (seven papers) and an evening session, dealing with nonvolatile memory (NVM). In the formal session, the papers that drew the most interest were a 4Mb EPROM from Toshiba and a 128K "flash" EEPROM from SEEQ Technology. There were no bipolar NVM papers presented, no mask ROM papers presented, and surprisingly, no high-speed MOS ROM, EEPROM, or EPROM papers presented.

In the informal evening session on "Future Non-Volatile Memory Technologies," the panelists from AMD, Intel, and SEEQ all expressed great expectations for the future of the flash EEPROM, and an improved flash EPROM (testable and speed-sortable OTP) to garner a large share of what is now the traditional EPROM market, and partly served by the full-featured EEPROM market.

Toshiba's 4Mb EPROM is the first described of that density, and utilizes a 9 sq. um cell (versus about 20 to 25 sq. um for the smallest in general production today). In addition, Toshiba was able to address the speed-sort after packaging problem with special circuitry for OTPs. The 4Mb device uses 0.7um design rules and is a die measuring 5.86 x 14.92mm.

SEEQ's flash EEPROM is akin to a similar product described in the 1985 ISSCC by Toshiba, but never brought to market. The 128K device has a cell more closely related to an EPROM than to a full-featured EEPROM. What is gained in this approach is a much smaller cell size and die size, and lower cost, at the expense of bit-erase flexibility (The flash EE has bulk erase only) and extended durability (many erase-write cycles without failure). Although this device has been around in one form or another for some time without being marketed, there was considerable expectation at the evening session that a market does exist for such a device and that it should capture a considerable portion of the EPROM market because of its innate reprogramming capability.

GaAs Doubles Paper Count in 1987

At the ISSCC two years ago, one wag commented, "Gallium arsenide--technology of the future--always has been and always will be." It is interesting to note that GaAs IC Presentations this year numbered eight, compared to just four in 1986. Dataquest has identified 55 GaAs ventures today, most of which have begun during the past four years. Still, in 1986, the estimated GaAs IC market rested at $43 million--less than 0.2 percent of the total IC market for 1986. Though extremely fast GaAs memories have been presented at the ISSCC since 1982, few are believed to be currently designed into a commercial system, or are available as a standalone component on the merchant market. (As recently as 1983, however, the densest GaAs memory was 1K, compared to a 16K device at this year's meeting.)

Furthermore, the technical achievements of established technologies, and their kin--CMOS, ECL and BICMOS--march forward at tremendous pace, while the progress of GaAs is still confounded by myriad technical and economic problems limiting commercial application. If the systems-oriented trends apparent at this conference maintain their momentum--on-chip caches, parallel processing, reduced emphasis of optimized circuits and heavier emphasis on system optimization--GaAs technology could be further constrained in its economic applicability.

It remains to be seen whether GaAs will face ever-shrinking market opportunities after years of effort (like bubble memories), or will realize great economic and technical advances, such as we have just seen in superconducting materials, where tremendous progress has recently been made after years of unrewarded effort and hundreds of millions of dollars of investment.

SESSIONS FOR SPECIALIZED PRODUCT AREAS

There were many other formal sessions and evening sessions that dealt with important topics not in the mainstream of the major trends listed above, with technology barriers not often related to the major thrust of the industry, but nonetheless important to progress in their own application area. At the 1987 ISSCC, such areas included formal sessions on Telecom ICs, Networking, A/D Converters, CCD Imaging, and Wideband Amplifiers. CCD imaging and A/D converters have always been a part of the ISSCC program, and are essential front-ends to the advancing digital system that constitutes the core of focus for the rest of the ISSCC program.

Also, there were informal evening sessions that discussed Smart Power and Broadband Networks.

ISSCC TRENDS AND INDUSTRY TRENDS

Technology is clearly the cornerstone of today's semiconductor industry. Just as clearly, however, is the importance of business issues not related to the silicon issues, for example the increasingly active role played by governments in balancing or unbalancing the markets. The bath of red ink suffered by nearly every company over the past two years and the extensive layoffs during the same period, indicate that proper capital spending, improved forecasts of future market conditions, innovative product and marketing strategies, and sheer financial mass can be as important as leading-edge technology in determining the success or failure of today's semiconductor companies.

This year's ISSCC, with its systems orientation, and the dominance of well-financed suppliers with broad expertise, also serves to underscore the changing nature of the semiconductor business as it matures from being silicon-driven to being driven by systems issues and systems companies.

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Patricia A. Galligan

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SECOND ANNUAL PROCUREMENT SURVEY--THE ISSUE IS COST

THE PRELIMINARY RESULTS ARE IN

Early results of our second annual procurement survey were announced at Dataquest's Semiconductor User and Application Conference held in Tampa, Florida in early February. The most prominent issue raised by major electronic equipment manufacturers was that of cost and competition--it became the theme of this year's survey.

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 nearly 50 percent response rate indicates that users expect to increase their 1987 semiconductor purchases by more than 13 percent. This is up from last year when they projected that 1986 purchases would grow by only 7 percent--that projection was met by within one percentage point by year-end 1986.

The Survey's Structure

Each year Dataquest's SAM industry service gathers information for semiconductor manufacturers about their customers and markets in the United States. Our target audience is manufacturers listed in a comprehensive annual ranking of the top electronics manufacturers, which is published by Electronic Business.

Last year we estimated that our respondents accounted for more than 45 percent of North American semiconductor consumption.

The original list of 200 companies was pared to eliminate semiconductor and other types of component manufacturers that do not buy semiconductors for use in their electronic systems and subassemblies. We also eliminated distributors from the survey audience. We telephoned

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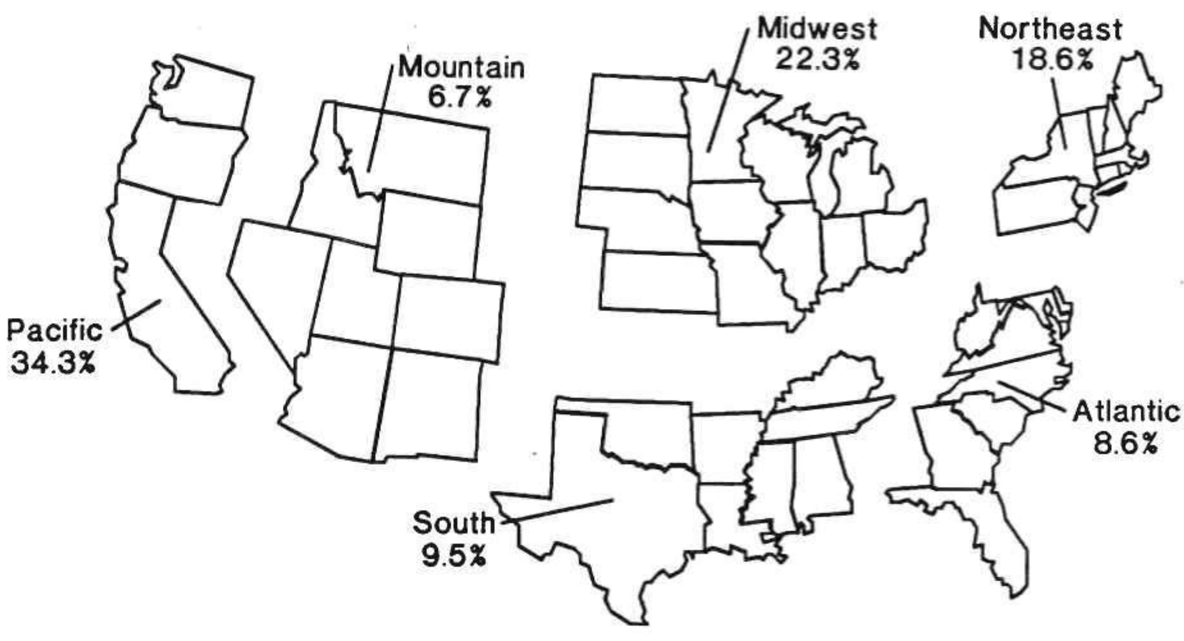
each location and interviewed individuals who are buyers, purchasing directors, or who are in material or corporate contract management. So far, more than 205 surveys have been completed.

Figure 1 shows the geographic locations of our survey respondents. These regions closely mirror the geographic distribution of the entire survey audience, leading us to believe that our survey had adequate representation across all regions. We have also checked the data that we gathered about the overall mix of their semiconductor purchases against Dataquest's 1986 estimates; Figure 2 shows how closely they reflect one another.

Figure 1

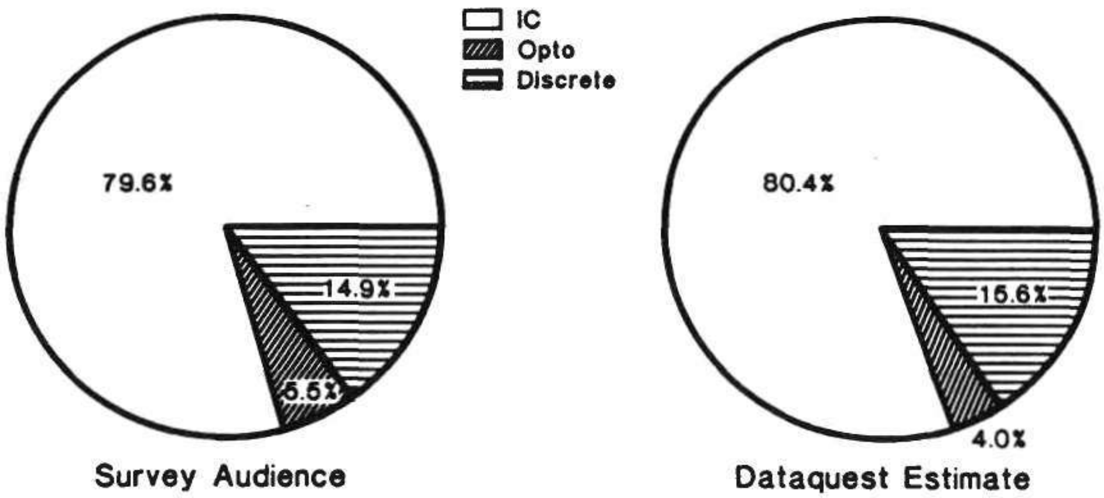
PROCUREMENT SURVEY RESPONDENTS
(Percent of Total)



Source: Dataquest
April 1987

Figure 2

1986 SEMICONDUCTOR MIX
(Percent of Total Dollars)



Source: Dataquest
April 1987

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. About 83 percent of purchases were made from U.S.-based semiconductor manufacturers. Japan and Europe came in at 14 and 1 percent, respectively. The ROW companies grew from 0.5 to 1.8 percent of this year's total. We found that the amount of components bought from non-U.S. suppliers was directly related to the type of equipment the electronic equipment manufacturer produced. Data processing and automotive manufacturers purchased much more than the average from Japan, because of the high use of MOS memory in data processing and the stringent quality requirements demanded by the automotive industry.

When asked about buying components offshore for U.S.-based equipment production (regardless of the supplier base), the data processing, consumer, and auto manufacturers were the most in favor of this procurement method.

Shifts Offshore

Table 1 shows the result of our question about shifting electronic equipment production offshore. Just less than half of the respondents expected some or a great deal of shift in their production activities. It is encouraging to note that many did not expect any shift at all.

Table 1

ANTICIPATED SHIFT TO OFFSHORE PRODUCTION
(Percent of Total Respondents)

	1985	1986
A Great Deal	8.4%	10.1%
Some	35.9	33.2
Not at All	55.7	56.7
Total	100.0%	100.0%

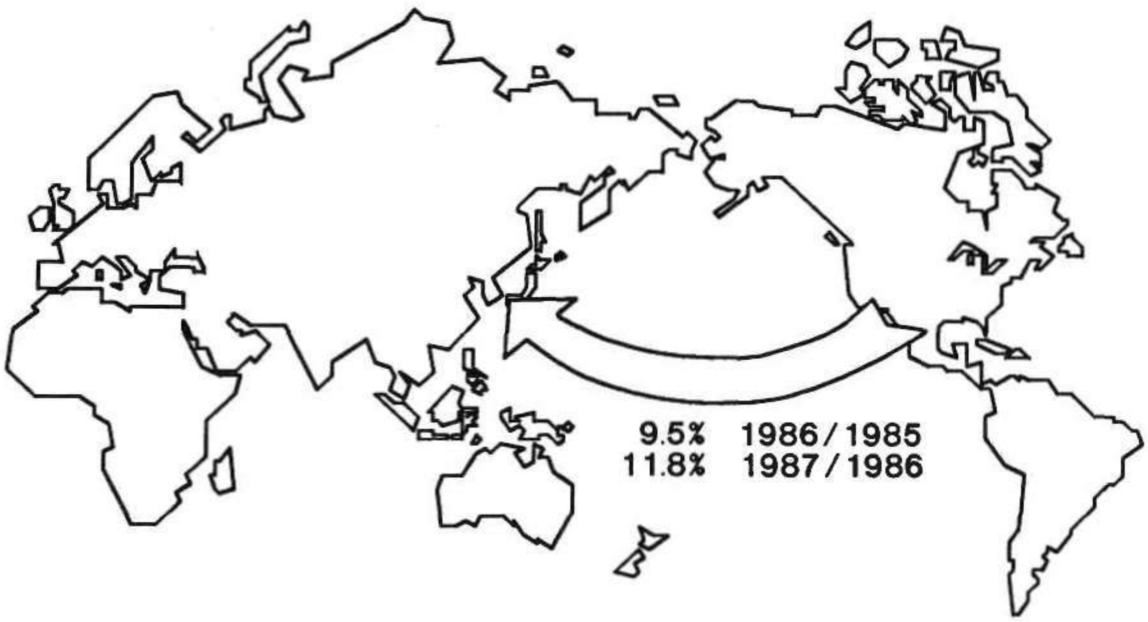
Source: Dataquest
April 1987

The caveat, however, lies in the fact that the respondents in data processing and communications markets were those that expected to shift some or a great deal of their production offshore. These two market segments are led by a few very large electronic equipment manufacturers that have the necessary resources or need to make this move. Because of their weight in the market, these two communities also make up over half of North American semiconductor consumption. The message to semiconductor manufacturers is be a worldwide participant or lose position in the global market.

Figure 3 reflects our attempt to quantify the impact on U.S. semiconductor consumption. We asked each survey respondent for the percent of their consumption that shifted in 1986 and what they believe could shift in 1987. At first, we simply took an average of the percent figures and arrived at about 5 percent in 1986 and 7 percent in 1987. When converted to dollars, however, the estimates were 9.5 percent and 11.8 percent, respectively. This confirmed our belief that it is the large manufacturers who have the resources to shift to offshore manufacturing or the need to do so. They also happen to be the large buyers. We believe that this is one key reason why the long-term growth rate of the industry may drop from historical growth patterns.

Figure 3

ESTIMATED U.S. SEMICONDUCTOR CONSUMPTION MOVING OFFSHORE (Percent of Total Dollars)



Source: Dataquest April 1987

Why the movement? This is where the issues of cost and competition first arose. The most often cited reasons for moving production and, ultimately, semiconductor consumption offshore were as follows:

- Lower manufacturing and labor costs
- Price and quality
- Competition
- Manufacturing moving offshore

- Buying subassemblies offshore
- Manufacturing already offshore
- Technology no longer available in the United States
- Increased production
- Merging divisions
- The U.S./Japan trade agreement

ASSESSING INVENTORY LEVELS

Clients have repeatedly asked Dataquest to assess inventory levels. In particular we were asked to include questions on this subject in this year's survey. Table 2 and Figure 4 show the results of our question concerning the status of target inventory levels. The commonly held belief that inventories are "at an all time low" does not appear to be the case. At first glance it appears that 71 percent of the respondents are at target or below. But 73 percent are at target or above. When faced with an analysis of whether the "glass is half full or half empty," we opted for the conservative approach. Our view was cemented when we looked at the data gathered in Figure 4, which clearly shows that most of the respondents expect to maintain the same or a decreased target inventory level.

Table 2

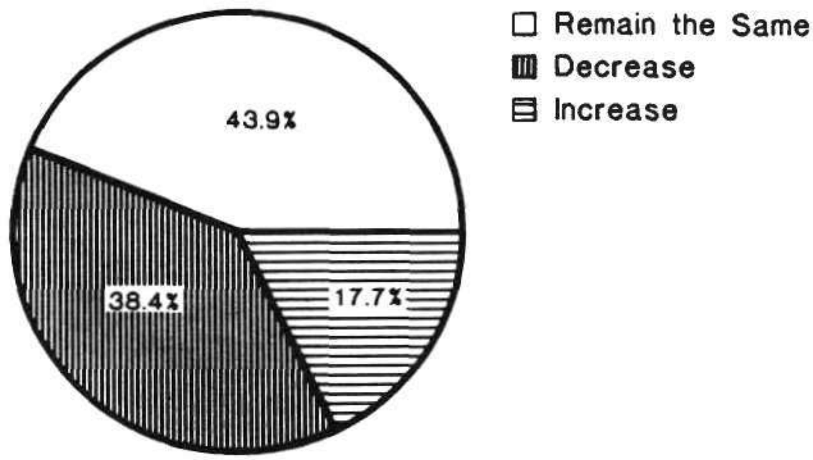
SEMICONDUCTOR INVENTORIES RELATIVE TO TARGET
(Percent of Total Respondents)

Extremely Low	4.9%
Somewhat Low	15.1
At Target	51.7
Above Target	22.0
In Significant Excess	6.3
Total	100.0%

Source: Dataquest
April 1987

Figure 4

EXPECTED CHANGE IN TARGET INVENTORY LEVELS
(Percent of Total Respondents)



Source: Dataquest
April 1987

Dataquest believes that fundamental industry transitions are occurring that are significantly changing manufacturing operations. Shifting production offshore is one, but streamlined operations, automation, and an overall concern about competitiveness are affecting the way manufacturers are doing business with their suppliers. The entire concept of "partnering" may pull in the whiplash affect associated with dramatic swings in inventory. These buyer/supplier links may be all the more entrenched because of the duration of the semiconductor industry recession.

For the skeptical semiconductor manufacturer we cite some interesting statistics recently published in Electronic Business. Xerox has reduced its overall supplier base from 5,000 to 300. A product group within Control Data Corporation has already reduced its supplier base from 1,100 to 300 and is aiming for 200. When Apple Computer opened its Fremont facility, it cut its supplier base in half. At our recent SAM conference, Dataquest noted with interest the comment from one senior executive from Motorola who said, "Our suppliers don't even know or understand the competitive struggle that they are in."

WHAT'S ON THE USER'S MIND

Every year we ask an open-ended question: What are the two major purchasing issues that you are facing. Below is our list in rank order of the twelve issues most frequently mentioned.

- Pricing
- Availability/leadtimes
- Quality/reliability
- On-time delivery
- FMVs/U.S./Japan trade agreement
- Cost control
- Inventory
- Surface mount
- New products/product obsolescence
- ASICs
- Offshore manufacturing and procurement
- Just-in-time delivery

The tone of the user's responses indicated a lot of concern over cost-related issues, much more so than last year. In fact, besides the trade agreement, which wasn't an issue last year, cost control, offshore manufacturing, ASICs, and surface mount did not even make last year's list. Just about every issue listed concerns cost. We believe that the technology-related issues of surface mount, new products, and ASICs, were mentioned because of their positive impact on overall system design, cost, and competitiveness.

DATAQUEST CONCLUSIONS

The time that members of the user community spent with us to discuss their use of semiconductors has provided insight on the dynamics shaping the industry. Overall, we believe that users expect moderate growth in purchases and that shifts in electronic equipment production offshore may have long-term implications for domestic semiconductor consumption.

Inventories are being affected by changing operations and, for the most part, users are dealing with significant business issues that are a function of a competitive global marketplace. Electronic equipment manufacturers need to protect their markets, access technology, and control costs in a win-win environment with their suppliers. Now is the time to cement these relationships.

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256K DRAM PRODUCTION CUTBACKS ACCELERATE 1MB DESIGNS

OVERVIEW

A rush of events in the first quarter appear to be producing a 256K DRAM shortage. Early in the year, the U.S. Department of Commerce accused certain Japanese companies of violating the U.S.-Japanese semiconductor trade arrangement. As a penalty, sanctions will be imposed on a variety of Japanese products, unrelated to semiconductors, such as television sets, laser printers, and disk drives. Prior to the penalties, MITI announced 11 percent cuts in 256K DRAM production in the second quarter of 1987, beyond the estimated 23 percent cut in the first quarter.

As a result, reports of a drying gray market have been coming in. Lead times in the United States have stretched out from ex-stock to 6 to 8 weeks for the more generic, Japanese-made 256K DRAMs. Several new personal computers were announced by IBM, which has reportedly been ordering large volumes of 256K DRAMs for its new PC series. Devices in PLCC packages, or with 100 nanosecond access times or faster, currently have lead times of 12 weeks that are stretching out to 16 weeks.

ESTIMATING THE POTENTIAL DEGREE OF SHORTAGE

Japanese manufacturers accounted for 82 percent of total 256K DRAM factory shipments in 1986. If these manufacturers reduce their production levels to 118 million units in the second quarter, as reported, and keep it flat through the year, their share of worldwide production will be only 56 percent. However, 1987 is projected to be the highest unit demand year for 256K DRAMs, growing to 850 million units, as shown in Figure 1.

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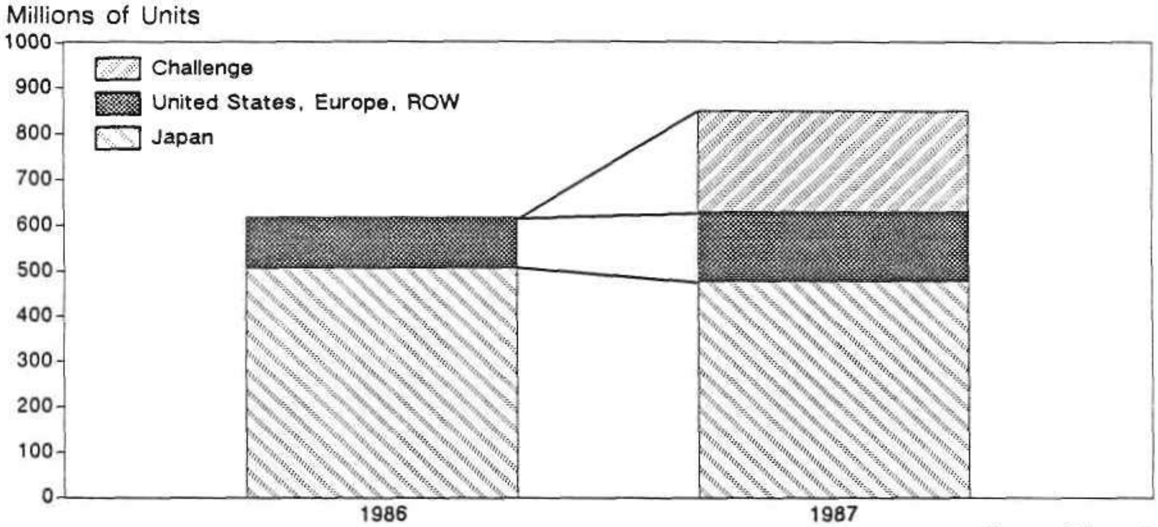
Figure 1

256K DRAM REGIONAL PRODUCTION
JAPAN VERSUS UNITED STATES, EUROPE, ROW



Source: Dataquest
April 1987

It is important to appreciate the magnitude of these production cuts. To meet the remaining 44 percent estimated demand in 1987, the combined production of U.S., Korean, and European firms must more than triple from 1986 rates. From these regions the high-volume producers are Texas Instruments, Samsung, and AT&T. It is not likely that they can produce to these levels by the end of the year. Given the production cutbacks and lack of non-Japanese capacity to fill the void, Dataquest estimates the year's shortage potential to be over 200 million units.

HOW LONG WILL THE SHORTAGE LAST?

Dataquest believes that extended lead times will be a fact of life at least through the third quarter. Bookings tend to grow as lead times increase. We estimate that it will take at least three months for Japanese companies to begin to return to increased production, if at all. The U.S., Korean, and European firms will face the same production lag. However, the high demand for high-speed or surface-mount DRAMs may remain high, keeping lead times of these parts extended through the year.

Another factor increasing the odds of a long-lasting shortage is that Japanese firms, and even some U.S. firms, may not be motivated to increase their production. The 256K DRAM cycle has matured and demand is expected to begin waning in 1988, with the price-per-bit crossover with the 1Mb DRAM estimated to be in the beginning of 1988. Many Japanese as well as U.S. firms may also want to encourage more 1Mb DRAM usage with the shortage and rising prices of 256K DRAMs.

Prices will certainly increase in this scenario. In fact, the high foreign market value prices in the United States will finally be validated, if not liked. The U.S. and Korean firms will likewise increase their prices with the shortage of parts and the lack of gray market competition. Dataquest estimates that average prices in the United States will increase to $2.35 by the middle of the year, from a first quarter average of $2.05. Prices in Europe and Asia are also expected to rise, alleviating the price pressures in those regions.

DATAQUEST ANALYSIS

It is still uncertain if Japanese companies will adhere to MITI's instructions. However, MITI's control of export licenses has been effectively used as a tool to convince them. If the companies comply, then the scenario mentioned above has a high likelihood of occurrence, which is even now obvious to Japanese manufacturers. The market will then accelerate 1Mb design-ins immediately and 1Mb purchases by the end of the year, to gain better availability and cost-effectiveness.

This situation points to the importance of long-term vendor-buyer relationships and of having a balanced supply of components from selected regions of the world. The DRAM buyer market that has been experienced for the last two years may be coming to a close. With supplies for this part tightening, communication lines between buyers and vendors must be finely tuned so that ship schedules do not become affected. The procurement systems set up over the past years will be put to the test for these parts. With supplies of the 1Mb DRAM increasing, the crossover to this part from the 256K DRAM may be accelerated, thus alleviating some of the pressure. It appears that one of the results of the semiconductor agreement is for supplies of parts to be controlled so that "fair prices" can be had by all.

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Research Newsletter

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GATE ARRAY SUPPLIERS POSITION FOR FUTURE GROWTH

EXECUTIVE SUMMARY

Semiconductor users undoubtedly face bewildering situations when it comes to selecting suppliers for specific component types. This is especially true with gate arrays. Changes in market conditions and the profile of a supplier base can translate into confusion when the time arrives for negotiation and commitment.

Dataquest has projected the $1.8 billion gate array market of 1986 to exceed $7.8 billion by 1992. Today, there are in excess of 100 merchant gate array suppliers. Fierce competition in the North American market has caused nonrecurring engineering charges (NRE) as well as device pricing to decline to the point where most suppliers sacrifice profits for market share.

Dataquest believes that large, broad-based IC suppliers will dominate the mainstream gate array market and force the small suppliers to be acquired, to move to niche markets, or to move out of the market altogether. Figure 1 shows that three out of the top five 1986 gate array suppliers are large, broad-based Japanese companies. Toshiba had a large number of designs go to production and went from eighth position in 1985 to fourth in 1986.

During 1986, worldwide MOS gate array consumption increased 49 percent compared to 1985, while bipolar gate array consumption rose 23 percent. North American companies shipped 46 percent of the total worldwide gate arrays while Japanese companies shipped 45 percent. However, Japanese companies had 43 percent of their shipment revenue generated from intracompany sales (sales to internal divisions) while North American companies only had 11 percent intracompany sales. The yen-to-dollar exchange rate also increased the market share of Japanese companies by changing from 238 in 1985 to 167 in 1986. This newsletter will address the following key areas:

- Preliminary 1986 company shipment estimates
- Technology forecast

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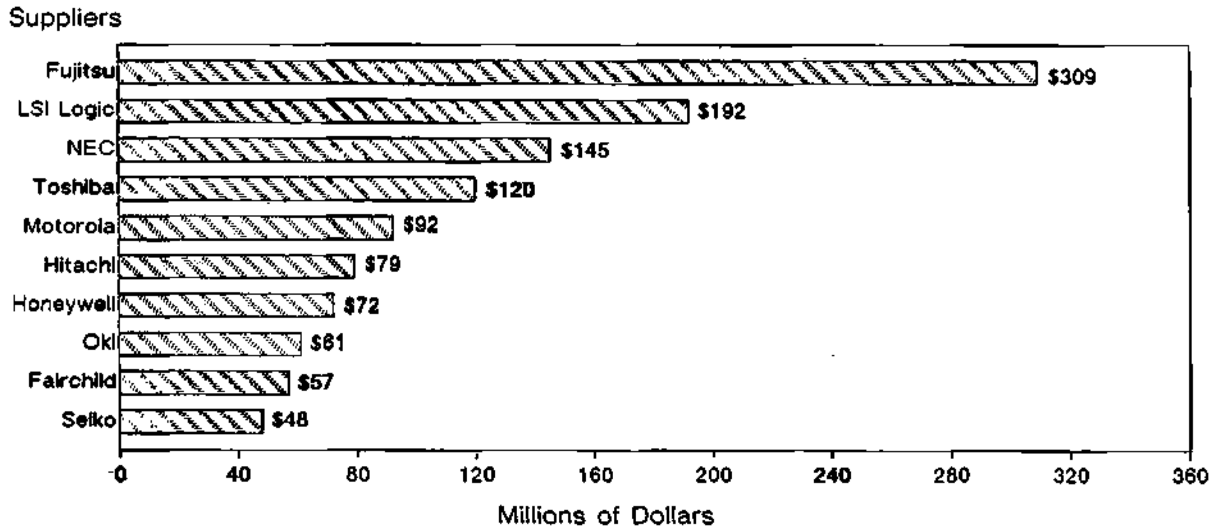
- Design starts
- Merchant revenue versus intracompany revenue
- NRE and device pricing
- Regional trends

Figure 1

ESTIMATED WORLDWIDE GATE ARRAY SHIPMENTS
TOP 10 SUPPLIERS--TOTAL



Source: Dataquest
April 1987

PRELIMINARY 1986 GATE ARRAY RESULTS

Dataquest Definitions

Dataquest defines the commonly used terms as follows:

- Gate arrays--These are digital or linear/digital integrated circuits containing a configuration of uncommitted elements customized by interconnecting one or more routing layers.
- NRE--These are nonrecurring engineering charges or simply the cost of developing the array.
- Intracompany revenue--When an IC manufacturer takes a product line, which was developed and produced for internal consumption, to the merchant market, the revenue associated with this internal consumption is called intracompany revenue; the revenue from sales to outside companies is called merchant revenue.
- Dataquest gate array shipments--The shipment revenue equals the estimated production revenue plus intracompany revenue plus NRE revenue.

Total Gate Arrays

As Figure 1 indicates, Fujitsu is the leader in total gate array revenue. Fujitsu is number two in MOS gate arrays and number one in bipolar arrays as shown in Tables 1 and 2, respectively. However, one must consider that a large portion of Fujitsu's revenue comes from sales to its own divisions. LSI Logic came in number two in total gate arrays with an exclusive MOS product line. NEC remains in third place with a healthy 54 percent increase in 1986 sales over 1985. Toshiba is climbing the top 10 supplier roster at a rapid rate, going from number eight in 1985 to number four in 1986. The next six suppliers are in a close race for market share. The top 10 suppliers in 1986 shared 65 percent of the total available market (TAM). During 1985, the top 10 suppliers shared 61 percent of the TAM. This comparison shows that the top 10 suppliers are gaining market share at the expense of the smaller suppliers.

However, it should be noted that even as the dedicated gate array suppliers are battling for valuable market share, there are other vendors whose primary business is either specialty arrays or another ASIC technology in addition to gate arrays. For example, Laserpath Corp. provides one-day quick turnaround of gate arrays, and VLSI Technology Inc. (VTI) is primarily a cell-based design company but can also do MOS gate arrays with its sophisticated design tools.

Table 1

ESTIMATED 1986 WORLDWIDE GATE ARRAY SHIPMENT REVENUE--MOS (Millions of Dollars)

1985 Rank	1986 Rank	Company	1985 Revenue	1986 Revenue
1	1	LSI Logic	$140.0	$192.0
2	2	Fujitsu	101.3	145.0
4	3	Toshiba	45.6	120.0
3	4	NEC	49.0	72.0
7	5	Oki	28.0	49.0
5	6	Sieko	33.8	48.0
6	7	Hitachi	29.1	45.0
8	8	Gould AMI	25.0	27.0
22	9	Honeywell	7.0	27.0
9	10	Hughes	19.2	22.0
Total			$478.0	$747.0

Source: Dataquest
April 1987

Table 2

ESTIMATED 1986 WORLDWIDE GATE ARRAY SHIPMENT REVENUE--BIPOLAR (Millions of Dollars)

1985 Rank	1986 Rank	Company	1985 Revenue	1986 Revenue
1	1	Fujitsu	$120.1	$164.0
2	2	Motorola	68.4	82.6
3	3	NEC	45.0	73.0
5	4	Fairchild	39.8	47.7
4	5	Honeywell	42.0	45.0
6	6	Ferranti Electronics	29.0	38.0
7	7	Hitachi	29.0	34.0
10	8	Siemens	23.4	26.0
8	9	Signetics	28.8	26.0
9	10	Texas Instruments	27.5	24.7
Total			$453.0	$561.0

Source: Dataquest
April 1987

MOS Gate Arrays

As Table 1 indicates, LSI Logic maintained its number one position in MOS gate arrays with a 37 percent growth in 1986 over 1985. However, Toshiba had a large number of designs go to production and it increased sales by an estimated 163 percent. Fujitsu captured many new designs in 1986 and remains in second place. Oki is gaining market share by capturing lower-density designs with high-production volumes. Four of the top 5 MOS suppliers are Japanese companies. The top 10 MOS suppliers accounted for 69 percent of the total 1986 MOS market, compared to 66 percent in 1985.

Bipolar Gate Arrays

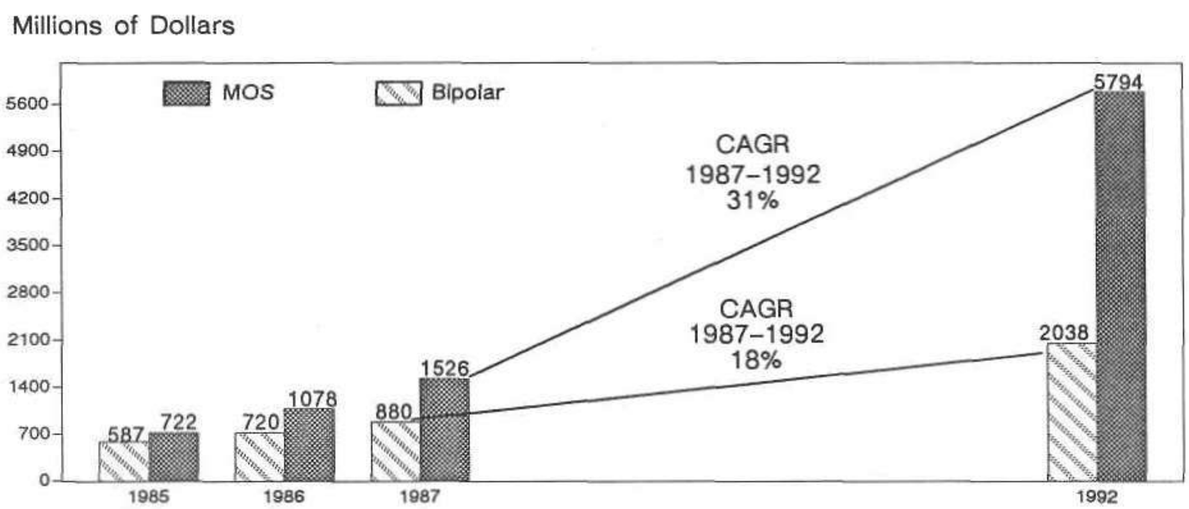
The ECL market continues to flourish while the TTL market fades. Mainframe computers are large consumers of ECL arrays. Fujitsu, Motorola, NEC, Fairchild, and Honeywell are the key suppliers to the mainframe manufacturers. These top 5 ECL suppliers shared 74 percent of the $412 million 1986 ECL market. AMCC is also a supplier of ECL arrays and had sales of 24 million dollars mainly in the military and industrial markets. Ferranti Interdesign and Exar dominate the North American linear and mixed linear/digital array markets. It is interesting to note that only 2 of the top 5 bipolar array suppliers shown in Table 2 are Japanese companies. The top 10 bipolar suppliers shared 78 percent of the total 1986 bipolar market, compared to 77 percent in 1985. This is a capital-intensive mature market dominated by large IC suppliers.

GATE ARRAY SUPPLIERS POSITION FOR FUTURE GROWTH

The worldwide gate array market is expected to increase from $1.8 billion in 1986 to $7.8 billion by 1992. Figure 2 illustrates that by 1992 the MOS market will dominate with a $5.8 billion market followed by the $2 billion bipolar market. The compounded annual growth rates from 1987 through 1992 for the MOS and bipolar gate array markets shown in Table 3 are 31 percent and 18 percent, respectively.

Figure 2

ESTIMATED WORLDWIDE GATE ARRAY CONSUMPTION BY TECHNOLOGY



Source: Dataquest
April 1987

Table 3

ESTIMATED WORLDWIDE GATE ARRAY CONSUMPTION BY TECHNOLOGY (Millions of Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992
Total	1,308.5	1,797.8	2,406.5	3,163.9	3,773.6	4,851.2	6,175.4	7,832.2
Total MOS	721.6	1,078.0	1,526.4	2,102.0	2,563.9	3,406.3	4,459.0	5,793.9
MOS Digital	704.1	1,057.0	1,500.9	2,071.3	2,527.0	3,360.9	4,402.8	5,723.6
MOS Linear	17.5	21.0	25.4	30.7	36.9	45.4	56.3	70.3
Total Bipolar	586.9	719.8	880.2	1,061.9	1,209.7	1,444.9	1,716.4	2,038.3
Bipolar Digital	516.9	646.8	801.3	977.5	1,120.3	1,351.3	1,618.7	1,937.7
TTL	135.9	154.1	169.5	178.0	176.2	172.7	164.0	150.9
ECL	313.6	412.6	540.5	697.3	836.7	1,071.0	1,349.4	1,686.8
Other	67.4	80.1	91.3	102.3	107.4	107.4	105.2	100.0
Bipolar Linear	70.0	73.0	78.8	84.4	89.4	93.9	97.6	100.6

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

Source: Dataquest
April 1987

During 1986, the MOS portion of the gate array market increased 49 percent compared to 1985, while the bipolar market experienced a more modest 23 percent growth. Most of the bipolar growth was attributed to ECL arrays with a 32 percent rise in 1986 consumption compared to 1985. Please remember that shipments and consumption include NRE, intracompany, and production. The yen-per-dollar exchange rate applied in 1985 was 238 and 167 in 1986.

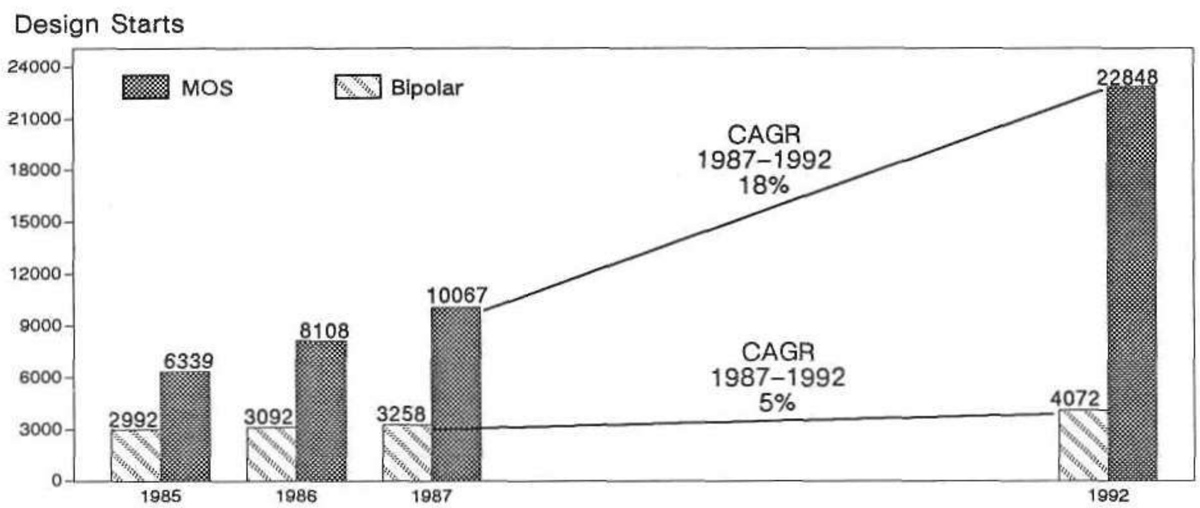
Most gate array suppliers are currently sacrificing today's profits for increased market share. During 1986, device pricing as well as NRE charges decreased in CMOS gate arrays to the point where most suppliers experienced small profits or even losses. Suppliers want to gain as much market share as possible so that they will be able to capitalize on the $7.8 billion market in 1992. NRE charges and device pricing will be addressed later in this newsletter.

DESIGN STARTS DETERMINE FUTURE GROWTH

Design starts are a leading indicator of future gate array revenue. Figure 3 illustrates that there were 11,200 total design starts in 1986 and we expect 26,920 total design starts in 1992. During 1986, MOS gate array design starts grew an estimated 28 percent compared to 1985, while bipolar design starts grew only 3 percent. This low growth rate in bipolar arrays can be attributed to the fact that TTL designs are being phased out while the number of ECL designs are increasing. Dataquest analysis indicates that designs captured in 1986 will take an average of 6 to 12 months to reach the production phase. Thus, a high number of designs in 1986 will result in high production revenue in 1987. However, the percentage of designs that ultimately reach production phase can vary widely. Our analysis indicates that the percentage of designs that go to production for the industry ranges from 30 percent during a depressed semiconductor economy to 70 percent in a thriving semiconductor economy.

Figure 3

ESTIMATED WORLDWIDE GATE ARRAY DESIGN STARTS BY TECHNOLOGY



Source: Dataquest
April 1987

Table 4 shows the number of designs captured in 1985 and 1986 by companies from each region. During 1986, North American companies experienced a 22 percent increase in MOS designs and an 11 percent decrease in bipolar designs. Part of the decline in bipolar designs can be attributed to the shift from TTL designs to ECL designs. However, Japanese companies grew 37 percent in MOS designs while increasing 22 percent in bipolar designs, which indicates that Japanese companies will gain market share in both the MOS and bipolar gate array markets during the next two years.

Table 4

ESTIMATED WORLDWIDE GATE ARRAY DESIGN STARTS BY REGION

	1985	1986
Worldwide Total	9,331	11,200
MOS	6,339	8,108
Bipolar	2,992	3,092
North American Companies	4,924	5,439
MOS	3,184	3,885
Bipolar	1,740	1,554
Japanese Companies	3,297	4,389
MOS	2,429	3,334
Bipolar	868	1,055
Western European Companies	1,041	1,272
MOS	657	789
Bipolar	384	483
ROW	69	100
MOS	69	100
Bipolar	0	0

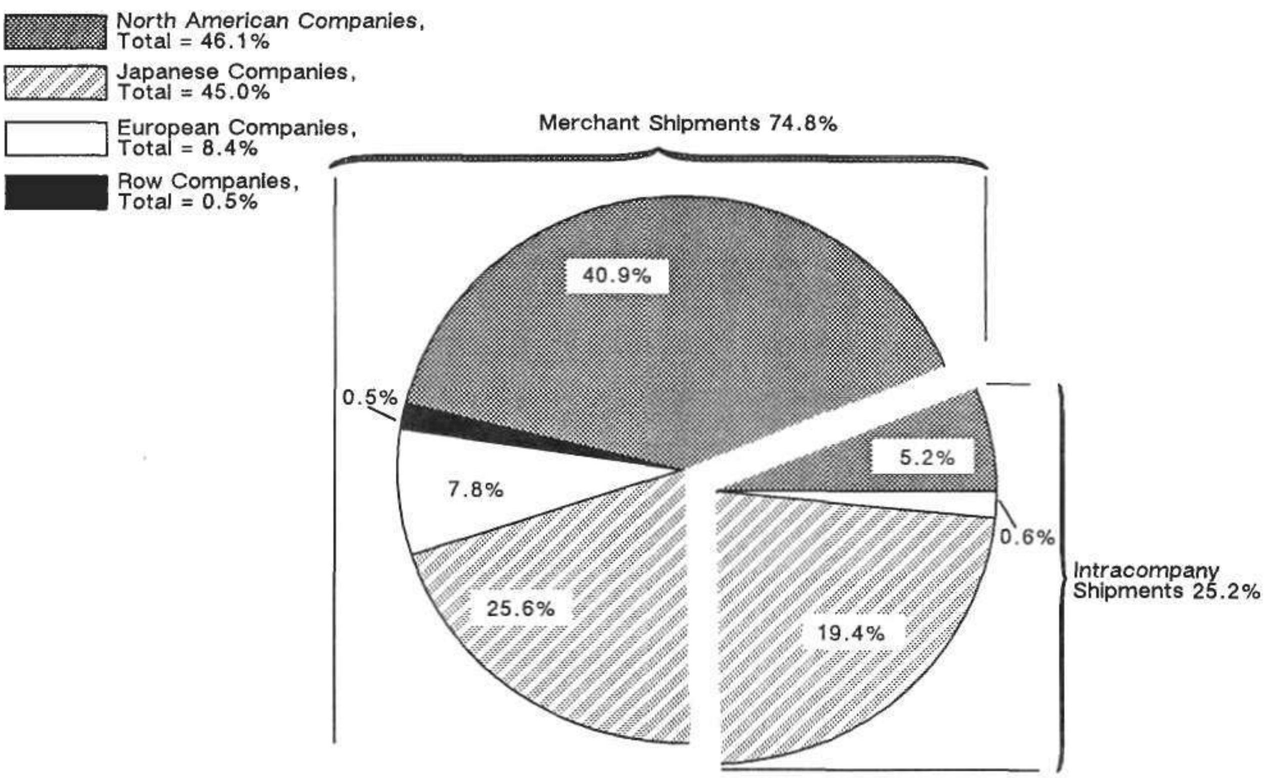
Source: Dataquest
April 1987

MERCHANT REVENUE VERSUS INTRACOMPANY REVENUE

It is important to examine the source of revenue when exploring regional trends. There was 25.2 percent intracompany revenue in the total 1986 worldwide gate array market as shown in Figure 4. Japanese companies had 43 percent of their 1986 worldwide revenue generated from sales to internal divisions compared to only 11 percent for North American companies. During 1986, Japanese companies had 77 percent of the $453 million intracompany market and 35 percent of the $1,345 million merchant market. North American companies had 21 percent of the intracompany market and 55 percent of the merchant market. Intracompany markets are less volatile and less vulnerable to outside competition. However, Figure 4 shows that the combined intracompany and merchant revenue for North American companies and Japanese companies is 46.1 percent and 45 percent, respectively.

Figure 4

ESTIMATED 1986 INTRACOMPANY AND MERCHANT WORLDWIDE SHIPMENTS BY REGION



Source: Dataquest
April 1987

MARKET TRENDS

Fierce competition from the more than 100 gate array suppliers produced the following trends:

- Amortized or low NRE pricing
- Declining device pricing
- Increased offshore manufacturing and consumption

NRE Pricing

Suppliers are experimenting with different NRE strategies. Some suppliers try to minimize the up-front NRE charge and amortize the cost of the design over production volume. This can be risky since some designs never go to production. Japanese companies in Japan charge low or zero NRE and require a production order. At the other extreme is the supplier that charges NRE and production cost separately, making each part self-reliant. Between these extremes are various combinations of NRE and production charges that may not represent the true cost of either part. In today's North American market, an increasing number of companies are offering NRE below cost and amortizing the cost of the design over the production volume.

Pricing on NRE for low-density CMOS arrays declined drastically in 1986. During 1985, 1,500-gate CMOS devices had a typical NRE charge of $25,000 to $30,000. In late 1986, these same devices had an average NRE charge of $15,000 to $20,000. This can be attributed to the competitive environment brought about by the 60 to 70 suppliers offering comparable products.

Device Pricing

The price per device is difficult to estimate because prices vary widely due to technology, gate count, and packaging configurations. Thus, a CMOS 2,000-gate device may sell for as low as $3 in high quantities, while an ECL 2,500-gate device may sell for $170. A better way to monitor gate array pricing is on a price-per-gate basis. For benchmarking purposes, users should refer to the quarterly pricing data in the SUIS "Industry Trends" volume.

The most popular gate arrays (CMOS, 2,000 gates, die only, in quantities of thousands) took a sharp price-per-gate drop from between $0.01 and $0.012 in 1984, to between $0.002 and $0.004 in 1985. During 1986, the price per gate for these same devices fell to between $0.001 and $0.003. Higher gate count CMOS devices took a much smaller drop annually. The price per gate for ECL gate arrays only took an estimated 15 percent drop annually. Price decreases did occur in gate arrays, but not equally across all product lines.

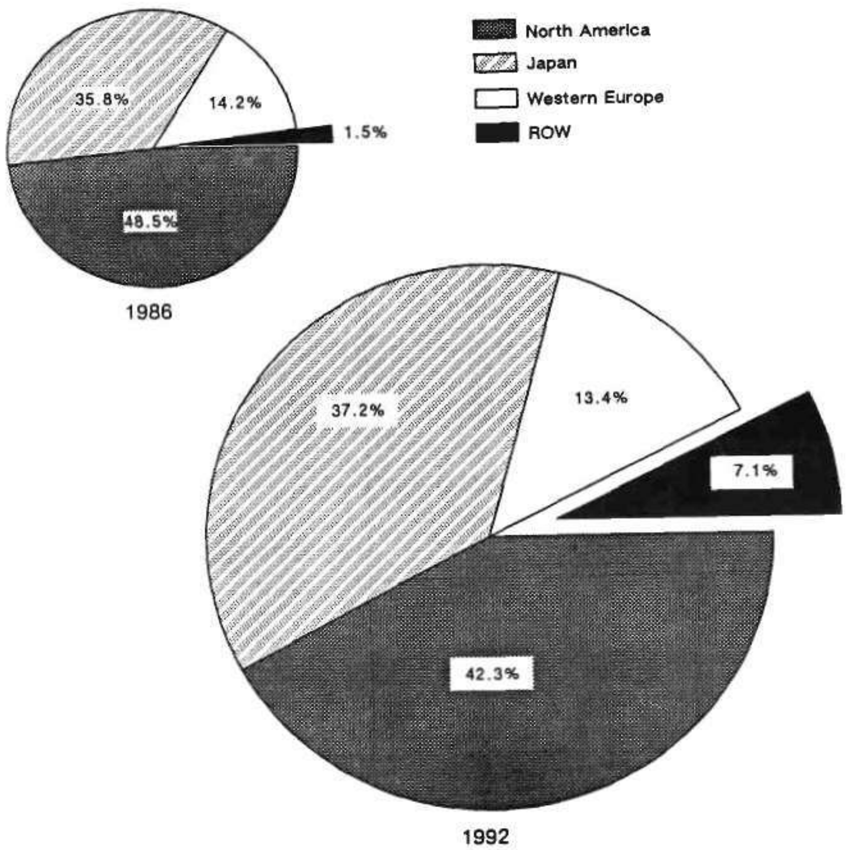
Few suppliers can make a profit with pricing at $0.001 per gate.

Offshore Manufacturing

The escalating value of the yen against other currencies is having a major impact on system manufacturers. This is especially true for those companies that make consumer electronics. In the highly competitive consumer electronics market, building the product at the lowest possible cost can make the difference between success or failure. We see a strong shift of system manufacturing to the Asian Pacific basin. This is true for Japanese system companies as well as North American companies. Dataquest has noted in other publications that there is an increasing demand for all types of semiconductors in Korea, Taiwan, Hong Kong, and Singapore. The Japanese Ministry of Finance reported that in 1986, Japan exported 498 million ICs to the United States while also exporting 444 million units to Korea, 442 million to Taiwan, and 481 million to Hong Kong. The trend in gate arrays is no different. Figure 5 illustrates that Dataquest expects the consumption of gate arrays in Rest of World (ROW) to increase from 1.5 percent in 1986 to 7.1 percent in 1992.

Figure 5

ESTIMATED WORLDWIDE GATE ARRAY CONSUMPTION BY REGION



Source: Dataquest
April 1987

DATAQUEST CONCLUSIONS

Suppliers need to position their design wins to capitalize on their strengths while avoiding major competition. We expect Japanese companies in the North American market to continue focusing on capturing lower-density, high-volume CMOS gate array designs as well as high-density ECL designs. North American companies are expected to focus more on capturing high-density CMOS designs and the full range of ECL designs. The gate array market is now dominated by large IC suppliers. The data suggest that Japanese companies will gain market share in both the MOS and bipolar gate array markets over the next two years. We expect 1987 to be the year of truth for the small gate array suppliers. They must decide which path to take: move to a niche market, look to be acquired, or retreat from the market altogether.

Food for Thought

In summary, being careful means understanding all of the subtle nuances involved in these market evolutions. Indeed, your requirements as users may mean seeking the best combination of price, technology, and supplier market position (or the importance of alternate sourcing). Here then, are several primary issues to consider:

- Prices have been decreasing and are forecast to continue dropping. NRE charges are also decreasing and some suppliers may eliminate them to draw business.
- Due to the competition, the gate array market is undergoing changes that will force realignments among surviving suppliers.
- ASIC vendors that are either special service companies or do gate arrays in addition to other design approaches should be considered.
- CMOS technology will be the process of choice in mainstream suppliers' portfolios.
- Japanese companies are serious about doing business. They will compete aggressively since they are broad-based suppliers and are targeting this market.

Brand Parks
Bryan G. Lewis

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PRELIMINARY 1986 MICROCOMPONENT MANUFACTURER RANKINGS

The top 10 companies listed in Table 1 accounted for more than 77 percent of the microcomponent market, and all of the 10 had revenue of more than $100 million each in this market segment. In 1986, Intel, NEC, and Motorola maintained first, second, and third place, respectively. Only 1 of the top 10 companies, Intel, experienced a decline in microcomponent revenue. Of the top 10 micro manufacturers, 6 were Japanese; the other 4 were U.S. manufacturers. Toshiba moved into the top 10 ranking while Texas Instruments dropped out. Total worldwide micro revenue increased approximately 28.14 percent in 1986 from 1985.

Table 1

PRELIMINARY TOP 10 1986
MICROCOMPONENT MANUFACTURERS
(Millions of Dollars)

1985 Rank	1986 Rank	Company	Revenue 1985	Revenue 1986	Growth
1	1	Intel	$670	$628	(6.27%)
2	2	NEC	$375	$490	30.67%
3	3	Motorola	$272	$340	25.00%
6	4	Hitachi	$110	$240	118.18%
-	5	Toshiba	$ 69	$187	171.01%
8	6	Mitsubishi	$100	$184	84.00%
4	7	National	$144	$168	16.67%
5	8	Matsushita	$111	$166	49.55%
7	9	Fujitsu	$106	$162	52.83%
10	10	AMD	$ 86	$113	31.40%

Source: Dataquest
April 1987

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GEOGRAPHIC MARKET SHARE

The geographic market share shifted significantly from 1985 to 1986, as shown in Table 2. Market share for Japan, Western Europe, and Rest of World increased, while market share for U.S. companies decreased. The shift in market share to Japanese companies was pronounced, a considerable portion of which resulted from the currency effect of a high yen value.

Table 2

GEOGRAPHIC MARKET SHARE FOR MICROCOMPONENT SHIPMENTS

	1985	1986
United States	57.03%	47.43%
Japan	36.68	45.62
Western Europe	5.67	6.18
Rest of World	0.62	0.77
Total	100.00%	100.00%

Source: Dataquest
April 1987

GROWTH RATES

The manufacturers with the highest growth rates in the microcomponent segment and in excess of the industry average growth rate are shown in Table 3.

Table 3

TOP GROWTH 1986 MICROCOMPONENT MANUFACTURERS
(Millions of Dollars)

	1985	1986	Growth
Inmos	$ 2	$ 10	400.00%
IDT	$ 1	$ 3	200.00%
Toshiba	$ 69	$187	171.01%
Rohm	$ 2	$ 5	150.00%
Hitachi	$110	$240	118.18%
United Microelectronics	$ 7	$ 15	114.29%
Mitsubishi	$100	$184	84.00%
Thomson	$ 40	$ 66	65.00%
Western Digital	$ 11	$ 18	63.64%
Intersil	$ 5	$ 8	60.00%
Fujitsu	$106	$162	52.83%
Eurosil	$ 2	$ 3	50.00%
Rockwell	$ 26	$ 39	50.00%
Matsushita	$111	$166	49.55%
SGS	$ 20	$ 27	35.00%
Oki	$ 45	$ 60	33.33%
AMD	$ 86	$113	31.40%
NEC	$375	$490	30.67%

Source: Dataquest
April 1987

1986 Market Summary

Tables 4 through 8 rank the worldwide microcomponent suppliers by total revenue and by region.

Table 4

PRELIMINARY WORLDWIDE
1986 MICROCOMPONENT MARKET SHARE RANKING
(Millions of Dollars)

	1985	1986	Growth
Intel	$ 670	$ 628	(6.27%)
NEC	375	490	30.67%
Motorola	272	340	25.00%
Hitachi	110	240	118.18%
Toshiba	69	187	171.01%
Mitsubishi	100	184	84.00%
Matsushita	111	166	49.55%
Fujitsu	106	162	52.83%
National	144	168	16.67%
AMD	86	113	31.40%
T.I.	88	94	6.82%
Philips	64	81	26.56%
Zilog	59	74	25.42%
Thomson	40	66	65.00%
Oki	45	60	33.33%
Harris	58	59	1.72%
Sanyo	36	45	25.00%
SMC	40	42	5.00%
Rockwell	26	39	50.00%
Sharp	46	39	(15.22%)
RCA	28	31	10.71%
SGS	20	27	35.00%
Sony	0	18	1,800.00%
Western Digital	11	18	63.64%
Siemens	16	16	0.00
Matra-Harris	12	15	25.00%
United Microelectronics	7	15	114.29%
ITT	11	13	18.18%
Inmos	2	10	400.00%
NCR	9	9	0.00

(Continued)

Table 4 (Continued)

PRELIMINARY WORLDWIDE
1986 MICROCOMPONENT MARKET SHARE RANKING
(Millions of Dollars)

	1985	1986	Growth
GI	8	8	0.00
Intersil	5	8	60.00%
Gould Semiconductor	7	6	(14.29%)
GTE	5	6	20.00%
Rohm	2	5	150.00%
Fairchild	10	4	(60.00%)
Eurosil	2	3	50.00%
IDT	1	3	200.00%
Hughes	3	2	(33.33%)
Erso	1	1	0.00
Gold Star	1	1	0.00
Japan Others	9	12	33.33%
ROW Others	8	10	25.00%
U.S. Others	28	7	(75.00%)
Total	$2,751	$3,525	28.14%

Source: Dataquest
April 1987

Table 5

PRELIMINARY 1986 WORLDWIDE MICROCOMPONENT MARKET SHARE RANKINGS FOR U.S. SUPPLIERS
(Millions of Dollars)

	1985	1986	Growth
AMD	$ 86	$ 113	31.40%
Fairchild	10	4	(60.00%)
GI	8	8	0.00%
Gould Semiconductor	7	6	(14.29%)
GTE	5	6	20.00%
Harris	58	59	1.72%
Hughes	3	2	(33.33%)
IDT	1	3	200.00%
Intel	670	628	(6.27%)
Intersil	5	8	60.00%
ITT	11	13	18.18%
Mostek	20	*	(100.00%)
Motorola	272	340	25.00%
NCR	9	9	0.00
National	144	168	11.32%
RCA	28	31	10.71%
Rockwell	26	39	50.00%
SMC	40	42	5.00%
T.I.	88	94	6.82%
Western Digital	11	18	63.64%
Zilog	59	74	25.42%
Others	8	7	40.00%
Total	$1,569	$1,672	6.56%

*Revenue counted under parent company, Thomson, in 1986

Source: Dataquest
April 1987

Table 6

PRELIMINARY 1986 WORLDWIDE MICROCOMPONENT MARKET SHARE RANKINGS FOR JAPANESE SUPPLIERS (Millions of Dollars)

	1985	1986	Growth
Fujitsu	$ 106	$ 162	52.83%
Hitachi	110	240	118.18%
Matsushita	111	166	49.55%
Mitsubishi	100	184	84.00%
NEC	375	490	30.67%
Oki	45	60	33.33%
Rohm	2	5	150.00%
Sanyo	36	45	25.00%
Sharp	46	39	(15.22%)
Sony	N/A	18	1,800.00%
Toshiba	69	187	171.01%
Others	9	12	33.33%
Total	$1,009	$1,608	59.37%

N/A = Not Applicable

Source: Dataquest
April 1987

Table 7

PRELIMINARY 1986 WORLDWIDE MICROCOMPONENT MARKET SHARE RANKINGS FOR WESTERN EUROPEAN SUPPLIERS (Millions of Dollars)

	1985	1986	Growth
Eurosil	$ 2	$ 3	50.00%
Inmos	2	10	400.00%
Matra-Harris	12	15	25.00%
Philips	64	81	26.56%
SGS	20	27	35.00%
Siemens	16	16	0
Thomson	40	66	65.00%
Total	$156	$218	39.74%

Source: Dataquest
April 1987

Table 8

PRELIMINARY 1986 WORLDWIDE MICROCOMPONENT MARKET SHARE RANKINGS FOR REST OF WORLD SUPPLIERS (Millions of Dollars)

	1985	1986	Growth
Erso	$ 1	$ 1	0
Gold Star	1	1	0
United Microelectronics	7	15	114.29%
Others	8	10	25.00%
Total	$17	$27	58.82%

Source: Dataquest
April 1987

SUMMARY

Preliminary market share data indicate that worldwide microcomponent revenue increased approximately 28.14 percent in 1986, which was higher than the approximately 24.9 percent growth experienced by the overall semiconductor market. Since the Japanese suppliers sold a large percentage of their production into their home market, a considerable portion of the growth evidenced by them was attributable to the appreciation of the yen against the dollar. Softness in the computer market segment particularly affected U.S. suppliers in a negative way. Thomson's acquisition of Mostek also resulted in 1986 revenue from Mostek being reported under the Western European section, which further detracted from the U.S. supplier base. While all regional segments saw increases in 1986 dollar revenue over 1985, only U.S. manufacturers lost market share.

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Research Newsletter

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CMOS PROGRAMMABLE LOGIC DEVICES: THE WATCHWORD IS ALTERNATIVES

INTRODUCTION

In the SUIS newsletter, number 1986-4, "Programmable Logic Devices: The Synergistic Intersection," we discussed the general movement of PLDs into the market and the technology diversity. The overall top five PLD suppliers in 1985 were primarily vendors of bipolar products. However, when viewing the complete scenario, it is easy to recognize that MOS technology (specifically CMOS) is entering the PLD arena in an aggressive manner and that a different set of suppliers occupy the top positions in CMOS.

This newsletter focuses on:

- The suppliers
- The architectures
- The general market direction

Figure 1 illustrates Dataquest's opinion of the relationship of bipolar and CMOS devices through 1992. We estimate that total PLD consumption will reach $1,058.6 million in 1991, with CMOS devices having a 51 percent share. While bipolar PLD sales (aided by ECL products) will continue to grow, we expect CMOS to dominate sales in 1991.

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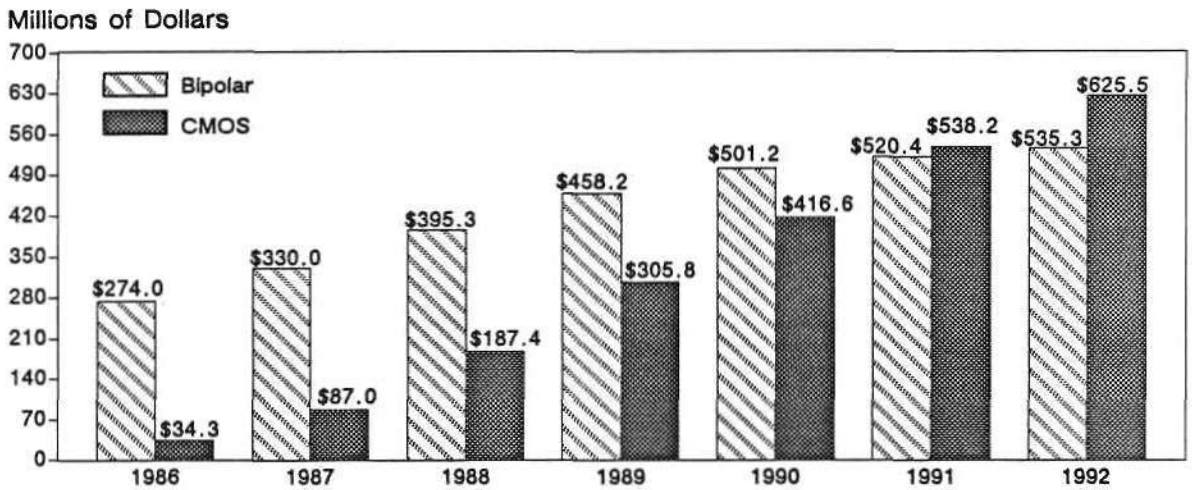
Figure 1

PRELIMINARY 1986
ESTIMATED WORLDWIDE CONSUMPTION OF PROGRAMMABLE LOGIC DEVICES
BY TECHNOLOGY



Source: Dataquest
April 1987

THE SUPPLIER BASE

Table 1 displays the major 1986 suppliers worldwide for all PLDs, while Table 2 shows the 1986 top five CMOS vendors. While bipolar technology has been the process leader in the market, CMOS PLD vendors are close behind in establishing their presence. In addition, there is a wider variety of programming methods for CMOS PLDs, which gives users more flexibility for selection. Table 3 provides a summary view of the products and features of the 1986 top five CMOS suppliers.

Currently the PLD market is dominated by North American suppliers. Nevertheless, we estimate that by late 1987 there will be an emergence of overseas suppliers, since several now have EPROMs or EEPROMs technology and experience. Toshiba, for example, has published research papers on PLDs and has used PLDs internally, but does not offer them in the merchant market. As the market continues to grow, we expect increased participation from overseas suppliers.

Table 1

WORLDWIDE PROGRAMMABLE LOGIC DEVICE SUPPLIERS--1986

Company	Bipolar TTL	Bipolar ECL	CMOS Fuse	CMOS Mask	CMOS EPLD	CMOS EEPLD	CMOS Other
Advanced Micro Devices	X	X				X	
Altera Corporation					X		
Atmel Corporation				X			
Cypress Semiconductor					X		
Exel Microelectronics Inc.						X	
Fairchild Semiconductor	X	X					
Gould Semiconductor						X	
Harris Semiconductor			X				
Intel Corporation					X		
International CMOS Technology						X	
Lattice Semiconductor						X	
Monolithic Memories	X	X					
National Semiconductor	X	X					X
Panatech Semiconductor					X		
Signetics	X	X			X		
Sprague Solid State					X		
Texas Instruments	X						
VLSI Technology				X	X	X	
Xilinx							X

Source: Dataquest
April 1987

Table 2

ESTIMATED 1986 REVENUE--TOP FIVE CMOS PLD SUPPLIERS
(Millions of Dollars)

Rank	Company	Revenue
1	Altera	$12.0
2	Monolithic Memories	$ 5.0
3	Xilinx	$ 4.0
4	Harris	$ 3.5
5	Intel	$ 3.0

Source: Dataquest
April 1987

Table 3

PRODUCTS AND FEATURES--1986 TOP FIVE CMOS PLD SUPPLIERS

Company	Product Type	Alternate Sources	Product Terms
Altera	EPLD	Intel	74 to 480
Monolithic Memories	LCAs ZPAL	Xilinx None	1,024, 1,600 equivalent gates 80
Xilinx	LCAs	Monolithic Memories	1,024, 1,600 equivalent gates
Harris	PAL	None	56, 64
Intel	EPLD	Altera	74-480

Source: Dataquest
April 1987

Another element driving the growth of the PLD market is the improvement in software and programming equipment. Table 4 lists the toolmaker suppliers and the products they support. Most third-party programmer suppliers have been cautious in the past when considering whether to support a start-up company until its product is accepted in the marketplace. As a result, start-ups have been forced to develop their own programming tools. Although most suppliers would prefer to leave the design of PLD-CAD tools to third-party companies, they have often been the leaders in developing innovative systems to support their own products. It is interesting to note that proprietary programmer tools were the key to success for start-up companies like Xilinx and Altera. We believe it is necessary for the start-up suppliers to join forces with third-party toolmaker suppliers in order to expand the market. Emerging products will continue to appear on proprietary development systems, and as they mature they will migrate to third-party systems.

Table 4

PROGRAMMABLE LOGIC DEVICE TOOLMAKER SUPPLIERS

PLD Supplier	Tool	Tool Supplier
Advanced Micro Devices	ABEL	Data I/O
	CUPL	PCAD
	AmCUPL	AMD
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Altera Corporation	PLDS2, PLCAD4	Altera
		Third-Party Supplier
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Atmel Corporation	ABEL	Data I/O
Cypress Semiconductor	ABEL	Data I/O
	Model 29B, 60A, 60B	Data I/O
	CUPL	PCAD Systems
	PLPL	AMD
	QuickPro Cy300	Cypress
	STAGPPZ, ZL32m	Stag Microsystems
	DIGILEC Model 803	Digilec
	ALLPROM	Logical Devices
	VDS160	Valley Data Sciences
Exel Microelectronics	Perfect	Valley Data Sciences
	ABEL	Data I/O
Fairchild Semiconductor	ZL30	Stag Microsystems
	UP803	Digilec
	ABEL, Model 29B	Data I/O
	CUPL	PCAD
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Gould Inc.	PEEL Dev. Syst.	ICT
	29B, 60	Data I/O
	PPZ, ZL30A	Stag Microsystems
	SD1040	Structured Design
	SP0300, GP1140	Varix
	VDS160	Valley Data Sciences

(Continued)

Table 4 (Continued)

PROGRAMMABLE LOGIC DEVICE TOOLMAKER SUPPLIERS

PLD Supplier	Tool	Tool Supplier
Harris Semiconductor	HELP	Harris
	ABEL	Data I/O
	CUPL	PCAD Systems
	VDS160	Valley Data Sciences
Intel Corporation	iPLD	Intel
	DASH	Data I/O
	PC-CAPS	PCAD
	VDS160	Valley Data Sciences
Int'l CMOS Technology	PEEL Dev. Syst.	ICT
	29B, 60	Data I/O
	PPZ, ZL30A	Stag Microsystems
	SD1040	Structured Design
	SP0300, GP1140	Varix
	VDS160	Valley Data Sciences
Lattice Semiconductor	ABEL	Data I/O
	CUPL	PCAD Systems
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Monolithic Memories	PALASM2	MMI
	ABEL	Data I/O
	CUPL	PCAD Systems
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
National Semiconductor	PLAN	NSC
	ABEL	Data I/O
	CUPL	PCAD Systems
	ECL-1, ECL-2	International Micros
	PALASM	
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Panatech Semiconductor	ABEL	Data I/O
	Model 29, Logic Pak	Data I/O
	EPLASM IPLG	Ricoh
	CUPL	Stag Microsystems
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences

(Continued)

Table 4 (Continued)

PROGRAMMABLE LOGIC DEVICE TOOLMAKER SUPPLIERS

PLD Supplier	Tool	Tool Supplier
Signetics Corporation	AMAZE	Signetics
	ABEL	Data I/O
	CUPL	PCAD Systems
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Texas Instruments	ABEL	Data I/O
	CUPL	PCAD Systems
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
VLSI Technology	ZPL30A	Stag Microsystems
		Data I/O
	PERFECT	Valley Data Sciences
	VDS160	Valley Data Sciences
Xilinx	XACT	Xilinx

Source: Dataquest
April 1987

Altera Corporation

Altera introduced the Erasable Programmable Logic Device (EPLD) in 1984. The company's approach has been to target users of semicustom devices by offering a product that solves many of the existing problems with current application-specific integrated circuit (ASIC) techniques. Altera's product reduces the cost element associated with semicustom solutions and improves CAD tools while offering devices that avoid long development cycles. These devices are based on EPROM technology for logic configuration storage and can, therefore, be erased in the same manner as EPROM memory devices.

Monolithic Memories

While Monolithic Memories (MMI) has been the bipolar leader in PLDs, its agreement with Xilinx gives it the much needed knowledge to expand its presence in an accelerating CMOS market. Additionally, MMI has acquired access to electrically erasable (EE) technology from Seeq Technology for inclusion in future products.

Xilinx

Xilinx's entry into the CMOS PLD market has been via its logic cell array (LCA) product line. The company has taken a slightly different approach as it considers these components to be programmable gate arrays with much more flexibility than typical PLDs. Xilinx has implemented an SRAM-based logic configuration storage architecture with emulation ability. Its latest innovations include a device of 1,800 equivalent usable gates and speed upgrades to 50 MHz and 70 MHz. Xilinx's goal is to produce devices of more than 6,000 gate densities and to continue to evolve the CAE tools/environment to further simplify the design process.

Harris

Harris produces CMOS PALs primarily for military and aerospace applications. It has no second sources and has made no recent announcements of any new PLD product lines.

Intel

Intel entered the market following a technology exchange agreement with Altera Corporation and successively signed on as Altera's second source for EPLDs. Intel began by offering the basic 600 through 1,800 gate devices and has most recently introduced a new EPLD with hard macros on chip for bus interfacing and control. The goal of this product is to optimize board space by combining several TTL functions with the flexibility of an EPLD in a bus-oriented design. This type of device fits in well with Intel's overall microcomponent strategy.

ARCHITECTURES: THE NEW BATTLEGROUND

Architectural innovations are significant because new structures offer the potential to solve many more design problems with user-programmable devices. PLDs are divided into two segments: products that offer faster performance and products that offer architectural flexibility and high density. At present, there are three basic PLD architectures on the market:

- PLD/IFL Programmable Logic Devices formerly called Integrated Fuse Logic (IFL) devices

- Programmable Array Logic (PAL) devices (PAL is a registered trademark of Monolithic Memories.)

- Microprogrammed structures called Logic Cell Arrays (LCAs) (Logic Cell Array is a trademark of Xilinx.)

The PAL and the PLD/IFL have similar internal AND/OR structures but vary in the allocation of logic features and the amount of programmability. The LCA uses a microcoded function that is programmed by a PROM.

History/Evolution of PLD Architectures

In 1978, Signetics introduced the IFL device. In 1980, designers at Monolithic Memories found that IFL devices offered a limited degree of flexibility, making PLDs difficult to use. They produced a more flexible device called the PAL, which was easier to use than the available IFL device. Currently, a surge of newer bipolar and CMOS architectures has been introduced that differ from the PLD/IFL and PAL architectures.

In 1985 AMD introduced the 22V10, a bipolar device that can be used to replace up to 20 PAL devices. Altera introduced a CMOS family of PLDs with equivalent gate counts of up to 1,800 gates and output macrocells offering a degree of flexibility unavailable in earlier PLDs. This part, with its user customization approach, was aimed at capturing designs from gate array applications, beginning a new wave of products offering a higher degree of flexibility.

In 1985, Xilinx introduced a unique PLD, the LCA. The LCA is programmed by loading a configuration program pattern from an external memory. Its chief advantage is that an LCA can be programmed while in the system, thereby allowing the system's logic or the device's architecture to be changed while the system continues to operate.

In May 1985, Lattice Semiconductor introduced an EEPROM-based CMOS device called the Generic Array Logic (GAL), offering programmable output macrocells that enable reprogrammability. The GAL replaces many PALs and also offers testability that guarantees the functionality of the device. Lattice then followed up with an enhanced GAL--the ispGAL (in-system programmable Generic Array Logic) device.

In late 1986, Signetics introduced a bipolar device, Programmable Macro Logic (PML), that provides users with a higher level of logic integration.

These are just a few enhanced architectures. Look to 1987 for the emergence of new suppliers offering higher degrees of PLD flexibility and density, thus fueling further growth of the PLD market.

WHAT TRENDS ARE PUSHING PLD MARKET GROWTH?

Dataquest believes that faster performance and flexible architectures will continue to fuel the growth of the PLD market. Early PLDs exhibited usable gate counts in the 100- to 300-gate range. Today gate counts are up to 1,800, and Dataquest expects that devices using 16,000 gates will be available in the early 1990s.

TTL, ECL, and CMOS process technologies are all improving in speed. By 1988, TTL PLDs should reach speeds in the 5ns to 10ns range. ECL devices, offering the ultimate in performance, will reach speeds in the 2ns range. But be aware that CMOS PLD speeds are approaching bipolar PLD speeds. Today, designers can reach speeds of 15ns to 35ns with CMOS devices. Overall, TTL or ECL processes have definite speed advantages but CMOS devices offer both architectural flexibility and high gate count.

While the first trend, enhancements in architectures, will push the limits of technical performance, the second trend will be a restructuring of product pricing. Today most TTL PLDs cost from 0.5 cents to approximately 1 cent per gate. Dataquest expects this pricing to decline on a per gate basis as CMOS technology becomes more popular and as more products emerge. Other factors that will influence a price restructuring include:

- The emergence of Japanese suppliers in 1987
- Fierce competition among suppliers
- A possible softening in the market due to a projected recession in 1989

Another trend fueling the growth of the PLD market is the off-the-shelf availability of PLDs. PLDs are the ideal ASIC products for distributors as PLD inventories can easily be sold to customers. Unprogrammed devices can be stocked on distributors' shelves and programmed later, giving distributors better inventory control. PLDs allow distributors to add value by making programming equipment available to customize the PLDs.

DATAQUEST CONCLUSIONS

In the final analysis, ASIC users will have a diverse set of products to choose from in the CMOS PLD market. This diversity will come from a variety of suppliers including non-U.S. companies. As a result, the market will come to a balance as new suppliers enter and others fall away because they have not maintained a competitive advantage.

Thus, the following basic issues should be considered:

- Will PLD vendors work hand-in-hand with programmer suppliers to ensure timely support of emerging architectures and decrease time to market?
- Will an all-purpose design tool emerge that will take advantage of all existing architectures?

- With their EPROM and EEPROM experience coupled with their business skills, will the Japanese dominate the PLD market?

- As competition increases, who will be the first to withdraw from the market?

As the market matures, we believe that there will be a growing synergy between programmer suppliers and PLD vendors, especially in the CMOS segment. Each participant--the PLD supplier, the third-party supplier, and the toolmaker--depends on the other in order to be successful in the market. They cannot survive as separate entities; they must communicate with each other to develop compatible architectures and tools to ensure rapid time to market and thus comprehensive and timely support for the PLD user.

This synergy could promote the emergence of all-purpose tools when users and suppliers realize that the proliferation of architectures could overwhelm them. Designers will begin to implement more than one type of PLD in a design. Changing software and development systems might become cumbersome, yet the demand for them will be evident.

Dataquest recommends that PLD users evaluate all of the considerations in selecting a new architecture and supplier since many product introductions and market changes are likely to occur.

Brand A. Parks
Andrew Prophet

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Research Newsletter

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START-UP COMPANIES EXPANDING

This newsletter is the first in a series of quarterly updates on recent activities of start-up semiconductor companies. This information supplements I.C. Start-Ups 1987, a new Dataquest directory of semiconductor start-ups, which was published in October 1986. The newsletters will include information on new companies formed, initial and additional rounds of financing, significant company announcements, and new alliances.

MAJOR DEVELOPMENTS

Start-up activity continues at a strong pace. Seven companies, formed in 1986, have emerged. Dataquest expects the number to grow as companies raise initial financing and complete their initial product offerings.

We have noted also that many of the start-ups are experiencing extraordinary growth. In 1986, Cypress Semiconductor approximately tripled its sales from $18 million in 1985; Samsung and UMC doubled their sales from $95 million and $33 million, respectively, in 1985. Many other companies increased revenue by 25, 30, or 50 percent.

Figure 1 illustrates the activity in company formation between 1957 and 1986.

Other major developments for start-up companies include the following:

- Start-up companies have attracted $73.6 million in additional financing.

- VLSI Technology acquired Visic, Inc.; Custom MOS Arrays and its sister company, California Micro Devices, merged activities.

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- Start-ups have expanded with the formation of subsidiaries in Asia and additional manufacturing facilities in the United States and Europe.

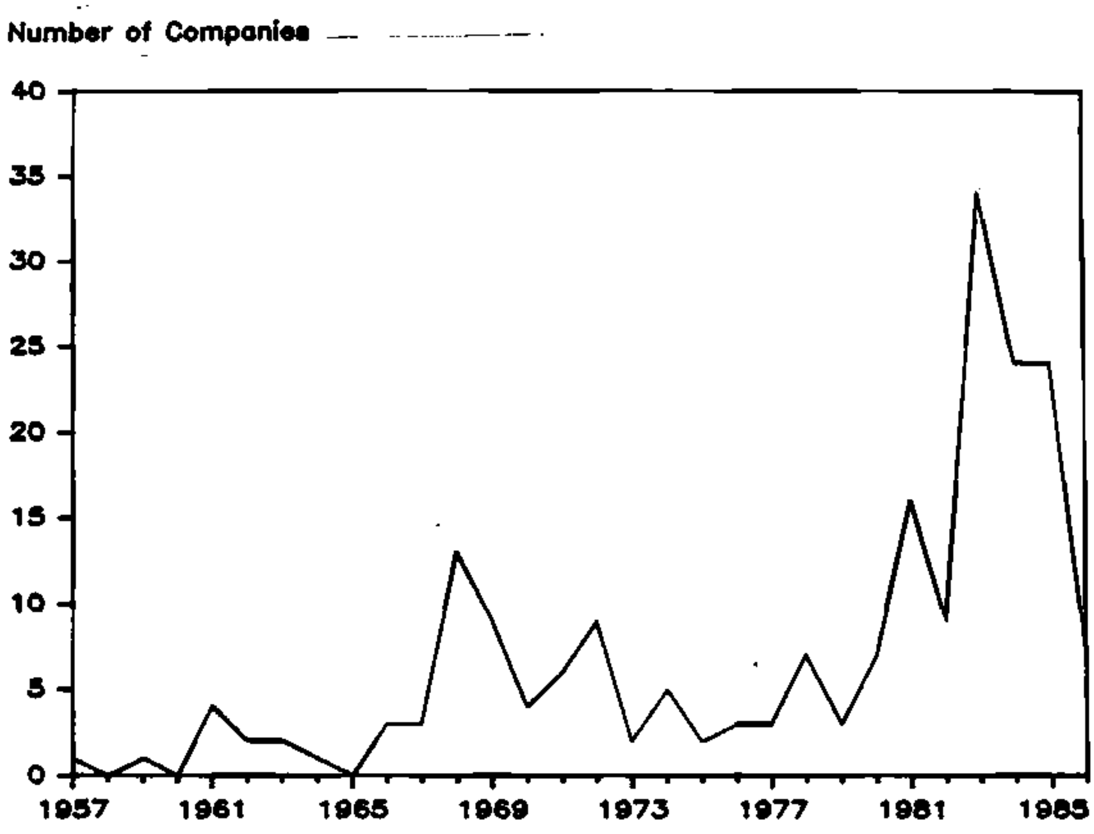
- Several start-ups have also announced reorganizations and changes of presidents and CEOs, indicating business expansion.

- Many new alliances have been formed, involving a total of 33 companies.

Table 1 lists the semiconductor companies formed in 1985 and 1986.

Figure 1

FORMATION OF COMPANIES
1957-1986



Source: Dataquest
March 1987

Table 1

START-UP COMPANIES

Companies Formed in 1986

Company	Location	Product
Gazelle Microcircuits	Sunnyvale, CA	GaAs digital
Graphics Communications	Japan	Graphics chips
Innovative Silicon Technology	Italy	ASICs
MemTech	Folsom, CA	Bubble memory
Solid State Technologies	San Jose, CA	Bipolar memory
Taiwan Semiconductor Mfg. Corp.	Taiwan	Foundry
Telcom Devices	Newbury Park, CA	GaAs opto

Companies Formed in 1985

Company	Location	Product
ABM Semiconductor, Inc.	San Jose, CA	AlGaAs Opto
ACTEL Corporation	Sunnyvale, CA	ASICs
Acumos, Inc.	San Jose, CA	CMOS ASICs
Advanced Linear Devices	Sunnyvale, CA	Linear
American Information Technology	Cupertino, CA	MPUs
Anadigics, Inc.	Warren, NJ	GAas A/D converters
BT&D Technologies, Inc.	United Kingdom	Optoelectronics
Catalyst Semiconductor	Santa Clara, CA	Memory
Chips & Technologies	Milpitas, CA	Micros
Dolphin Integration	Europe	ASICs
European Silicon Structures	West Germany	ASICs

(Continued)

Table 1 (Continued)

START-UP COMPANIES

Companies Formed in 1985

Company	Location	Product
GAIN Electronics	Somerville, NJ	GaAs
Hittite Microwave Corp.	Massachusetts	GaAs
Intercept Microelectronics	San Jose, CA	ASICs
Level One Communications	Folsom, CA	Linear
Orbit Semiconductor	Sunnyvale, CA	Foundry
Sahni Corporation	Sunnyvale, CA	Closed (1986)
Saratoga Semiconductor	Cupertino, CA	Memory
Spectrum Semiconductor	Canada	ASICs
III-V Semiconductor	Arizona	GaAs
Tachonics Corporation	Bethpage, NY	GaAs
Topaz Semiconductor	San Jose, CA	DMOS ICs
Triad Semiconductor Intl.	Colorado	Memory
Wolfson Microelectronics	United Kingdom	ASICs

Source: Dataquest
March 1987

NEW COMPANIES

American Information Technology

American Information Technology (AIT), a start-up company in Cupertino, California, was formed in 1985. AIT has recently raised additional financing, is in its development stage, and will be releasing information on its activities later this year.

Gazelle Microcircuits, Inc.

Gazelle was founded in the summer of 1986 by ex-GigaBit Logic executives Andy Graham and David McMillan. In January 1987, Jerry Crowley, vice chairman and founder of Oki Semiconductor, left Oki to head the start-up. Gazelle is located in Sunnyvale, California, and was recently financed by Hambrecht & Quist and Kleiner, Perkins, Caufield & Byers. The company also has floated 900,000 shares of preferred stock at $1 a share and currently is putting together another round of financing. Gazelle will concentrate on very high speed digital ICs for military, telecommunications, and EDP applications.

Graphics Communications Technology

Ascii Inc., a Japanese software house, established a graphics start-up called Graphics Communications. Graphics Communications will be 70 percent financed by the joint MITI/MPT (Ministry of Posts & Telecommunications) Key Technology Research Promotion Center and 30 percent by 11 companies, including Iwasaki Communications, Mitsui Corporation, and Okura Electric. Ascii will maintain a 5 percent share in the venture, which will be headed by Ascii vice president, Kazuhiko Nishi.

Innovative Silicon Technology

Innovative Silicon Technology (IST) is a spin-off of SGS that was formed in May 1986 and is headed by Piero Martinotti and others from Motorola. SGS transferred the assets of its ASIC activities to IST, which will use a 1.5-micron, double-layer metal and direct-write on E-beam. It is providing gate arrays in one and one-half weeks and standard cells in two weeks. IST is planning a new R&D facility, fab, and operations, separate from SGS, that will be located northeast of Milan, Italy. Products are expected in 1987.

MemTech

MemTech was formed to acquire Intel's bubble memory operation. In February 1987, Intel signed the final purchase agreement covering the sale of Intel's magnetics operation to MemTech. The final sale terms provide for the transfer of Intel bubble memory manufacturing and test equipment, inventory, product designs, personnel, and manufacturing and quality specifications to MemTech for an undisclosed price. Operations will remain in Folsom, California.

MemTech is affiliated with Helix Systems & Development, Canoga Park, California, a bubble memory systems manufacturer. MemTech is headed by Richard H. Loeffler, formerly chairman and chief executive of Helix, and William H. Almond, the former head of Eaton's microlithography division. MemTech offers a complete bubble memory product line that includes 1- and

4-megabit bubble memory components and support circuitry, bubble memory boards, subsystems, and a cassette product, all available in a variety of temperature ranges.

Solid State Technologies

Solid State Technologies is a 1986 start-up located in San Jose, California. The company was founded by George W. Brown, presently serving as president, and Marshall Wilder, vice president of operations, both from Advanced Micro Devices. Initially, Solid State Technologies plans to offer high-performance bipolar memory products. It is presently in its developmental stage and will be releasing more information in a few months.

Taiwan Semiconductor Manufacturing Corp.

Taiwan Semiconductor Manufacturing Corp. (TSMC) has been set up as a foundry operation that will produce a wide variety of ICs. Taiwan's Executive Yuan, or legislature, has earmarked monies from its Development Fund for a 48 percent stake in the new company. N.V. Philips will take a 27.5 percent share in the $150 million investment in TSMC.

Chips are now being produced at the company's initial fab, which is capable of producing 10,000 6-inch wafers per month. In the second phase, which will be completed in 1988, it will be able to produce 30,000 1.5-micron, 6-inch wafers per month.

Telcom Devices Corp.

Telcom Devices was formed in early 1986 to offer indium gallium arsenide (InGaAs) photodiodes and indium gallium phosphide (InGaP) light-emitting diodes. Telcom Devices is a subsidiary of Opto Diode Corp. (ODC) and is operating from ODC's facilities in Newbury Park, California. The two companies share clean room and manufacturing space. Larry Perillo, formerly with Rockwell, is director of optoelectronics materials. Telcom Devices started volume production of its first product in May 1986, an InGaAs PIN photodiode for fiber-optic applications.

FINANCING

Table 2 lists by company the funding raised in the third quarter of 1986 and the first quarter of 1987.

Table 2

ADDITIONAL START-UP FINANCING

Company	Date	Round	Amount	Sources
Anadigics Inc.	Nov. 1986	2	$10.0M	Century IV Fund; Englehard Corp.; Memorial Drive Fund; Metropolitan Life Insurance Co.
California Devices Inc.	Oct. 1986	3	$ 3.9M	Alan Patricof Assoc.; Partners; Brentwood Assoc.; Dougery, Jones & Wilder; Edelson Technology; Hook Partners; InnoVen Group; John Hancock Ventures; Lambda Fund; Merrill Lynch Venture; Oxford Partners; J.F. Shea & Co.; Xerox
Cirrus Logic Inc.	Nov. 1986	3	$ 4.5M	Brentwood Assoc.; Institutional Venture Partners; Kuwait & Middle East Financial; Nazem & Co.; New Enterprises Assoc.; NY Life Insurance; Robertson, Colman & Stephens; Technology Venture
Elantec Inc.	Dec. 1986	4	$ 7.8M	Harvard Mgmt.; Cypress Fund; Morgan-Holland; New England Capital; Riksa Trust; Sequoia Capital; St. James Venture Capital Fund; U.S. Venture Partners; CEI; and others
European Silicon Systems	Nov. 1986	Equity	$ 9.0M	Banque International a Luxembourg; European Investment Bank
Krysalis Corp.	Dec. 1986	1	$ 3.0M	Columbine; Crosspoint Venture Partners; Meadows Resources; OSCCO Ventures
Laserpath Corp.	Dec. 1986	2	$ 4.5M	Crosspoint Venture Partners; Emerging Growth Partners; GE Venture Capital; Wolfensen Assoc.

(Continued)

Table 2 (Continued)

ADDITIONAL START-UP FINANCING

Company	Date	Round	Amount	Sources
Performance Semiconductor Inc.	Nov. 1986	1	$10.0M	Advanced Technology Ventures; Albion Venture Fund; Asset Mgmt.; Brentwood Assoc.; DSV Partners; Harvard Mgmt.; IAI Venture Partners; North Star Ventures; Northwest Venture Capital; Reynolds Creek Ltd. Partnership; L.F. Rothschild, Unterberg Towbin; Taylor & Turner; U.S. Venture Partners; VenWest Partners
Seeq Technology Inc.	Oct. 1986	Private placement post IPO	$ 6.0M	Bridge Capital; GE Venture Capital; Hillman Ventures; John Hancock; Kleiner, Perkins, Caufield & Byers
Sensym Inc.	Aug. 1986	3	$ 1.5M	Becton & Dickinson
Vitesse Electronics Corp.	Feb. 1987	2	$10.0M	Sequoia Capital and others
Xilinx Inc.	Jan. 1987	3	$ 3.4M	Fleming Ventures Ltd.; Hambrecht & Quist; Kleiner, Perkins, Caufield & Byers; Interfirst Venture; Interwest Partners; Matrix Partners; Morgan Stanley; Rainier Venture Partners; Security Pacific Venture Capital; J. H. Whitney

Source: Dataquest
March 1987

COMPANY ANNOUNCEMENTS

Acrian Inc.

Acrian Inc. has named Gary Irvine president and chief operating officer. Jack Harris remains as chairman and chief executive. Mr. Irvine, formerly president of EH Electronics, will be responsible for new products and market expansion as well as possible acquisitions by the company.

Adaptec, Inc.

Adaptec announced plans to open a subsidiary in Singapore in the first quarter of 1987 to manufacture surface mount controllers. The new company, called Adaptec Manufacturing (Singapore) Private Ltd., plans to begin pilot production in April and full production in early summer.

Altera Corporation

Altera entered the military market with its EPLDs, offering the first products to meet Class B specifications of MIL-STD-883 Rev. C--the EP310 and EP1210.

California Devices Inc.

Douglas Ritchie has been elected chairman of the board of CDI in addition to his responsibilities as president and chief executive officer. Wilmer R. Bottoms, the former chairman, has been named vice chairman.

Custom MOS Arrays

Custom MOS Arrays has merged with California Micro Devices (CMD). CMD was incorporated in 1980 to acquire the assets of a thin-film company. No changes in personnel assignments are planned. Handel Jones, formerly president of Custom MOS Arrays, will be the president and chief operating officer of the new combined company.

Cypress Semiconductor Corporation

Cypress announced that it will file a registration statement with the SEC to offer 4,400,000 shares of common stock. The proceeds will be used as working capital and to increase its capital base.

Harris Microwave Semiconductor

Harris Microwave Semiconductor has transferred its CAE tools developed for CMOS digital ASICs in Melbourne, Florida, to its GaAs operation in Milpitas, California. The company has set up a commercial GaAs standard cell operation.

Integrated Device Technology Inc.

Leonard C. Perham, former vice president and general manager of IDT's SRAM Division, has assumed the duties of president and chief operating officer of Integrated Device Technology Inc. John Carey remains as chief executive officer and chairman of the board.

International Microelectronic Products Inc.

Barry Carrington, president, has been promoted to chief executive officer from chief operating officer. Mr. Carrington succeeds George W. Gray, who remains IMP's chairman.

Krysalis Corporation

Franc R.J. deWeeger has joined Krysalis as president and chief executive officer. Joseph T. Evans, who was a Krysalis cofounder and served as the company's president, now becomes vice president of research and engineering. Mr. deWeeger was previously at ASM International, where he served as president since 1984; he remains on the ASM America board of directors. Before that, he spent two years as president of Zilog, Inc.

Lattice Semiconductor Corporation

Lattice announced that Rahul Sud resigned as president and Jay McBride resigned as general manager. C. Norman Winningstad, chairman of the board, is acting CEO. Lattice also announced that Rahul Sud, Jay McBride, S. Robert Breitbarth, and Kishan C. Sud resigned from Lattice's board of directors.

Linear Technology Corporation

LTC has established a Japanese company to strengthen its services to its Japanese customers. The company is called Linear Technology K.K. and is wholly subscribed by the U.S. parent. Robert Swanson has been appointed president, and Atsushi Nakata has been appointed general manager.

LSI Logic Corporation

LSI Logic has reorganized into four strategic business units with separate profit and loss responsibilities. The four units and vice presidents heading them are: Components and Technology, Cy Hannon; Engineering Services, Ven Lee; Software and Computer Services, Jim Koford; and Military/Aerospace, Norm Chanoski. Each of the four vice presidents will report to George Wells; each unit will be supported by decentralized sales, marketing, purchasing, finance, and MIS staff.

LSI Logic also plans to offer part of its European affiliate, LSI Logic Europe, on London's second-tier Unlisted Securities Market (USM). More than 80 percent is owned by the parent company, with the remainder held by local private investors, insurance companies, and other financial interests. The most visible industrial investor in LSI Logic Europe is Sulzer Brothers AG, a Swiss engineering firm.

In West Germany, LSI Logic Europe is building a mass production assembly and test facility in Braunschweig, which will form part of the corporation's worldwide capacity. It should be operational later this year, acting as a subcontractor to the U.S. parent company.

Micron Technology, Inc.

Micron has placed approximately 3,500,000 shares of common stock with certain foreign institutional investors at a price of $4.375 per share in a private placement assisted by Montgomery Securities.

Samsung Semiconductor Inc.

Samsung announced that it is building a new facility in San Jose, California, which will house its headquarters, R&D operations, and research fab. Included in the new 80,000-square-foot facility will be a 12,000-square-foot fab equipped with 6-inch wafer processing equipment.

Seeq Technology Inc.

Monolithic Memories Inc. purchased a 16 percent equity in Seeq Technology for $4 million. The two companies also have agreed to a four-year joint product and technology program to develop CMOS PLDs. Seeq received MIL-STD-883 Rev. C Class B specifications for its products.

Sierra Semiconductor Corporation

Sierra Semiconductor announced Stephen Forte as president of its new European joint venture, Sierra Semiconductor B.V., formed in June 1986 in the Netherlands.

Silicon Systems Inc.

Stephen E. Cooper, formerly senior vice president and general manager of the Microperipheral Division of Silicon Systems, succeeds Carmelo J. Santoro as president and chief operating officer. Mr. Santoro remains as chairman and chief executive officer.

Telmos Inc., Universal Semiconductor Inc., and Zytrex

Investment Management International Inc. (IMI), the finance group that acquired Zytrex last spring, has acquired Universal Semiconductor and the assets and product rights of Telmos Inc.

Vitesse Electronics Corp.

The Vitesse Electronics' Integrated Circuit Division raised $10 million and is now an independent company, called Vitesse Semiconductor Corporation. Dr. Louis R. Tomasetta, former president of the IC Division, is president and CEO of the new company. Vitesse Semiconductor will remain in the 70,000-square-foot existing facility and will use the new funding to develop additional products and expand into higher-volume production.

VLSI Technology, Inc.

VLSI Technology's Government Products Division in Phoenix, Arizona, has been certified for production of devices that are fully compliant with MIL-STD-883C.

VLSI Technology completed the acquisition of Visic, Inc. Visic will maintain its own board of directors, which will include members of both Visic and VLSI Technology. Products designed and developed by Visic will be manufactured in the VLSI Technology facility and marketed under the VLSI name.

VLSI Technology's ASIC operation is now a separate division, joining the memory, logic, and government divisions. Former vice president of design and technology, Douglas G. Fairbairn, has been promoted to the new position of vice president and general manager of the new ASIC Division. He will continue to report to both chairman Alex Stein and president Henri Jarrat.

Xicor, Inc.

Xicor announced that it has completed MIL-STD-883C Class B qualification for its X28256 EEPROM device. This qualification affects all versions of the X28256 in the 32-pad leadless chip carriers.

Table 3 lists some recent alliances involving start-up companies.

Penny Sur

Table 3

ALLIANCES INVOLVING START-UP COMPANIES

Company	Date	Comments
Altera WaferScale Sharp	Jan. 1987	Altera and WSI agreed to a 5-year technology exchange to develop new user-configurable logic products; Sharp will manufacture the products using WSI's process.
Chips Ascii Corp.	Sept. 1986	Chips & Technologies and Ascii, a major software company in Japan, will start a new company to develop communication products. Chips will design the products; manufacturing will be done by companies in Japan. Chips and Ascii will hold equal shares of the majority interest in the new venture.
Chips NSC	Nov. 1986	National Semiconductor will second source Chips & Technologies CMOS ICs in exchange for fabrication services. National is Chips' first U.S. source.
Cirrus Logic Silicon Systems	Oct. 1986	Cirrus Logic and Silicon Systems will exchange controller and buffer manager functions and mutually second source the ASICs. Both chips will be processed in 2-micron CMOS.
Crystal Asahi Chemical	Jan. 1987	Asahi Chemical acquired an 8 percent share in Crystal Semiconductor for about $4 million. Asahi will provide foundry services in exchange for a license to all of Crystal's existing products and to be its principle distributor in the Far East. Both companies will develop new products.
Custom Silicon NCR	Feb. 1987	NCR has licensed CSi's standard cell library, including 342 TTL macrocells and microcomputer building blocks of up to 5,863 gates. CSi's library was built from NCR's existing library, which CSi licensed.

(Continued)

Table 3 (Continued)

ALLIANCES INVOLVING START-UP COMPANIES

Company	Date	Comments
ES2 N.V. Philips TI	Feb. 1987	Texas Instruments Ltd. of England and Philips International N.V. will offer accelerated prototyping for the SystemCell Library of standard cells in cooperation with ES2. The SystemCell Library is the result of a collaborative relationship between TI and Philips who provide high volume manufacturing and standard prototyping.
ICT Asahi Chemical	Jan. 1987	Asahi Chemical Industry will receive technology from ICT (International CMOS Technology) and will also market its EEPROMs.
IDT VTC, Inc.	Jan. 1987	VTC will second source Integrated Device Technology's FCT product line of TTL-compatible CMOS logic devices.
iLSi Sumitomo Corp.	Dec. 1986	Sumitomo licensed ASIC design technology from Integrated Logic Systems Inc. (iLSi); in addition to royalty payments, iLSi has gained rights to use any foundries Sumitomo uses.
IMP Micro Linear MBB	Aug. 1986	International Microelectronic Products and Micro Linear have agreed to transfer ASIC design know-how to Messerschmitt-Bolkow-Blohm GmbH over a three-year period.
Lattice SGS	Feb. 1987	Lattice Semiconductor signed a technology agreement with SGS Semiconductor, giving SGS a license to second source Lattice's GAL products. SGS will manufacture GAL products for Lattice, and both companies will cooperate on the design of future PLD products.
Seeq MMI	Nov. 1986	Monolithic Memories purchased a 16 percent equity in Seeq for $4 million. The companies also agreed to a 4-year joint product and technology program to develop CMOS PLDs.

(Continued)

Table 3 (Continued)

ALLIANCES INVOLVING START-UP COMPANIES

Company	Date	Comments
Seeq Motorola	Dec. 1986	Seeq and Motorola agreed to work on a multimillion-dollar EEPROM technology project.
XTAR Fairchild	Sept. 1986	Fairchild agreed to second source XTAR's 2-chip set graphic MPU.

Source: Dataquest
March 1987

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Research Newsletter

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JAPANESE SEMICONDUCTOR MARKET QUARTERLY UPDATE: RECOVERY IN 1987

SUMMARY

Due to a better-than-expected third quarter 1986 semiconductor market in Japan, we have revised our 1986 forecast up slightly, to a positive 1.8 percent growth in yen (44.9 percent growth in dollars).

In our forecast, we have used actual quarterly exchange rates for 1986: ¥188, ¥170, ¥156, and ¥160 per dollar, respectively. The fourth quarter exchange rate of ¥160 is carried forward through the eight quarters of 1987 and 1988.

The yen/dollar exchange rate was fairly stable throughout the fourth quarter of 1986; however, in mid-January the dollar began to fall again after President Reagan indicated that a still-lower dollar was needed to lower the U.S. trade deficit. Any prolonged fall of the dollar below the ¥160 mark will significantly alter the dollar growth rates of our forecast. In addition, further rises in the value of the yen will push already hard-pressed Japanese exporting firms to cut costs even more than they already have; this could impact our yen forecast downward either by pushing more semiconductor consumption offshore to Asia and the United States or by eliminating a portion of the end-equipment market as a result of higher consumer prices for Japanese electronics.

A comparison of Figures 1 and 2 shows the effect of the ascending yen on 1986 quarterly growth rates. Figure 1 shows quarter-to-quarter percent growth in yen for the Japanese semiconductor market from the first quarter of 1986 through the fourth quarter of 1988. Figure 2 presents the same data in dollars.

FORECAST

Our quarterly forecast, in both yen and dollars, is shown in Tables 1 through 4.

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We expect 1987 to be healthier than 1986 in Japan. We believe that electronic equipment production will be up around 5 percent in yen above 1986; semiconductor growth will be almost twice that rate, at 9 percent. We expect semiconductor growth to be much better in 1988, at 19 percent.

We believe that the adjustment to the high yen will continue for the first two quarters of 1987; therefore, we forecast low consumption growth in those quarters.

There is still overcapacity in the industry, and this, combined with a desire to lower per unit production costs, continues to provide impetus to sell as much as possible at low prices. Therefore, we believe that competitive pricing pressures will continue unabated through the first two quarters of 1987.

MITI is under intense pressure from the U.S. government to prevent Japanese firms from selling memories below the assigned foreign market value (FMV) prices both in third countries and in Japan. The FMVs are now at their lowest levels yet; however, there is considerable skepticism within the industry as to whether or not the U.S.-Japan Semiconductor Trade Arrangement will last out the year. Therefore, we do not expect the trade agreement to have too much effect on semiconductor consumption in Japan.

DATAQUEST CONCLUSIONS

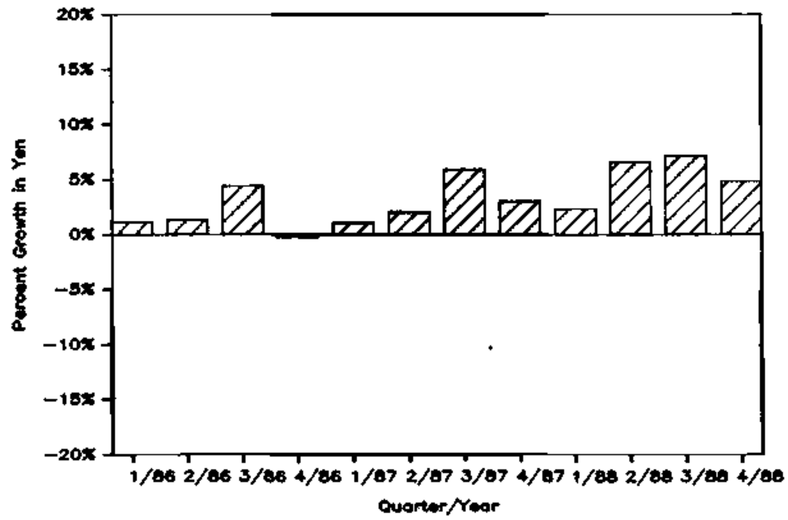
The Japanese market surpassed the U.S. market as the world's largest semiconductor market for the first time in 1986. However, much of this growth is due to the dramatic ascent of the yen against the dollar. While the market grew almost 45 percent in dollars, it grew less than 2 percent in yen.

Japan's industry and economy are going through now what the United States has been experiencing since the early 1980s: increased competition from abroad (the newly industrializing countries), rising unemployment, and a sluggish economy. If Japanese unemployment were measured in the same way as U.S. unemployment, it is estimated that the unemployment rate would be more than 5 percent; as it is measured, it is less than 3 percent. The presence in Japan of a strong Ministry of International Trade and Industry to guide corporations should help Japanese industry to cope with the new conditions in which it finds itself. We continue to believe in the underlying strength of the Japanese market for semiconductor consumption, and we believe that 1987 and 1988 will be growth years for the industry.

Mark Giudici
Patricia S. Cox

Figure 1

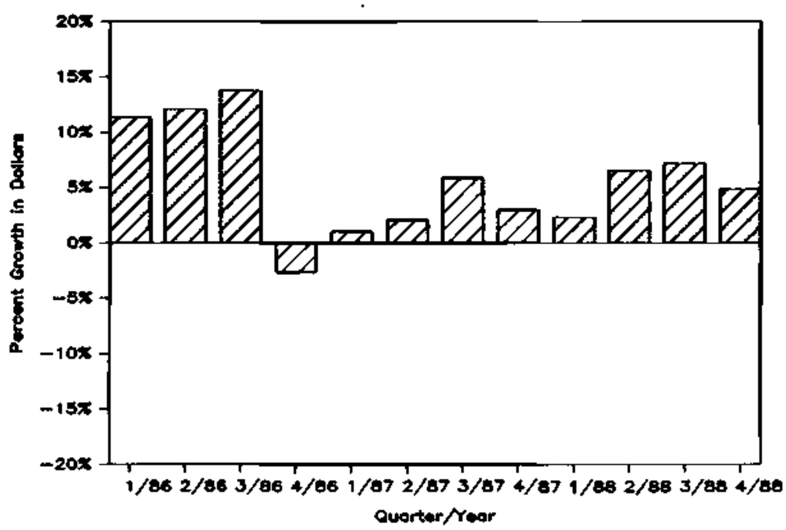
JAPANESE SEMICONDUCTOR MARKET
ESTIMATED QUARTER-TO-QUARTER GROWTH IN YEN



Source: Dataquest
January 1987

Figure 2

JAPANESE SEMICONDUCTOR MARKET
ESTIMATED QUARTER-TO-QUARTER GROWTH IN DOLLARS



Source: Dataquest
January 1987

Table 1

JAPANESE SEMICONDUCTOR CONSUMPTION
(Percent Change in Terms of Yen)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	1.1%	1.4%	4.4%	(0.2%)	1.8%
Total IC	2.3%	1.9%	4.9%	0.9%	2.7%
Bipolar Digital	(1.0%)	6.3%	0.9%	3.6%	(2.8%)
Memory	0	3.1%	0	1.5%	(12.0%)
Logic	(1.1%)	6.8%	1.0%	3.9%	(1.4%)
MOS	5.2%	0.7%	7.6%	1.9%	2.5%
Memory	1.9%	2.3%	2.4%	2.5%	(12.3%)
Micro Device	6.7%	(5.9%)	10.2%	0.4%	19.2%
Logic	7.1%	5.0%	10.1%	2.5%	6.1%
Linear	(1.0%)	1.9%	2.3%	(2.0%)	5.5%
Discrete	(4.1%)	(0.1%)	4.0%	(5.8%)	(4.6%)
Optoelectronic	2.7%	(0.6%)	(1.0%)	2.3%	11.3%

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	1.1%	2.0%	5.9%	3.0%	9.0%
Total IC	1.3%	2.4%	7.1%	3.7%	11.6%
Bipolar Digital	4.0%	3.7%	5.1%	2.4%	15.4%
Memory	1.4%	4.2%	5.4%	3.8%	17.9%
Logic	5.2%	4.6%	3.0%	1.0%	15.1%
MOS	2.9%	3.1%	9.6%	5.3%	17.9%
Memory	6.1%	9.9%	11.1%	7.6%	14.8%
Micro Device	7.8%	9.7%	12.0%	7.2%	18.2%
Logic	6.0%	8.0%	6.0%	6.2%	20.4%
Linear	(3.0%)	0.5%	3.0%	0.9%	(0.9%)
Discrete	1.4%	2.3%	2.1%	2.0%	(1.4%)
Optoelectronic	2.3%	1.3%	1.3%	0.9%	4.2%

	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	2.3%	6.6%	7.2%	4.8%	19.0%
Total IC	2.6%	7.8%	8.1%	5.8%	22.6%
Bipolar Digital	6.0%	4.5%	5.0%	5.2%	19.8%
Memory	1.2%	0	6.0%	0	10.3%
Logic	6.6%	5.1%	4.8%	5.9%	21.1%
MOS	2.3%	10.7%	10.6%	7.5%	29.9%
Memory	2.2%	20.4%	13.4%	7.6%	43.1%
Micro Device	1.0%	2.3%	7.9%	4.8%	19.6%
Logic	3.3%	9.0%	10.0%	9.5%	27.1%
Linear	1.7%	3.1%	3.9%	1.6%	9.0%
Discrete	0.5%	1.1%	1.5%	0.1%	2.8%
Optoelectronic	3.0%	3.6%	7.4%	1.6%	13.1%

Source: Dataquest
January 1987

Table 2

JAPANESE SEMICONDUCTOR CONSUMPTION
(Billions of Yen)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	504.9	511.8	534.4	533.5	2,084.6
Total IC	385.6	392.8	412.2	415.9	1,606.5
Bipolar Digital	52.1	55.4	55.9	57.9	221.3
Memory	6.4	6.6	6.6	6.7	26.3
Logic	45.7	48.8	49.3	51.2	195.0
MOS	209.8	211.3	227.3	231.6	880.0
Memory	68.8	70.4	72.1	73.9	285.2
Micro Device	65.6	61.7	68.0	68.3	263.6
Logic	75.4	79.2	87.2	89.4	331.2
Linear	123.7	126.1	129.0	126.4	505.2
Discrete	88.5	88.4	91.9	86.6	355.4
Optoelectronic	30.8	30.6	30.3	31.0	122.7
Exchange Rate (yen/dollar)	188.0	170.0	156.0	160.0	167.0

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	539.2	550.2	582.6	599.9	2,271.9
Total IC	421.2	431.5	462.0	478.9	1,793.6
Bipolar Digital	60.2	62.4	65.6	67.2	255.4
Memory	7.2	7.4	8.2	8.2	31.0
Logic	53.0	55.0	57.4	59.0	224.4
MOS	238.4	245.9	269.5	283.7	1,037.5
Memory	74.4	76.2	85.8	91.0	327.4
Micro Device	70.7	73.4	81.3	86.1	311.5
Logic	93.3	96.3	102.4	106.6	398.6
Linear	122.6	123.2	126.9	128.0	500.7
Discrete	87.0	87.2	88.0	88.2	350.4
Optoelectronic	31.0	31.5	32.6	32.8	127.9
Exchange Rate (yen/dollar)	160.0	160.0	160.0	160.0	160.0

	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	613.9	654.2	701.1	734.9	2,704.1
Total IC	491.5	529.6	572.6	605.7	2,199.4
Bipolar Digital	71.2	74.4	78.1	82.2	305.9
Memory	8.3	8.3	8.8	8.8	34.2
Logic	62.9	66.1	69.3	73.4	271.7
MOS	290.1	321.0	355.0	381.7	1,347.8
Memory	93.0	112.0	127.0	136.6	468.6
Micro Device	87.0	89.0	96.0	100.6	372.6
Logic	110.1	120.0	132.0	144.5	506.6
Linear	130.2	134.2	139.5	141.8	545.7
Discrete	88.6	89.6	90.9	91.0	360.1
Optoelectronic	33.8	35.0	37.6	38.2	144.6
Exchange Rate (yen/dollar)	160.0	160.0	160.0	160.0	160.0

Source: Dataquest
January 1987

Table 3

JAPANESE SEMICONDUCTOR CONSUMPTION
(Percent Change in Terms of Dollars)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	11.4%	12.1%	13.7%	(2.6%)	44.9%
Total IC	12.7%	12.7%	14.3%	(1.6%)	46.3%
Bipolar Digital	9.1%	17.7%	9.8%	1.1%	38.8%
Memory	9.7%	14.7%	7.7%	0.0%	25.6%
Logic	9.0%	18.1%	10.1%	1.3%	40.8%
MOS	15.9%	11.4%	17.2%	(0.6%)	46.4%
Memory	12.3%	13.1%	11.6%	0.0%	25.9%
Micro Device	17.5%	4.0%	20.1%	(2.1%)	68.3%
Logic	17.9%	16.2%	20.0%	0.0%	52.0%
Linear	9.0%	12.8%	11.5%	(4.5%)	49.5%
Discrete	5.6%	10.4%	13.3%	(8.1%)	35.4%
Optoelectronic	13.1%	9.8%	7.8%	0.0%	57.1%
	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	1.0%	2.0%	5.9%	3.0%	14.0%
Total IC	1.2%	2.5%	7.0%	3.7%	16.7%
Bipolar Digital	3.9%	3.7%	5.1%	2.4%	20.6%
Memory	7.1%	2.2%	10.9%	0.0%	22.9%
Logic	3.4%	3.9%	4.4%	2.8%	20.3%
MOS	2.9%	3.2%	9.6%	5.3%	23.2%
Memory	0.6%	2.4%	12.6%	6.2%	20.1%
Micro Device	3.5%	3.8%	10.7%	5.9%	23.6%
Logic	4.3%	3.3%	6.3%	4.1%	25.5%
Linear	(3.0%)	0.5%	3.0%	0.9%	3.7%
Discrete	0.6%	0.2%	0.9%	0.2%	3.3%
Optoelectronic	0.0%	1.5%	3.6%	0.5%	9.3%
	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	2.3%	6.6%	7.2%	4.8%	19.0%
Total IC	2.6%	7.7%	8.1%	5.8%	22.6%
Bipolar Digital	6.0%	4.5%	4.9%	5.3%	19.8%
Memory	2.0%	0.0%	5.8%	0.0%	10.9%
Logic	6.5%	5.1%	4.8%	6.0%	21.0%
MOS	2.3%	10.6%	10.6%	7.5%	29.9%
Memory	2.1%	20.5%	13.4%	7.6%	43.2%
Micro Device	1.1%	2.2%	7.9%	4.8%	19.6%
Logic	3.3%	9.0%	10.0%	9.5%	27.1%
Linear	1.8%	3.1%	3.9%	1.6%	9.0%
Discrete	0.5%	1.1%	1.4%	0.2%	2.8%
Optoelectronic	2.9%	3.8%	7.3%	1.7%	13.0%

Source: Dataquest
January 1987

Table 4

JAPANESE SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	2,686	3,011	3,425	3,335	12,457
Total IC	2,051	2,311	2,642	2,600	9,604
Bipolar Digital	277	326	358	362	1,323
Memory	34	39	42	42	157
Logic	243	287	316	320	1,166
MOS	1,116	1,243	1,457	1,448	5,264
Memory	366	414	462	462	1,704
Micro Device	349	363	436	427	1,575
Logic	401	466	559	559	1,985
Linear	658	742	827	790	3,017
Discrete	471	520	589	541	2,121
Optoelectronic	164	180	194	194	732
Exchange Rate (yen/dollar)	188	170	156	160	167

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	3,370	3,439	3,641	3,749	14,199
Total IC	2,632	2,697	2,887	2,993	11,209
Bipolar Digital	376	390	410	420	1,596
Memory	45	46	51	51	193
Logic	331	344	359	369	1,403
MOS	1,490	1,537	1,684	1,773	6,484
Memory	465	476	536	569	2,046
Micro Device	442	459	508	538	1,947
Logic	583	602	640	666	2,491
Linear	766	770	793	800	3,129
Discrete	544	545	550	551	2,190
Optoelectronic	194	197	204	205	800
Exchange Rate (yen/dollar)	160	160	160	160	160

	Q1/88	Q2/88	Q3/88	Q4/88	1988
Total Semiconductor	3,837	4,089	4,382	4,594	16,902
Total IC	3,072	3,310	3,579	3,786	13,747
Bipolar Digital	445	465	488	514	1,912
Memory	52	52	55	55	214
Logic	393	413	433	459	1,698
MOS	1,813	2,006	2,219	2,386	8,424
Memory	581	700	794	854	2,929
Micro Device	544	556	600	629	2,329
Logic	688	750	825	903	3,166
Linear	814	839	872	886	3,411
Discrete	554	560	568	569	2,251
Optoelectronic	211	219	235	239	904
Exchange Rate (yen/dollar)	160	160	160	160	160

Source: Dataquest
January 1987

SUIS Code: Newsletters
1987-4

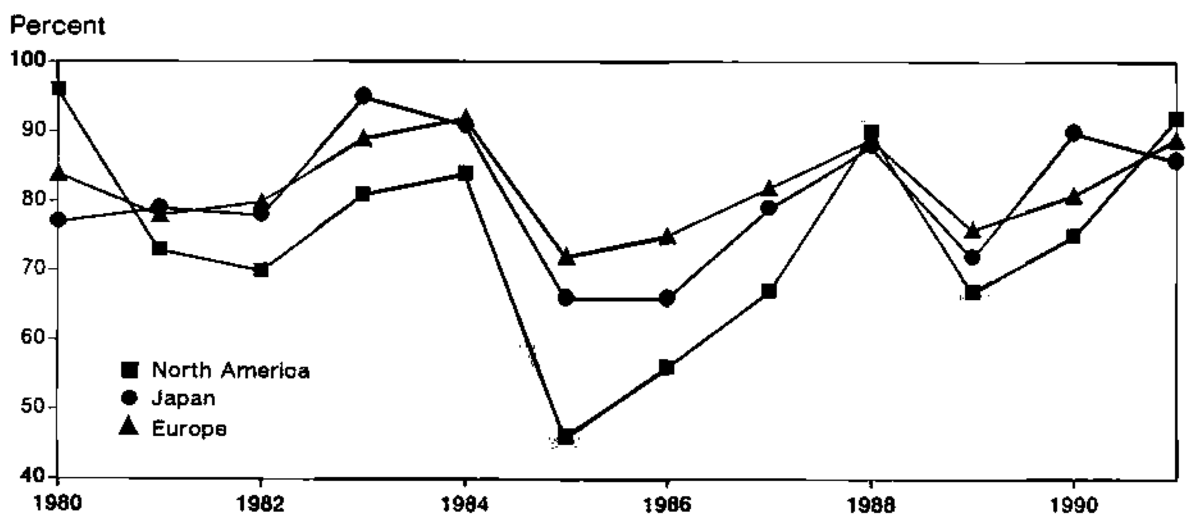
FIRST QUARTER PRICE UPDATE: AT THE BOTTOM LOOKING UP

OVERVIEW

The results of our latest price survey show that although prices continue to decline, the effects of capacity absorption will begin by midyear 1987. Initially, lead times will begin to stretch out; first in standard logic parts, then memory and microprocessors. As lead times increase, price reductions will slow and in many cases reverse as prices are forecast to rise in many areas in 1988. A look at the worldwide capacity situation (see Figure 1) quickly explains how capacity shortages will soon be affecting pricing. The current trend to reduce vendors in exchange for timely shipments of quality products will be tested during the next 18 months. Existing long-term relationships need to be reinforced now to ensure smooth supplies as business turns up.

Figure 1

ESTIMATED CAPACITY UTILIZATION



Source: Dataquest
March 1987

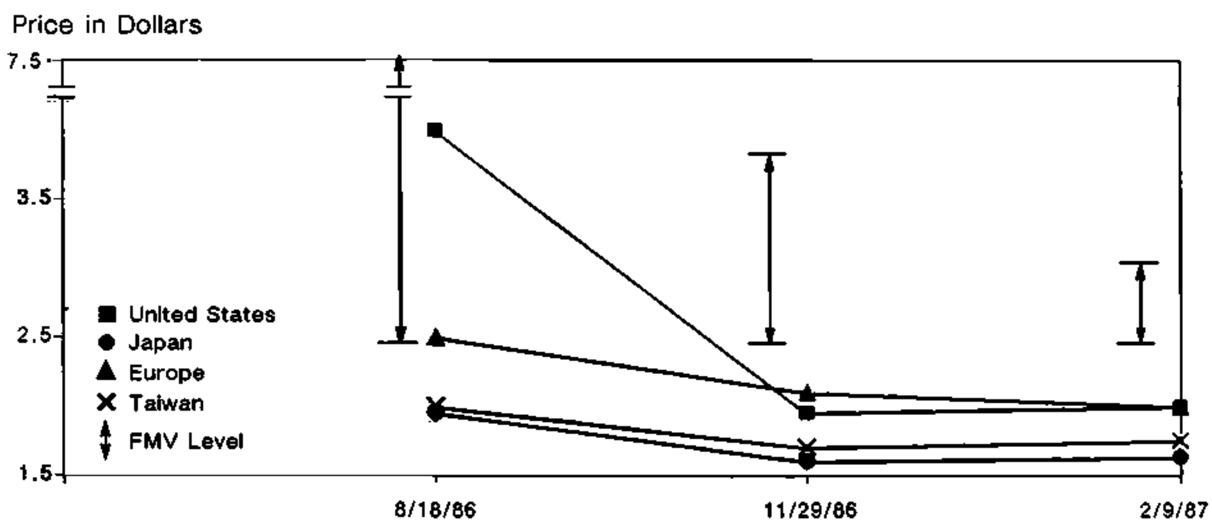
Dataquest Incorporated, a company of The Dun & Bradstreet Corporation
1290 Ridder Park Drive / San Jose, CA 95131-2398 / (408) 971-9000 / Telex 171973

SEMICONDUCTOR AGREEMENT

The effects of the U.S.-Japan Semiconductor Trade Arrangement have primarily affected Japanese memory sales in the United States by raising official Japanese prices--foreign market values (FMVs)--for these products. Nonaffected manufacturers (U.S., Korean, and European) of these products and the quasi-legal grey market of surplus parts sold through brokers have effectively been able to sell below the lowest Japanese FMV levels, thus lowering the average price for affected memories. The FMVs have been a stabilizing influence in the memory market, but the continued multitiered pricing has currently jeopardized the trade agreement. Some of the options that are being considered by the U.S. DOC are to impose tariffs on Japanese components and/or systems or to require a set percentage of domestic content in export products. Whether these options or others are used as is or as bargaining chips to require adherence to the agreement will result in generally higher-priced Japanese memory products in the United States. Prices in the Far East have traditionally been low if not the lowest in the world. Dumping may not be the only reason that prices in the eastern Pacific Rim countries are lower; their business practices do not require the same profit margins needed in the United States and Europe. We continue to foresee a differential in prices between the United States, Far East, and Europe that has existed throughout the agreement as shown in Figure 2.

Figure 2

SEMICONDUCTOR AGREEMENT EFFECTS
REGIONAL 256K DRAM PRICING



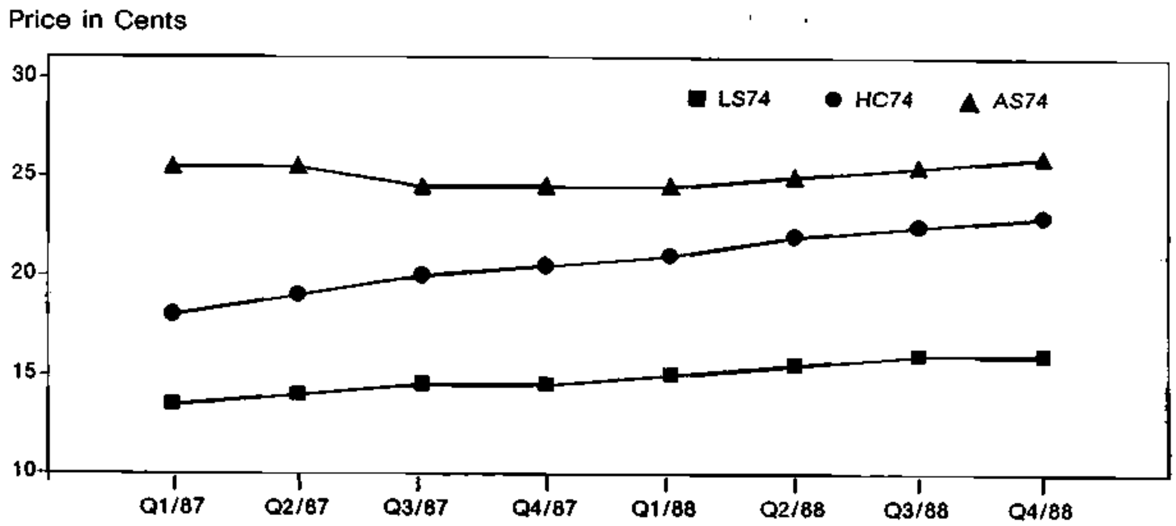
Source: Dataquest
March 1987

LOGIC TRENDS

Figure 3 shows the overall trend of stabilized to rising prices beginning in the second quarter of this year for comparative devices in different technologies. As mentioned earlier, as capacity utilization picks up, lead times and prices begin to rise reflecting the supply and demand of the market. Underlying growth of 24 percent and 27 percent in 1987 and 1988, respectively, will fuel this trend of lengthened lead times and higher prices.

Figure 3

U.S. STANDARD LOGIC PRICE TRENDS



Source: Dataquest
March 1987

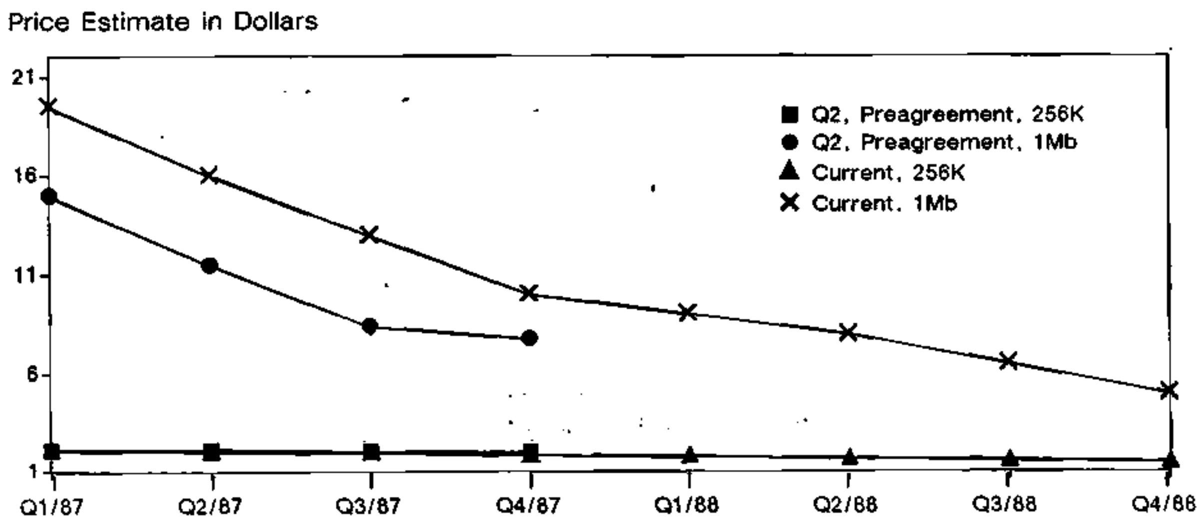
MEMORY TRENDS

Price trends have settled down to the point where 256K DRAM price trends have come into line with our pre-agreement estimates. FMV levels do not appear to have influenced prices beyond the second half of 1986. Rather, they have lent a stabilizing influence to a traditionally volatile market. One-megabit DRAM pricing has been influenced by the agreement as seen in Figure 4. Price trends have been shifted out by three to six months for this part as stabilization in the 256K market has affected 1Mb DRAM prices. The 5X crossover point is expected to occur in the fourth quarter of this year.

Other memory devices have shown relative stability, but some SRAM and EPROM prices have come down since our last survey. Despite the attention from the DOC, these two areas continue to receive strong competitive pricing from domestic and foreign vendors. ROMs and EEPROMs continue to come down in price, but the reduction rate is relatively unchanged.

Figure 4

U.S. DRAM PRE- AND POST-AGREEMENT PRICE COMPARISON



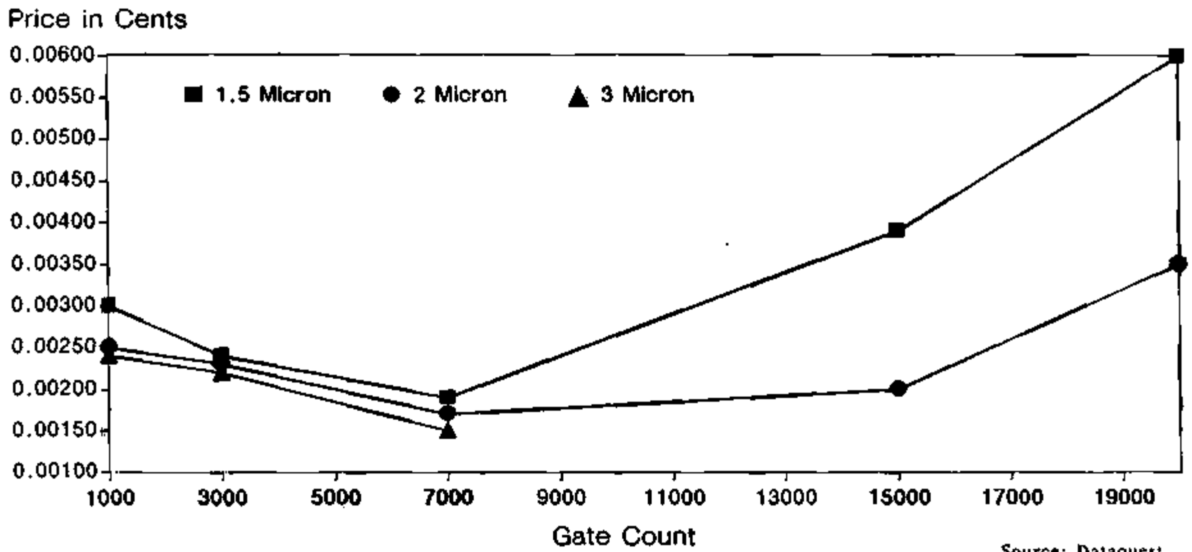
Source: Dataquest
March 1987

ASIC TRENDS

Price-per-gate differentials between technologies for gate arrays continue to narrow in the low-density range (see Figure 5). This is mainly due to the high demand for the low-density arrays as more and more "glue logic" is consolidated using this technique. The two-micron technology continues to be the price/performance leader, but prices per gate of the 1.5-micron arrays continue to put pricing pressure here.

Figure 5

1987 GATE ARRAY PRICE TRENDS
DIE PRICE PER GATE



Source: Dataquest
March 1987

Cell-based design pricing continues to be relatively stable. Programmable logic devices (PLDs) have shown some price erosion in the CMOS electrically erasable devices with prices settling in the sub-$5.00 range for below 25-pin-count parts. ECL PLD availability has increased and prices continue their experience-curve based declines. Currently, prices for ECL PLDs range between $15.50 and $28.00 depending on speed.

DATAQUEST OUTLOOK AND RECOMMENDATIONS

As the industry continues to grow at a gradual rate, the inevitable absorption of existing capacity will begin being felt in longer lead times and flat-to-rising prices by the third quarter. Now is a good time to secure long-term contractual pricing (if it has not been done already) as the cycle begins to pick up. The current buyer's market will soon come into balance and it will be the long-term buyer-vendor relationships that will best be served as supplies become scarce. The current growth cycle is not being fueled by a specific rising star product, but rather a more sustained enhancement or replacement of existing products that promises gradual if not meteoric growth.

Quasi-regulated pricing will most likely result in being a stabilizing factor in this volatile market and not the "official" price set under governmental aegis. Even though MITI has requested production cutbacks, the combination of current ample supply and the maturing of the industry will continue to put pressure on commodity-memory prices for the next three to six months, regardless of the intentions of political planners. While price ranges now do not carry much importance in the market, the combination of gradual growth and stable pricing can prevent the scale and extent of the 1989 anticipated downturn.

Current overall price trends reflect the beginning of increased order rates, if not levels. Prices are still heading down, but at a slower rate. Some product prices have already flattened. Lead times have stabilized while capacity becomes absorbed. The four- to six-month training lag time needed for capacity to come on-line has not yet begun for the major semiconductor manufacturers, so as demand continues, lead times can be expected to lengthen before they improve. Keeping in line with current vendor-reduction programs is the need for supplies to be balanced from different regions of the world where applicable. The logistic resources needed for a balance of domestic and offshore sourcing must be carefully thought out, but a balance of supply can be used to advantage in the current market climate.

Mark Giudici

SUIS Code: Newsletters
1987-3

DATAQUEST'S USER CONFERENCE REVIEWS PARTNERING OPPORTUNITIES IN THE GLOBAL ELECTRONIC INDUSTRY

SUMMARY

Dataquest's third annual conference for semiconductor users was held at the Saddlebrook Golf and Tennis Resort in Tampa, Florida, from February 4 to 6. Managers from major electronics and semiconductor manufacturing companies spent three days exchanging their views on the current industry environment and its impact on both industries. Companies represented included major participants from both industries.

Electronic Manufacturers	Semiconductor Manufacturers
AT&T	Fujitsu
Apple Computer	Hitachi
Digital Equipment	IDT
Eastman Kodak	MMI
Emerson Electric	National
Ford	RCA
General Motors	Siemens
Hewlett-Packard	Texas Instruments
Honeywell	Thomson
IBM	
Motorola	
NCR	
Northern Telecom	
Olivetti	
Tektronix	
Teradyne	

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The conference was sponsored by Dataquest's Semiconductor User Information and Semiconductor Application Markets services. The theme was "Partnering in a Global Economy." The conference was organized into four segments:

- Global issues
- Manufacturing strategies
- Customer/vendor relationships
- Dataquest view of industry trends

SPEAKER HIGHLIGHTS

We have summarized each speaker's key points. These speeches provided a variety of perspectives of the industry "in the trenches," where the current focus is in the current global economic battles. The conference agenda is attached for your information.

Global Issues

Impact of the Global Electronics Industry
Fred Zieber, Dataquest

The electronics industry has entered an era of global competition where technology is widely available and many aggressive competitors pursue the available markets. This has created an environment in which computers have become commodities. Alliances have become widely used to achieve competitive advantage and to marshal resources in the slower-growing worldwide markets. Trade issues and protection of intellectual property have complicated the market structures for both customers and their suppliers. Companies that are to compete effectively in the global economy must be world class, adopting worldwide procurement and marketing strategies and effectively using partnerships with their suppliers to remain competitive.

Programs for Competing Internationally
Brad Kroha, Motorola

Global competitors are rapidly switching from conventional purchasing methods to a better approach--supply management. Supply management focuses resources on fewer suppliers in a win-win partnership environment. Supply managers focus on the entire line of supply, looking for the best-in-class suppliers. A major goal of the program is to build supplier expertise into new products. Supply managers also work with suppliers to compress supply lead times in order to improve the responsiveness of the entire supply line to shifts in customer needs.

Supply management is facilitated through commodity management teams. These teams consist of personnel from purchasing, engineering, manufacturing, and other necessary groups. The job of the commodity management team is to set levels of supplier performance in an effort to reduce the supplier base to those best-in-class suppliers who can contribute to the customer's long-term success in the market.

Japanese Perspective on Partnering
Kosei Nomiya, Hitachi

Customer/vendor relationships are an extension of the relationship between a company and its employees. Each is a long-term agreement to achieve mutual goals. As part of this agreement, the supplier is expected to provide the customer with a better product at a lower price and with superior service. In addition, the supplier is expected to accept part of the responsibility for achieving the customer's goal.

One excellent example of this is observed in quality circle teams, which include members from both the customer and the supplier. These teams review incoming inspection, factory floor data, and field data to cooperatively determine how to improve product quality.

In this environment, both parties see themselves as a crew aboard a ship together. If the ship begins to sink, they all act together to save it.

A U.S. Perspective on Partnering
Doug Newman, National Semiconductor

There are three types of customer/vendor relationships among U.S. companies, all of which may be viewed as partnerships at different levels. A buyer/seller or deal-based relationship generally is built around mutual respect of the sales engineer and the buyer, based upon vendor competitiveness and a track record of customer support. The positioning partnership involves confidence in vendor support and technology resulting in a higher-level management relationship and use of existing vendor proprietary products. Partnerships are total commitments based upon mutual trust and mutually beneficial technology and service relationships. In these relationships, the customer and supplier openly examine each other's strengths and needs and identify opportunities for mutual competitive benefit. These relationships require interdependency, long-term commitment, and contributions by both parties. Typically, customers and suppliers can only undertake a limited number of these types of partnerships, but their benefits accrue across the industry. True partnerships require less effort per dollar of sales produced and generally produce greater profits for both parties.

The Benefits of Lead-Time Reduction
Phil Thomas, Thomas Group

The demands of the current global competition require shorter development cycles and improved responsiveness to customer needs. Total corporate cycle time is the key to achieving these thrusts. The service benefits of short cycle times are well known and are being exercised by major customers with their suppliers. A second and less well-understood impact of shortened cycle times is the impact on vendor cost. Experience cost curves are driven by cycles of learning, rather than simple cumulative unit volume. One cycle of learning is the number of days per manufacturing cycle. If a vendor can double the number of cycles of learning for a given production volume, he can move from a 70 percent experience curve to a 60 percent curve, reducing costs at a faster rate than a competitor with a longer manufacturing cycle. This cost improvement coupled with the service benefit can significantly enhance the customer's competitive position.

U.S. Japanese Trade Agreement: Progress Report
Gil Kaplan, U.S. Department of Commerce

Progress by the Japanese government on implementing the trade agreement has been far slower than we expected. MITI's first steps were taken on September 20, seven weeks after the signing of the agreement, when it established a monitoring office and requested Japanese companies not to sell in third countries below cost. Actual monitoring did not start until October 1, using unverified cost figures. They did change export licensing requirements to shipments valued at ¥50,000 down from ¥1 million, effective January 1987.

Japan has made an effort to enhance access to the six largest semiconductor users in Japan, which represent less than 40 percent of the Japanese market. In the last consultation, they agreed to extend these efforts to the top 55 users, which account for most of Japanese semiconductor consumption.

The U.S. government is monitoring prices in third markets very carefully during the next one to two months. If we do not see improvement, we have told Japan that we reserve the right to revert to the dumping penalties that have already been set. MITI and the Japanese government must work to build a consensus to support this agreement, or the U.S. Congress is likely to pass very protectionist legislation that may not benefit either country.

Manufacturing Strategies

Automation's Role in Competition

Dave Penning, Dataquest

Modern manufacturing operations include both the product development and the fabrication function. Successful factory automation requires that companies break down the walls between engineering and production. Automated factories evolve from hand assembly operations to automatic equipment to intelligent factories by progressive application of electronic controls, computerization, and incorporation of sensor technology.

Automation of design, production, and information can produce substantial benefits in reducing design cycle time and costs, inventories, and production lead times, while increasing factory capacity, yield, equipment utilization, and effective sharing of information and decision support. Automated factories will be smaller and will require fewer workers with specific knowledge to operate them.

Modern factories will require substantial investment, new manufacturing methods, and complex implementation. Successful implementation of automation will be necessary to survive in the global competitive environment.

A Worldwide Manufacturing Strategy

Hal Edmondson, Hewlett-Packard

Hewlett-Packard has defined a corporate manufacturing strategy that guides decisions about its manufacturing operations worldwide. Implementation of this strategy leads Hewlett-Packard to establish international activities when it is appropriate to do so.

The advantages of international activities include satisfying market access requirements. They also take advantage of lower operating costs, business incentives, and a broader knowledge base. A number of disadvantages also exist, including duplication of people and equipment, extended lines of control, and purchasing start-up costs.

Hewlett-Packard's approach of including purchasing, manufacturing, and R&D at most facilities has proven to be a successful one for an international corporation.

IBM's New Austin Facility--A Perspective on Automation
Clark Preston, IBM

IBM's Automated Logistics and Production System, called ALPS, is a state-of-the-art flexible automated manufacturing facility. Products produced in this facility are designed for simplified automated assembly. For example, a product comparable to a Selectric typewriter today is assembled from 52 components (a PC card is one of them). The original Selectric had 3,000 parts.

IBM's ALPS has evolved over several years, starting with a vehicle (the Displaywriter) using "islands of automation." This was used as a base project for identifying those characteristics required for automated assembly of a product, and ultimately for designing a product and building a fully automated manufacturing system. ALPS has not yet reached the ultimate level of automation, but continues to be refined and improved as manufacturing technology improves.

The Role of Contract Manufacturing
Gene Sapp, SCI Systems, Inc.

The growth of contract manufacturing has been stimulated by intense competition in the marketplace, shortened product life cycles, asset and capital management considerations, rapidly changing manufacturing technologies, users' demands for quality, and multinational market opportunities. The number of users of contract manufacturing services is growing rapidly as market pressures tighten, technology changes, and the benefits are appropriately analyzed.

Contract manufacturers offer more companies access to state-of-the-art manufacturing facilities and high-volume buying power for components. This can make capital resources available to electronics manufacturers to invest a higher-level facility automation.

The successful contract manufacturing operation of tomorrow will offer fully integrated SMT services, including design for producibility. It will be in tune with the latest processes; its automation will be optimized for low cost, high quality and flexibility; and its customers will rely on it for worldwide support in both material acquisition and multinational market penetration.

Customer/Vendor Relationships

Customer/Vendor Relationships--An International Perspective
Bernard Hadley, STACK

STACK is an association of 11 European and U.S. companies that was formed in 1974. Its purpose is to work together to reduce the cost of ownership of semiconductor components by sharing efforts, particularly in the technical, service, and quality areas.

One concern of the members of STACK is the impact of the U.S./Japanese semiconductor trade agreement. They do not believe that there is any long- or short-term benefit to actions that raise prices to customers. Semiconductor tariffs have done nothing to help the European semiconductor industry.

Some of STACK's key objectives in working with suppliers are to facilitate improved vendor performance in quality and service for members, to encourage the use of electronic data interchange and standard packaging and labeling, and to offer realistic pricing. STACK also attempts to achieve common and more effective computerized device models, realistic ASIC second sources, productive R&D, and, in the end, lower cost of ownership.

The Changing Face of Distribution in Technology Partnerships

Bob Gardner, Hamilton/Avnet

Distributors remain the suppliers of service to 90 percent of the customers in the electronics industry. However, the definition of service is changing rapidly, from simple financial services and value-added component services to sophisticated technical support for VLSI semiconductors and system products. Distribution is positioning itself to provide technical expertise to the broad customer base not served directly by the semiconductor manufacturers.

In a role similar to the third-party design companies, distributors will facilitate the design interfaces from their customers to a variety of semiconductor manufacturers, then provide the services required to deliver the production product to the customer.

Technology Partnerships for ASIC Product

Mike Callahan, MMI

MMI believes that programmable logic devices (PLDs) and logic cell arrays will be used more widely by customers than is currently forecast by Dataquest. MMI's reasons include rapid progression down the experience curve due to the high cumulative volumes per product type, and mask production limitations that will limit gate array and standard cell growth. Standard cell designs will have to be cooperatively designed by customers and suppliers to create families of cell-based arrays that can be used in a variety of customer system designs.

In any customer-specific product program, customer and supplier as partners must understand the costs involved and work together to reduce them. Key factors are manufacturing cycle times and diagnostics. Excellent performance on these can reduce production and nonrecurring engineering charges.

Gate array and standard cell programs do not generally allow for realistic second sourcing. In sole-source arrangements, it is imperative that the customer is assured of receiving his product when he needs it over the long haul and that the supplier is assured of long-term profitability.

Poor Quality--An Expensive Bad Habit
Chuck Harwood, Quality Improvement Co.

In typical companies, the cost of waste caused by poor quality throughout the organization can be 20 to 30 percent of sales. Forty to fifty percent of the white collar worker's time is spent dealing with the consequence of defects, errors, mistakes, or missed promises.

Poor quality is a result of management neglect, and can only be corrected by management attention. An effective quality improvement system involves clear definition of all requirements, quality improvement by defect prevention, and an ultimate goal of zero defects.

Results that have been achieved by effective quality improvement programs are:

- 10x to 100x reduction in defects
- Savings of $7 for every $1 invested
- Savings of one-third of a company's pretax earnings
- Reduction of throughput by a factor of four

Vendor Performance Rating--A Quality Report Card
John Durkin, Unisys

Unisys' Component Engineering and Procurement Organization (CEPO) has developed a supplier quality improvement program. The key elements of this program include a quality council with each major supplier, quarterly senior management reviews, a certification program, and feedback and analysis of manufacturing plants' quality data. Quality performance is measured on the basis of parts per million (ppm) reject rates to Unisys specifications. Quality performance is fed into a supplier effectiveness model that establishes a cost of ownership for each supplier. The model also involves factors for delivery timeliness, delivery volume, and service. A supplier effectiveness factor is calculated that is used to convert unit costs to cost of ownership. Supplier business awards are made using lowest cost of ownership as a deciding factor.

Since first quarter 1985, reject rates have dropped from 8,500 ppm to 500 ppm in the fourth quarter of 1986. In fourth quarter 1986, supplier quality levels ranged from less than 50 ppm to about 1,700 ppm. One supplier out of the 11 suppliers tracked was certified. Unisys' goal is zero defects. This program of shared responsibility, effective communication, and cooperative problem solving has enabled Unisys to make substantial progress toward that goal.

Dataquest View of Industry Trends

1987 Outlook

Gene Norrett, Semiconductor Industry Group

In 1986, the semiconductor industry was affected by large financial losses, slow computer industry growth, continued shift of technology and market leadership to Japan and Asia, and the U.S.-Japan trade agreement. Worldwide semiconductor growth of 23.4 percent was due mostly to the weakening of the dollar against European and Japanese currencies. This and the U.S.-Japan trade agreement drove more companies to shift manufacturing to newly industrialized Pacific Rim countries whose currencies were more closely tied to the dollar. This shift, coupled with growing industrial strength within the countries, caused ROW consumption to grow more than 50 percent. Japanese semiconductor manufacturers gained the top three positions in the world semiconductor competition.

More stable exchange rates are expected to moderate industry growth in 1987 to 15 percent, although North American consumption is forecast to double from 1986. Increasing competition from Japan, Europe, and the newly industrialized countries will keep pressure on prices and keep availability good in 1987.

New growth opportunities that Dataquest expects will drive the market in 1988 and beyond include:

- Smart cards and related electronic systems
- Digital televisions and VCRs
- Personal communications
- 32-bit PCs with speech recognition
- Automotive electronics

Second Annual Procurement Survey

Anthea Stratigos, Semiconductor Application Markets

This survey is conducted annually among the Electronic Business 200--a list of the 200 largest U.S. electronics companies. The survey respondents said that they expect to spend 13.6 percent more on semiconductors in 1987 than they did in 1986. In 1986 they purchased 12 percent of their requirements from distributors. Semiconductor purchases made outside the United States for use in U.S.-based products ranged from 4 percent in communications and industrial segments to 29 percent in the transportation segment.

The shift to offshore consumption continued in 1987 with almost 12 percent of purchases expected to move from the United States to offshore. Buyers indicated that they are generally at or below target inventory levels, but 28 percent said that their inventories were above targets. Almost 40 percent of the respondents said that they are planning to reduce their inventory targets in 1987.

To buyers, the five most important issues in the fourth quarter of 1986 were:

- Pricing
- Availability/lead times
- Quality/reliability
- On-time delivery
- FMVs/trade agreement

Our conclusion from this response is that customers are beginning to feel that vendor quality has improved substantially and that cost and service are prime concerns for remaining profitable in a highly competitive global market.

Capacity and Capital Spending

Bob McGeary, Semiconductor Equipment and Materials Service

Slower end-market growth and overinvestment in semiconductor manufacturing capacity has created an environment where semiconductor manufacturers have reduced their investment plans for new manufacturing facilities during the next few years. Capacity utilization in the United States, Japan, and Europe ranged from 40 to 70 percent in 1985, and is not expected to return to high levels until 1988. This situation will keep pressure on pricing in the short term and keep most products readily available.

We expect the industry to return to near full capacity utilization by 1988, especially in advanced 1-micron and smaller technology. This is expected to return the industry to a strong recovery in 1988 as new products using advanced technology enter volume production.

Application-Specific Integrated Circuits
Stan Bruederle, Semiconductor User Information Service

Purchasing ASICs is a very complex job. A variety of factors are changing the industry and its customers' needs.

Technology improvements drive complexities higher. Customers use PLDs where gate arrays have been used and gate arrays where standard cells once seemed best suited. As a result, customers use a wider variety of ASICs but want to buy them from a limited supplier base.

Different semiconductor companies lead the competition in each ASIC product category. As customers use a greater variety of ASIC products, semiconductor companies have begun to add new families to their product portfolios.

Many of the major broad line suppliers and some of the new entrants offer or plan to offer a variety of gate array, standard cell, and PLD products.

Increasingly complex technology and growing complexity are raising the cost of participating in the ASIC market. We believe that these factors will drive smaller companies out of the industry during the next five years. Mask programmable ASICs will consume huge numbers of mask sets between now and 1990. We expect shortages to occur that will affect suppliers' deliveries of products to their customers.

Prices vary widely, with PLDs being the most expensive but decreasing rapidly as MOS technology becomes more widely used and competition increases. Gate arrays are generally the lowest-cost ASIC approach. Standard cells are the lowest cost at very high complexities and volumes.

Gate array and standard cell companies are entering a race to achieve the single-chip solution, the ultimate ASIC objective.

Successful use of ASICs requires that users have an in-depth understanding of product and technology changes and the developing industry relationships that will affect them.

Microdevice Update
Brand Parks, Semiconductor User Information Service

Dataquest forecasts that by 1990, companies will spend almost $9 billion on microcomponents, or 21 cents of every purchasing dollar. The top five microcomponent suppliers are Intel, NEC, Motorola, Mitsubishi, and Matsushita. The United States is currently the largest consumer of microcomponents in the world. We forecast that by 1991, Japan will be. Other trends impacting the market will be the offering of original products by Japanese companies, the continuing battle over intellectual property, and the emergence of video and graphics as high-growth business opportunities.

Design and development support is becoming very costly for new, highly complex devices, making product selection a very expensive activity. It is essential that users have a complete system perspective when making product decisions. Microperipheral devices are becoming critical parts of total product offerings; they are the essential ingredient for effective performance in specific applications. Corporate involvement is becoming necessary in the strategic selection of microdevices.

Memory Update

Mark Giudici, Semiconductor User Information Service

As a result of very short product life cycles, the memory market is extremely dynamic. Products introduced in 1987 will represent 80 to 90 percent of consumption by 1991. The fastest-growing products include 1Mb EPROMs, 256K SRAMs, 256K EEPROMs, and very high-density ROMs.

The shift to off-shore manufacturing is pulling more memory consumption to the Far East. Dataquest expects the ROW area to represent 8.5 percent of worldwide consumption by 1988, up from 5.1 percent in 1986.

Competition is growing in all product areas, with 15 to 25 companies competing for each important memory market. In every segment except ROMs, the 10 largest suppliers have 88 to 96 percent of the market. Suppliers are introducing a variety of specialty products to provide unique features or offer solutions for specific applications. These products reduce customer system costs while giving suppliers higher average selling prices.

The U.S.-Japan trade agreement has resulted in some short-term price increases in Europe and the Asia/Pacific region, but prices in Japan continue to decline. We expect to see continued price differentials between the United States and the rest of the world.

Stan Bruederle

1987 SUIS/SAM SEMICONDUCTOR PROCUREMENT CONFERENCE

Partnering in a Global Economy

February 4-6, 1987
Saddlebrook Golf and Tennis Resort
Wesley Chapel, Florida

TUESDAY, February 3

5:00 p.m. to 8:00 p.m.	**Registration**	*Pegasus South Foyer*
7:00 p.m. to 9:00 p.m.	**Cocktails**	*Lagoon Pavilion*

WEDNESDAY, February 4

8:00 a.m.	**Registration Continues**	*Pegasus South Lobby*
	Buffet Breakfast	*Pegasus East*
9:00 a.m.	**Dataquest Welcome and Introduction** Stan Bruederle Vice President, Director, Semiconductor User Information Service Dataquest Incorporated Anthea C. Stratigos Associate Director, Semiconductor Application Markets Dataquest Incorporated	*Pegasus South*
	GLOBAL ISSUES	
9:15 a.m.	**Impact of the Global Electronics Industry** Fred Zieber Vice President, General Manager of Technology Operations Dataquest Incorporated	*Pegasus South*
9:45 a.m.	**Program for Competing Internationally** Brad Kroha Corporate Vice President and Director of Communications Sector Sourcing Motorola, Inc.	*Pegasus South*
10:30 a.m.	**Coffee Break**	*Pegasus South Foyer*
11:00 a.m.	**Japanese Perspective on Partnering** Kosei Nomiya President Hitachi Microsystems International, Inc.	*Pegasus South*
11:30 a.m.	**A U.S. Perspective on Partnering** Douglas H. Newman Vice President, Marketing National Semiconductor Corporation	*Pegasus South*
12:00 Noon	**Lunch**	*Lagoon Pavilion*
1:30 p.m.	**The Benefits of Lead Time Reduction** Philip R. Thomas President Thomas Group, Inc.	*Pegasus South*
2:00 p.m.	**The U.S./Japanese Trade Agreement: Progress Report** Gil Kaplan Deputy Assistant Secretary, Import Administration, International Trade Administration U.S. Department of Commerce	*Pegasus South*
6:00 p.m.	**Cocktails**	*Lagoon Pavilion*
7:00 p.m.	**Dinner**	*Lagoon Pavilion*

(over)

THURSDAY, February 5

8:00 a.m.	**Buffet Breakfast**	*Lagoon Pavilion*
	MANUFACTURING STRATEGIES	
9:00 a.m.	**Automation's Role in Competition** David C. Penning, CMfgE Director, Manufacturing Automation Service Dataquest Incorporated	*Pegasus South*
9:30 a.m.	**A Worldwide Manufacturing Strategy** Hal Edmondson Vice President, Manufacturing Hewlett-Packard Company	*Pegasus South*
10:00 a.m.	**IBM's New Austin Facility: A Perspective on Automation** Clark Preston Manager of Manufacturing Technical Services IBM Corporation	*Pegasus South*
10:30 a.m.	**Coffee Break**	*Pegasus South Foyer*
11:00 a.m.	**The Role of Contract Manufacturing** Gene Sapp President SCI Systems, Inc.	*Pegasus South*
	CUSTOMER/VENDOR RELATIONSHIPS	
11:30 a.m.	**Customer/Vendor Relationships—An International Perspective** Bernard Hadley Managing Director Stack GmbH	*Pegasus South*
12:00 Noon	**Lunch**	*Lagoon Pavilion*
1:30 p.m.	**The Changing Face of Distribution in Technology Partnerships** Robert M. Garner General Manager, Vice President of ASIC Operations Hamilton/Avnet Electronics	*Pegasus South*
2:00 p.m.	**Technology Partnerships for ASIC Products** Michael J. Callahan Executive Vice President and Chief Operating Officer Monolithic Memories Incorporated	*Pegasus South*
2:30 p.m.	**Coffee Break**	*Pegasus South Foyer*
3:00 p.m.	**Poor Quality: An Expensive Bad Habit** Charles C. Harwood Partner Quality Improvement Co.	*Pegasus South*
3:30 p.m.	**Vendor Performance Rating—A Quality Report Card** John Durkin Manager of Procurement and Contracts for Memories and Custom Technology Unisys	*Pegasus South*
6:00 p.m.	**Cocktails**	*Pegasus East 1-4*
7:00 p.m.	**Dinner**	*Pegasus East*
8:30 p.m.	**Dinner Speaker** Christopher Hegarty President C.J. Hegarty & Company	*Pegasus East*

FRIDAY, February 6

7:15 a.m.	**Buffet Breakfast**	*Lagoon Pavilion*
	INDUSTRY TRENDS	
8:30 a.m.	**Industry Forecast** Gene Norrett Vice President and Group Director, Semiconductor Industry Group Dataquest Incorporated	*Pegasus South*
9:00 a.m.	**Second Annual Procurement Survey: The User's View** Anthea C. Stratigos Associate Director, Semiconductor Application Markets Dataquest Incorporated	*Pegasus South*
9:30 a.m.	**The "Supply Side" Effect: Capacity and Capital Spending** Bob McGeary Director, Semiconductor Equipment and Materials Service Dataquest Incorporated	*Pegasus South*
10:00 a.m.	**Coffee Break**	*Pegasus South Foyer*
	PRODUCT AND TECHNOLOGY	
10:30 a.m.	**ASIC Devices** Stan Bruederle Vice President, Director, Semiconductor User Information Service Dataquest Incorporated	*Pegasus South*
11:00 a.m.	**Micro Devices** Brand Parks Industry Analyst, Semiconductor User Information Service Dataquest Incorporated	*Pegasus South*
11:30 a.m.	**Memory Devices** Mark Giudici Industry Analyst, Semiconductor User Information Service Dataquest Incorporated	*Pegasus South*
12:15 p.m.	**Buffet Lunch**	*Lagoon Pavilion*

Conference Adjourns

SUIS Code: Newsletters
1987-2

1986 PRELIMINARY MARKET SHARE
CURRENCY REVALUATIONS CHANGE MARKET STANDINGS

Preliminary estimates of the world semiconductor market indicate a 26.1 percent increase in revenue when measured in dollars. By this measure, Japanese producers fared well, chalking up approximately a 43 percent growth in worldwide factory shipments. European producers had the next best growth with a 16 percent increase in factory shipments and the North American region fared worst of all with only a 10 percent growth.

These figures do not correlate with the emotional response heard from the major producing regions: cries of anguish from Japan, distress from Europe, and the loud sound of bullet biting in North America. The real market picture is perhaps different from that portrayed by the growth of revenue expressed in dollars.

A different picture appears when consumption in the three regions is expressed in local currencies: The North American region shows a 6.4 percent growth, Japan shows a negative growth of 2.0 percent, and European producers have a market decline of 6 percent. This helps explain the reaction of producers in the three regions, but it still may not be an accurate view.

If producers outside North America can increase their dollar market shares in the face of increasing dollar prices it must be that their products were undervalued. By this argument, the dollar market share is significant. Japanese sales in 1986 outside Japan (expressed in yen) fell only 8 percent from 1985. Currency revaluations against the dollar were an increase of 43 percent in Japanese yen and an increase of 20 percent in the European basket of currencies.

Dataquest believes that the true impact of currency revaluations on market standing lies somewhere between the local-currency point of view and the dollar-denominated point of view. We anticipate that suppliers in various geographic regions will continue to adjust their strategies to further compensate for these changes during 1987.

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1986 MARKET SUMMARY

Tables 1 through 8 rank the top 50 major worldwide suppliers by total semiconductor, integrated circuits, bipolar, MOS, linear, discrete and optoelectronics (opto) product areas. These rankings are all stated in dollars. In each instance, these suppliers accounted for at least 90 percent of the total world market and thus give a good preliminary snapshot of 1986. The total world market increased 26.1 percent, and was made up of an increase of 26.4 percent in ICs and 25.3 percent in discrete and opto. Among the markets comprising ICs, MOS digital exhibited the fastest growth at 28.1 percent and bipolar digital noted the slowest growth at 19.5 percent. Generally, Japanese suppliers exhibit higher growth than European suppliers which in turn exhibit higher growth than North American suppliers. These variations in growth rates reflect the currency revaluations discussed above. In spite of this, a number of North American suppliers exhibited growth rates above the world averages in their segments, reflecting, Dataquest believes, a successful search for niches. These suppliers will be pointed out in the discussion of each table.

SEMICONDUCTOR MARKET SHARE

In total semiconductor, as indicated in Table 1, NEC maintained its first place ranking. Hitachi and Toshiba made it to second and third place, respectively, passing Motorola and Texas Instruments. Toshiba showed an above average growth rate even when currency effects are accounted for. Dataquest believes Toshiba is currently expanding its productive capacity in a bid for even greater market share. In the top 10, Mitsubishi is a new entrant, pushing National Semiconductor from the top 10.

A number of smaller North American companies showed growth rates above the industry average of 26.1 percent. These include TRW, LSI Logic, Honeywell, and VLSI Technology. Dataquest believes these firms have successfully exploited market niches in this difficult year.

IC MARKET SHARE

IC market share rankings are shown in Table 2. These company sales are included in the total semiconductor sales of Table 1. NEC ascended to first position in these rankings, followed by Hitachi, thus relegating Texas Instruments to third place. Toshiba advanced two positions, pushing Motorola from third place to fifth place. In the top 10, Mitsubishi is a new entry, replacing Advanced Micro Devices.

Smaller North American companies showing growth rates above the industry average for this segment of 26.4 percent include Honeywell, Integrated Device Technology, LSI Logic, Silicon Systems TRW, and VLSI Technology.

Gold Star and United Microelectronics are new to the list this year. Gold Star is a Korean company and United Microelectronics is located in Taiwan. This is significant because it is the first time Asian suppliers outside Japan have achieved this ranking. Both companies had growth rates much higher than the world average, which is also significant because both of these countries have currencies that are tied to the dollar.

BIPOLAR DIGITAL MARKET SHARE

The bipolar digital market shares are shown in Table 3. These figures are included in the IC totals of Table 2. This market has fewer suppliers than other markets in the integrated circuit category.

In the top 10, Texas Instruments retained its first place ranking. Philips-Signetics edged out Motorola for second place and Fujitsu climbed into fourth place edging out Fairchild. No new players appear in the top 10.

Honeywell and Raytheon are two North American companies that showed growth rates significantly in excess of the 19.5 percent growth rate of this segment.

MOS DIGITAL MARKET SHARE

MOS digital market shares are shown in Table 4. These figures are included in the IC totals of Table 2.

In the top 10, NEC retains its first place ranking, followed by Hitachi and Toshiba who pushed Intel from second to fourth place. New entrants to the top 10 include Matsushita and Oki, which replace National Semiconductor and Advanced Micro Devices.

North American companies that show growth rates above the average for this segment of 28.1 percent include LSI Logic, Integrated Device Technology, Rockwell, VLSI Technology, Cypress Semiconductor, Micron Technology, and Honeywell.

Two East Asian companies outside Japan showing high growth rates are Samsung and United Microelectronics. Dataquest believes these firms benefitted by being exempt from the U.S. Department of Commerce FMV prices for memory devices, as did Micron Technology, Cypress, and Integrated Device Technology.

LINEAR MARKET SHARE

Linear market shares are shown in Table 5. These figures are included in the IC totals of Table 2.

In the top 10, Matsushita advanced to first place passing National Semiconductor, long the world's leading supplier of linear devices. Toshiba advanced to number three position and NEC maintained its number four slot. There were no new entrants to the top 10.

North American companies that show growth rates above the average for this segment of 27.1 percent include Silicon Systems, TRW, Mitel, Linear Technology, Cherry Semiconductor, Unitrode, and Solitron.

East Asian companies outside of Japan showing above average growth rates include Gold Star, Samsung, and KEC.

DISCRETE/OPTO MARKET SHARE

Discrete/opto market shares are shown in Table 6. These figures are added into the totals of Table 1.

In the top 10, Toshiba advanced to first place, edging out Motorola, long the leader in this segment. Hitachi and NEC retained their third and fourth positions respectively. There were no new entrants to the top 10.

North American companies showing growth above the world average for this segment include TRW and Supertex.

A new entrant to the list this year is Powerex. This company includes the former discrete operations of Westinghouse and a portion of the discrete business of General Electric. The new entity was backed in financing and technology by Mitsubishi.

DISCRETE MARKET SHARE

Discrete market shares are shown in Table 7. These figures are added into the totals of Table 6.

In the top 10, Motorola retained its number one position. Toshiba advanced to second place, pushing Hitachi down to third place. NEC maintained its position as number four. ROHM and Fuji Electric were new additions to the top 10, replacing ITT and International Rectifier. North American companies showing growth above the world average for this segment include TRW and Hewlett-Packard.

OPTO MARKET SHARE

Table 8 gives world market shares of optoelectronics. These figures are added into the totals of Table 6. Note that opto equals the MOS digital area in high growth of 28 percent.

In the top 10, Sharp advanced to first place, edging out Hewlett-Packard. Matsushita and Sony advanced to third and fourth place respectively, relegating Toshiba to fifth place rather than third place. ROHM was a new entrant to the top 10, replacing Hitachi.

RCA was the only North American firm showing growth in excess of the segment average.

<u>Definitions</u>

Our data includes semiconductor revenue from products shipped to non-semiconductor segments of the same company where those products are initiated in the semiconductor group. These products are valued as if they were sold on the merchant market. By using this definition, Dataquest seeks to account for true manufacturing capability of semiconductor suppliers. Because of our definition, we differ from publicly reported semiconductor sector data for companies such as Motorola. Dataquest includes hybrid circuits, if they are manufactured in the semiconductor group. NRE costs are also included for those gate arrays, standard cells, and custom products included in a company's ASIC revenue.

Dataquest's preliminary Market Share Service Section is currently being completed and will be available to all binder holders this month.

Penny Sur
Barbara Van

Table 1

PRELIMINARY 1986 WORLD SEMICONDUCTOR MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	1	NEC	1984	2638	33.0%
2	4	HITACHI	1671	2305	37.9%
3	5	TOSHIBA	1468	2261	54.0%
4	2	MOTOROLA	1830	2025	10.7%
5	3	TEXAS INSTRUMENTS	1742	1820	4.5%
6	6	PHILIPS-SIGNETICS	1068	1356	27.0%
7	7	FUJITSU	1020	1310	28.4%
8	10	MATSUSHITA	906	1233	36.1%
9	11	MITSUBISHI	642	1177	83.3%
10	8	INTEL	1020	991	-2.8%
11	9	NATIONAL SEMICONDUCTOR	925	990	7.0%
12	12	ADVANCED MICRO DEVICES	615	629	2.3%
13	14	SANYO	457	585	28.0%
14	13	FAIRCHILD	492	510	3.7%
15	22	SONY	252	475	88.5%
16	16	SHARP	329	456	38.6%
17	17	THOMSON *	324	436	34.6%
18	15	SIEMENS	420	429	2.1%
19	19	OKI	307	427	39.1%
20	23	ROHM	249	379	52.2%
21	20	SGS	300	370	23.3%
22	18	RCA	310	370	19.4%
23	21	ITT	270	312	15.6%
24	24	HARRIS	247	264	6.9%
25	25	ANALOG DEVICES	226	232	2.7%
26	31	SANKEN	155	220	41.9%
27	29	TELEFUNKEN ELECTRONIC	170	219	28.8%
28	26	HEWLETT-PACKARD	206	217	5.3%
29	30	FUJI ELECTRIC	156	213	36.5%
30	36	TRW	125	213	70.4%
31	28	MONOLITHIC MEMORIES	172	210	22.1%
32	27	GENERAL INSTRUMENT	201	205	2.0%
33	32	LSI LOGIC	140	192	37.1%
34	41	SAMSUNG	95	183	92.6%
35	42	SEIKO EPSON	93	167	79.6%
36	44	HONEYWELL	88	157	78.4%
37	33	AMERICAN MICROSYSTEMS	140	155	10.7%
38	34	INTERNATIONAL RECTIFIER	128	145	13.3%
39	38	SILICONIX	110	126	14.5%
40	39	PLESSEY	99	112	13.1%
41	48	VLSI TECHNOLOGY	78	110	41.0%
42	49	BURR-BROWN	78	95	21.8%
43	N/A	POWEREX	0	95	N/A
44	40	FERRANTI	98	95	-3.1%
45	45	SPRAGUE	87	94	8.0%
46	43	UNITRODE	89	90	1.1%
47	37	GENERAL ELECTRIC	118	89	-24.6%
48	52	PRECISION MONOLITHICS	68	81	19.1%
49	46	INMOS	85	80	-5.9%
50	50	NCR	75	80	6.7%
		Top 50 total	21928	27623	26.0%

*NOTE: MOSTEK AND THOMSON REVENUES ARE AGGREGATED IN 1986 BUT NOT 1985.

Source: Dataquest
January 1987

Table 2

PRELIMINARY 1986 WORLD IC MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	2	NEC	1603	2154	34.4%
2	4	HITACHI	1236	1771	43.3%
3	1	TEXAS INSTRUMENTS	1653	1728	4.5%
4	6	TOSHIBA	1004	1605	59.9%
5	3	MOTOROLA	1281	1405	9.7%
6	7	FUJITSU	940	1198	27.4%
7	9	PHILIPS-SIGNETICS	808	1041	28.8%
8	5	INTEL	1020	991	-2.8%
9	8	NATIONAL SEMICONDUCTOR	882	956	8.4%
10	12	MITSUBISHI	465	923	98.5%
11	11	MATSUSHITA	595	807	35.6%
12	10	ADVANCED MICRO DEVICES	615	629	2.3%
13	13	FAIRCHILD	451	464	2.9%
14	14	SANYO	314	407	29.6%
15	15	OKI	289	402	39.1%
16	22	THOMSON *	197	293	48.7%
17	17	SGS	240	291	21.3%
18	24	SONY	155	290	87.1%
19	19	RCA	225	268	19.1%
20	16	HARRIS	247	264	6.9%
21	21	SHARP	201	259	28.9%
22	18	ANALOG DEVICES	226	232	2.7%
23	20	SIEMENS	205	216	5.4%
24	23	MONOLITHIC MEMORIES	172	210	22.1%
25	27	LSI LOGIC	140	192	37.1%
26	26	ITT	140	168	20.0%
27	30	SEIKO EPSON	93	167	79.6%
28	29	ROHM	105	163	55.2%
29	37	SAMSUNG	75	159	112.0%
30	25	AMERICAN MICROSYSTEMS	140	155	10.7%
31	45	HONEYWELL	57	122	114.0%
32	35	VLSI TECHNOLOGY	78	110	41.0%
33	31	PLESSEY	89	98	10.1%
34	33	BURR-BROWN	78	95	21.8%
35	53	TRW	43	88	104.7%
36	40	TELEFUNKEN ELECTRONIC	68	82	20.6%
37	39	PRECISION MONOLITHICS	68	81	19.1%
38	48	SANKEN	53	81	52.8%
39	32	INMOS	85	80	-5.9%
40	36	NCR	75	80	6.7%
41	34	FERRANTI	78	78	0.0%
42	44	ZILOG	59	74	25.4%
43	51	INTEGRATED DEVICE TECH.	50	72	44.0%
44	50	SILICON SYSTEMS	51	72	41.2%
45	46	WESTERN DIGITAL	56	70	25.0%
46	41	SILICONIX	63	69	9.5%
47	38	INTERSIL	70	68	-2.9%
48	60	GOLD STAR	32	65	103.1%
49	43	SPRAGUE	60	65	8.3%
50	58	UNITED MICROELECTRONICS	33	65	97.0%
		Top 50 total	16963	21423	26.3%

*NOTE: MOSTEK AND THOMSON REVENUES ARE AGGREGATED IN 1986 BUT NOT 1985.

Source: Dataquest
January 1987

Table 3

PRELIMINARY 1986 WORLD BIPOLAR DIGITAL MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	1	TEXAS INSTRUMENTS	796	875	9.9%
2	3	PHILIPS-SIGNETICS	372	427	14.8%
3	2	MOTOROLA	379	398	5.0%
4	6	FUJITSU	267	347	30.0%
5	4	FAIRCHILD	329	341	3.6%
6	7	HITACHI	195	339	73.8%
7	5	ADVANCED MICRO DEVICES	276	303	9.8%
8	9	MONOLITHIC MEMORIES	170	206	21.2%
9	8	NATIONAL SEMICONDUCTOR	194	206	6.2%
10	10	NEC	129	176	36.4%
11	11	MITSUBISHI	75	155	106.7%
12	16	TOSHIBA	33	129	290.9%
13	12	HONEYWELL	50	86	72.0%
14	13	FERRANTI	49	43	-12.2%
15	15	SIEMENS	41	36	-12.2%
16	22	RAYTHEON	22	33	50.0%
17	24	MATSUSHITA	21	30	42.9%
18	17	PLESSEY	30	30	0.0%
19	21	OKI	22	26	18.2%
20	26	ROHM	15	25	66.7%
21	23	AMCC	21	24	14.3%
22	25	SANYO	18	23	27.8%
23	14	HARRIS	43	21	-51.2%
24	20	INTEL	22	21	-4.5%
25	18	SGS	26	20	-23.1%
26	19	THOMSON	24	10	-58.3%
27	29	GOLD STAR	4	7	75.0%
28	28	INTERDESIGN	6	5	-16.7%
29	27	RIFA	9	5	-44.4%
30	33	CHERRY SEMICONDUCTOR	3	3	0.0%
31	34	TELEDYNE	3	3	0.0%
32	32	TRW	4	3	-25.0%
33	35	FUJI ELECTRIC	1	2	100.0%
34	30	MATRA-HARRIS	4	1	-75.0%
		Top 34 total	3653	4358	19.3%

Source: Dataquest
January 1987

Table 4

PRELIMINARY 1986 WORLD MOS DIGITAL MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	1	NEC	1174	1615	37.6%
2	3	HITACHI	852	1167	37.0%
3	4	TOSHIBA	736	1106	50.3%
4	2	INTEL	998	970	-2.8%
5	6	FUJITSU	631	791	25.4%
6	5	MOTOROLA	668	727	8.8%
7	10	MITSUBISHI	290	583	101.0%
8	7	TEXAS INSTRUMENTS	522	501	-4.0%
9	11	MATSUSHITA	269	384	42.8%
10	12	OKI	264	372	40.9%
11	8	NATIONAL SEMICONDUCTOR	318	366	15.1%
12	13	PHILIPS-SIGNETICS	228	314	37.7%
13	9	ADVANCED MICRO DEVICES	305	290	-4.9%
14	14	SHARP	173	214	23.7%
15	20	THOMSON *	107	210	96.3%
16	15	RCA	160	194	21.3%
17	17	LSI LOGIC	140	192	37.1%
18	21	SEIKO EPSON	93	167	79.6%
19	16	AMERICAN MICROSYSTEMS	140	155	10.7%
20	32	SAMSUNG	55	123	123.6%
21	19	HARRIS	111	117	5.4%
22	29	SONY	59	116	96.6%
23	26	VLSI TECHNOLOGY	78	110	41.0%
24	23	ITT	90	107	18.9%
25	24	SGS	88	106	20.5%
26	22	SIEMENS	92	89	-3.3%
27	28	SANYO	68	88	29.4%
28	25	INMOS	85	80	-5.9%
29	27	NCR	75	80	6.7%
30	30	ZILOG	59	74	25.4%
31	34	INTEGRATED DEVICE TECH.	50	72	44.0%
32	31	WESTERN DIGITAL	56	70	25.0%
33	42	UNITED MICROELECTRONICS	33	65	97.0%
34	35	ROCKWELL	44	64	45.5%
35	33	STANDARD MICROSYSTEMS	54	56	3.7%
36	51	CYPRESS SEMICONDUCTOR	18	50	177.8%
37	39	MICRON TECHNOLOGY	36	49	36.1%
38	38	MATRA-HARRIS	36	44	22.2%
39	36	GENERAL INSTRUMENT	42	40	-4.8%
40	43	XICOR	32	40	25.0%
41	37	HUGHES	36	39	8.3%
42	40	PLESSEY	35	39	11.4%
43	62	HONEYWELL	7	36	414.3%
44	41	SEEQ	33	31	-6.1%
45	48	EUROSIL	21	30	42.9%
46	46	IMP	25	30	20.0%
47	44	SOLID STATE SCIENTIFIC	28	30	7.1%
48	50	ASEA-HAFO	18	22	22.2%
49	47	FAIRCHILD	22	22	0.0%
50	49	MEDL	20	22	10.0%
		Top 50 total	9574	12259	28.0%

*NOTE: MOSTEK AND THOMSON REVENUES ARE AGGREGATED IN 1986 BUT NOT 1985.

Source: Dataquest
January 1987

Table 5

PRELIMINARY 1986 WORLD LINEAR MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	3	MATSUSHITA	305	393	28.9%
2	1	NATIONAL SEMICONDUCTOR	370	384	3.8%
3	5	TOSHIBA	235	370	57.4%
4	4	NEC	300	363	21.0%
5	2	TEXAS INSTRUMENTS	335	352	5.1%
6	9	PHILIPS-SIGNETICS	208	300	44.2%
7	7	SANYO	228	296	29.8%
8	6	MOTOROLA	234	280	19.7%
9	10	HITACHI	189	265	40.2%
10	8	ANALOG DEVICES	226	232	2.7%
11	13	MITSUBISHI	100	185	85.0%
12	14	SONY	96	174	81.3%
13	11	SGS	126	165	31.0%
14	16	ROHM	85	129	51.8%
15	15	HARRIS	93	126	35.5%
16	12	FAIRCHILD	100	101	1.0%
17	18	SIEMENS	72	91	26.4%
18	17	BURR-BROWN	78	95	21.8%
19	19	PRECISION MONOLITHICS	68	81	19.1%
20	26	SANKEN	53	81	52.8%
21	21	RCA	65	74	13.8%
22	20	THOMSON	66	73	10.6%
23	27	SILICON SYSTEMS	51	72	41.2%
24	30	TRW	39	70	79.5%
25	22	SILICONIX	60	65	8.3%
26	23	SPRAGUE	60	65	8.3%
27	24	TELEFUNKEN ELECTRONIC	55	63	14.5%
28	28	ITT	50	61	22.0%
29	29	FUJITSU	42	60	42.9%
30	25	INTERSIL	53	53	0.0%
31	38	GOLD STAR	22	48	118.2%
32	35	SHARP	28	45	60.7%
33	33	MITEL	29	38	31.0%
34	31	ADVANCED MICRO DEVICES	34	36	5.9%
35	32	EXAR	30	36	20.0%
36	40	SAMSUNG	20	36	80.0%
37	39	LINEAR TECHNOLOGY	22	29	31.8%
38	36	PLESSEY	24	29	20.8%
39	34	RAYTHEON	29	28	-3.4%
40	44	FUJI ELECTRIC	13	26	100.0%
41	37	FERRANTI	23	24	4.3%
42	45	CHERRY SEMICONDUCTOR	11	18	63.6%
43	43	INTERDESIGN	18	17	-5.6%
44	41	GENERAL INSTRUMENT	19	15	-21.1%
45	42	GTE MICROCIRCUITS	18	14	-22.2%
46	47	TELEDYNE	11	13	18.2%
47	50	UNITRODE	8	13	62.5%
48	49	SOLITRON	8	12	50.0%
49	48	KEC	8	11	37.5%
50	46	MICRO POWER SYSTEMS	11	10	-9.1%
		Top 50 total	4428	5617	26.9%

Source: Dataquest
January 1987

Table 6

PRELIMINARY 1986 WORLD DISCRETE/OPTO MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	2	TOSHIBA	464	656	41.4%
2	1	MOTOROLA	549	620	12.9%
3	3	HITACHI	435	534	22.8%
4	4	NEC	381	484	27.0%
5	5	MATSUSHITA	311	426	37.0%
6	6	PHILIPS-SIGNETICS	260	315	21.2%
7	9	MITSUBISHI	177	254	43.5%
8	8	HEWLETT-PACKARD	206	217	5.3%
9	10	ROHM	144	216	50.0%
10	7	SIEMENS	215	213	-0.9%
11	16	SHARP	128	197	53.9%
12	21	SONY	97	185	90.7%
13	13	FUJI ELECTRIC	136	178	30.9%
14	11	SANYO	143	178	24.5%
15	12	GENERAL INSTRUMENT	140	150	7.1%
16	15	INTERNATIONAL RECTIFIER	128	145	13.3%
17	14	ITT	130	144	10.8%
18	17	THOMSON	127	143	12.6%
19	19	SANKEN	102	139	36.3%
20	20	TELEFUNKEN ELECTRONIC	102	137	34.3%
21	24	TRW	82	125	52.4%
22	26	FUJITSU	80	112	40.0%
23	23	RCA	85	102	20.0%
24	N/A	POWEREX	0	95	N/A
25	22	TEXAS INSTRUMENTS	89	92	3.4%
26	18	GENERAL ELECTRIC	112	81	-27.7%
27	27	SGS	60	79	31.7%
28	25	UNITRODE	81	77	-4.9%
29	29	SEMIKRON	48	72	50.0%
30	30	SILICONIX	47	57	21.3%
31	32	FAIRCHILD	41	46	12.2%
32	33	KEC	34	39	14.7%
33	36	BROWN-BOVERI	29	35	20.7%
34	34	HONEYWELL	31	35	12.9%
35	31	NATIONAL SEMICONDUCTOR	43	34	-20.9%
36	35	SOLITRON	30	30	0.0%
37	37	SPRAGUE	27	29	7.4%
38	42	OKI	18	25	38.9%
39	41	SAMSUNG	20	24	20.0%
40	38	ACRIAN	23	18	-21.7%
41	44	TAG	18	18	0.0%
42	40	FERRANTI	20	17	-15.0%
43	45	MEDL	15	17	13.3%
44	43	RAYTHEON	18	16	-11.1%
45	39	VARO	22	15	-31.8%
46	49	PLESSEY	10	14	40.0%
47	46	ASEA-HAFO	10	13	30.0%
48	48	PIHER	10	11	10.0%
49	47	INTERSIL	10	7	-30.0%
50	50	SUPERTEX	5	7	40.0%
		Top 50 total	5493	6873	25.1%

Source: Dataquest
January 1987

Table 7

PRELIMINARY 1986 WORLD DISCRETE MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	1	MOTOROLA	532	602	13.2%
2	3	TOSHIBA	368	549	49.2%
3	2	HITACHI	393	484	23.2%
4	4	NEC	351	439	25.1%
5	6	MATSUSHITA	227	293	29.1%
6	5	PHILIPS-SIGNETICS	235	288	22.6%
7	7	MITSUBISHI	177	254	43.5%
8	11	FUJI ELECTRIC	126	170	34.9%
9	13	ROHM	110	160	45.5%
10	10	INTERNATIONAL RECTIFIER	128	145	13.3%
11	9	ITT	130	144	10.8%
12	12	THOMSON	123	138	12.2%
13	8	SIEMENS	140	133	-5.0%
14	16	SANKEN	97	132	36.1%
15	14	SANYO	103	129	25.2%
16	15	GENERAL INSTRUMENT	100	115	15.0%
17	N/A	POWEREX	0	95	N/A
18	20	TELEFUNKEN ELECTRONIC	61	84	37.7%
19	19	RCA	76	83	9.2%
20	21	SGS	60	79	31.7%
21	18	UNITRODE	81	77	-4.9%
22	24	SEMIKRON	48	72	50.0%
23	31	TRW	36	70	94.4%
24	26	SONY	42	65	54.8%
25	22	TEXAS INSTRUMENTS	56	58	3.6%
26	25	SILICONIX	47	57	21.3%
27	17	GENERAL ELECTRIC	92	56	-39.1%
28	27	HEWLETT-PACKARD	40	51	27.5%
29	29	FUJITSU	37	48	29.7%
30	28	FAIRCHILD	39	45	15.4%
31	34	BROWN-BOVERI	29	35	20.7%
32	32	KEC	32	35	9.4%
33	30	NATIONAL SEMICONDUCTOR	37	34	-8.1%
34	33	SOLITRON	30	30	0.0%
35	35	SPRAGUE	27	29	7.4%
36	39	SAMSUNG	20	24	20.0%
37	36	ACRIAN	23	18	-21.7%
38	41	TAG	18	18	0.0%
39	38	FERRANTI	20	17	-15.0%
40	42	MEDL	15	17	13.3%
		Top 40 total	4306	5372	24.8%

Source: Dataquest

Table 8

PRELIMINARY 1986 WORLD OPTO MARKET SHARE RANKING
(Millions of Dollars)

1986 RANK	1985 RANK	COMPANY	1985	1986	Percent Change
1	2	SHARP	128	197	53.9%
2	1	HEWLETT-PACKARD	166	166	0.0%
3	4	MATSUSHITA	84	133	58.3%
4	6	SONY	55	120	118.2%
5	3	TOSHIBA	96	107	11.5%
6	5	SIEMENS	75	80	6.7%
7	8	FUJITSU	43	64	48.8%
8	13	ROHM	34	56	64.7%
9	7	TRW	46	55	19.6%
10	10	TELEFUNKEN ELECTRONIC	41	53	29.3%
11	9	HITACHI	42	50	19.0%
12	12	SANYO	40	49	22.5%
13	16	NEC	30	45	50.0%
14	11	GENERAL INSTRUMENT	40	35	-12.5%
15	15	HONEYWELL	31	35	12.9%
16	14	TEXAS INSTRUMENTS	33	34	3.0%
17	17	PHILIPS-SIGNETICS	25	27	8.0%
18	18	GENERAL ELECTRIC	20	25	25.0%
19	20	OKI	14	19	35.7%
20	23	RCA	9	19	111.1%
21	19	MOTOROLA	17	18	5.9%
22	22	PLESSEY	10	14	40.0%
23	21	FUJI ELECTRIC	10	8	-20.0%
24	26	SANKEN	5	7	40.0%
25	25	ASEA-HAFO	5	6	20.0%
		Top 25 total	1099	1422	29.4%

Source: Dataquest
January 1987

SUIS Code: Newsletters
1987-1

THE SILICON COMPILATION MAZE: WHERE DOES IT LEAD AND WHO'S IN IT?

INTRODUCTION

Users of application-specific integrated circuits (ASICs) face increasingly complex and expensive decisions concerning design tools. As these users move to the higher end of ASIC complexity and performance involving cell-based designs, methodologies such as silicon compilation become necessary for doing the complete design. The goal is to give the system designer who has little IC design knowledge, a means of generating an IC from a high-level functional description. That is, describing the working blocks of a complete circuit and "compiling" that description into an actual device for fabrication. In the ASIC market, silicon compilation presents itself as a leading-edge, yet confusing, technology--a technology composed of a variety of products with different abilities. The issue then, is: What are these products called silicon compilation, and who has them?

In Dataquest's SUIS Research Newsletter, "Silicon Compilation: Myth, or Opportunity," we discussed how, despite many misconceptions, silicon compilation is entering the integrated circuit (IC) CAD market. We defined two types of silicon compilation capability: silicon compilers and compiler generators. The increased support required by users of this unfamiliar methodology often blurs the roles and responsibilities of those companies providing design tools and design services and those companies actually fabricating the chips. Does silicon compilation consist of design tools, design libraries, design services, or finished silicon? To address this dilemma, this newsletter will focus on the following issues:

- Commercially available compilation products
- Compilation vendors and their role in the market
- Dataquest's analysis of related issues

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PRODUCTS

Dataquest defines silicon compilation as two basic types of design tools: silicon compilers and compiler generators (see Figure 1). These two product types differ functionally in the level of silicon expertise required of users and also in their targeted markets. And, as the markets for these products mature, vendors are more clearly delineating product offerings to express these differences.

Silicon compilers such as Chipsmith from Lattice Logic, the Concorde C3 and C4 from Seattle Silicon Technology (SST), and Genesil from Silicon Compilers Incorporated (SCI) are targeted at the system engineer who is a novice chip designer. Such tools allow system engineers the ability to automatically design application-specific integrated circuits (ASICs). Silicon compiler programs offer a user access to design "data books" or libraries containing the process rules, primitives, simulation models, and physical design information.

To design the chip, users select the desired functions from a menu and fill in a form with their design-specific requirements. The modified functional blocks are then either manually or automatically placed and routed. Ideally, users will be able to "shop" their designs around, comparing costs and design output of different foundries.

We have observed that compiler vendors Lattice, SCI, and SST target their products at system houses and ASIC houses. Additionally, for those companies with in-house IC designers wishing to expand compiler libraries, these vendors offer compiler generator tools, such as SCI's Genesis and SST's Concorde C5, which contains SST's SLIC design language. Lattice offers Shapesmith, mask data preparation software, as an adjunct to its compiler.

In contrast, compiler generator tools offered by SDA Systems and Silicon Design Labs (SDL) are aimed directly at the silicon-sophisticated IC designer in either the system house or semiconductor company. This user's goal is more efficient IC design. To such a user, compiler generators represent a more evolved IC design methodology than that of geometry-based, polygon pushers. Compiler generators offer many improvements, such as providing the structural means of capturing the original intent of a design for future reuse by a compiler. Compiler generators facilitate library development, and, in contrast with polygon pushers, are unique in their ability to combine electrical and geometric information. The design information is in a more intelligible, accessible, and recompilable format than designs completed with traditional IC CAD systems. (When we refer to compiler generators aimed at the hard-core IC designer independent of front-end silicon compiler considerations, we mean such products as SDL's GDT and SDA's ChipEdge.)

Both GDT and ChipEdge allow design specification through either schematics or language. SDL's GDT consists primarily of a design layout language called L, a hierarchical data base, and L-sim mixed-mode and behavioral simulator. SDA Systems offers its SKILL design language to control the leaf-cell structure compiler of ChipEdge.

Figure 2 lists the major compiler products and vendors. Profiles of the six major vendors of commercial compilation products can be found in Tables 1 through 6.

COMPANIES

Probably more confusing than the concept of silicon compilation itself is figuring out who the compiler players are and how they fit into the overall IC CAD market. Are they CAD vendors or design brokers? For example, SCI, SDL, and SST have alliances with EDA vendors Daisy, Mentor, and Valid. The marketing objectives of some compiler companies have undoubtedly undergone revision, as their products find their way to customers.

Some silicon compiler vendors offer design services in addition to the usual customer support. SCI and SST, for example, each consider design brokerage to be a substantial component of their businesses, and Seattle Silicon has even conceptualized it as its first silicon product. SST, which began business as a design house, refers to the design service portion of its business as First Silicon Services. However, Dataquest considers silicon compilers and related technology libraries to be the primary business of these companies.

VLSI Technology Incorporated (VTI), an ASIC house and standard cell market leader, sells compilation tools based on its own cell libraries in addition to its design and manufacturing services. VTI's tools include compilers and libraries of standard cells and compilable cells. We believe that a company such as VTI would have no reason to market compiler generator capability. Other foundries, such as Cirrus Logic, Gould-AMI, and LSI Logic, offer silicon compilation capability only as a design service that they themselves perform.

We classify SDL and SDA as primarily compiler-generator vendors, although SDL markets some libraries created with its compiler-generator tools. SDL's announced strategic direction, however, is toward the eventual offering of a full-fledged silicon compiler. SDA, in contrast, currently sells no libraries, only the tools to develop them. SDA views its business as providing a wide range of IC CAD tools, such as a layout editor, automatic place and route, and design rule checking, in addition to its compiler generator.

DATAQUEST ANALYSIS

The growth of the ASIC market is fueling the demand for more automated IC CAD tools. However, questions of design responsibility and guarantees of manufacturability remain problematic for both IC manufacturers and end users. IC companies want to know who will guarantee a compiler's design library. End users wonder who should provide design support.

Almost by definition, silicon compilers stand as the interface between silicon manufacturers and end users. At present, chip manufacturers foresee nothing but problems with users supplying their own layout. And, unquestionably, compilation is limited by the silicon expertise available to the silicon compiler company. The designs available on compilers have necessarily been generalized to guarantee working silicon. Efficiency in terms of speed and silicon utilization has also been sacrificed as part of this generalization.

Dataquest believes that relationships with IC companies are absolutely critical to the success of silicon compilation. Close links between the chip manufacturers and tool vendors will mean reasonable guarantees of manufacturability to end users without sacrificing speed or silicon utilization. We can easily foresee more players addressing this problem. It is not difficult to envision a market niche opening for library development companies supplying foundry-specific and/or technology-specific compiler libraries.

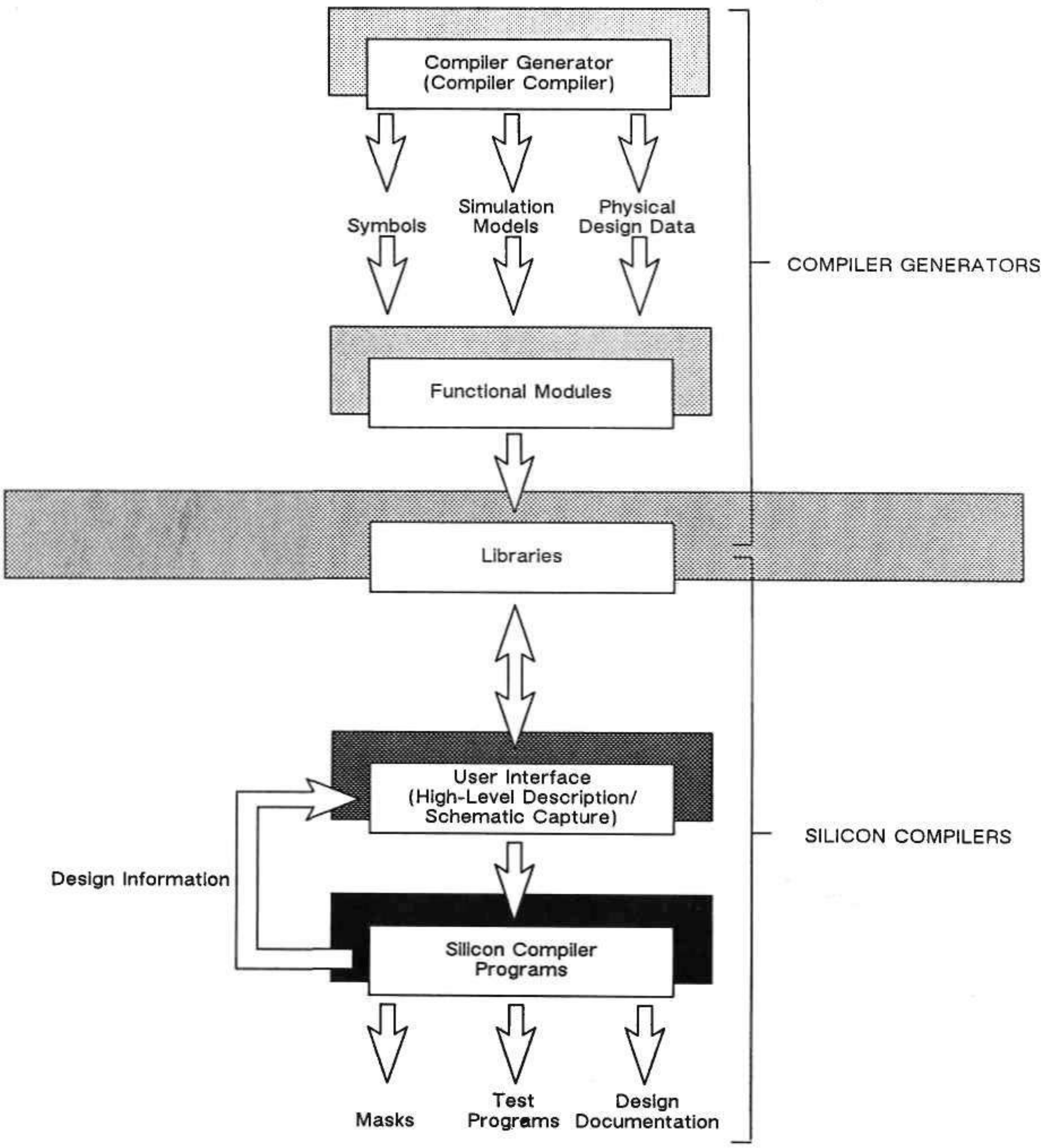
Support remains a critical and cost-intensive part of a compiler company's business. Branching out into design services may seem to be the only logical business alternative to operating in the red. However, Dataquest believes that if compilation is to move from a visionary methodology to a commercially viable product, the tools themselves will have to fulfill their original promise and stand on their own. In our opinion, this means increasing degrees of automation and more specific design expertise incorporated in the tools themselves.

(Portions of this newsletter were originally published by Dataquest's CAD/CAM Industry Service.)

Brand A. Parks
Tony Spadarella

Figure 1

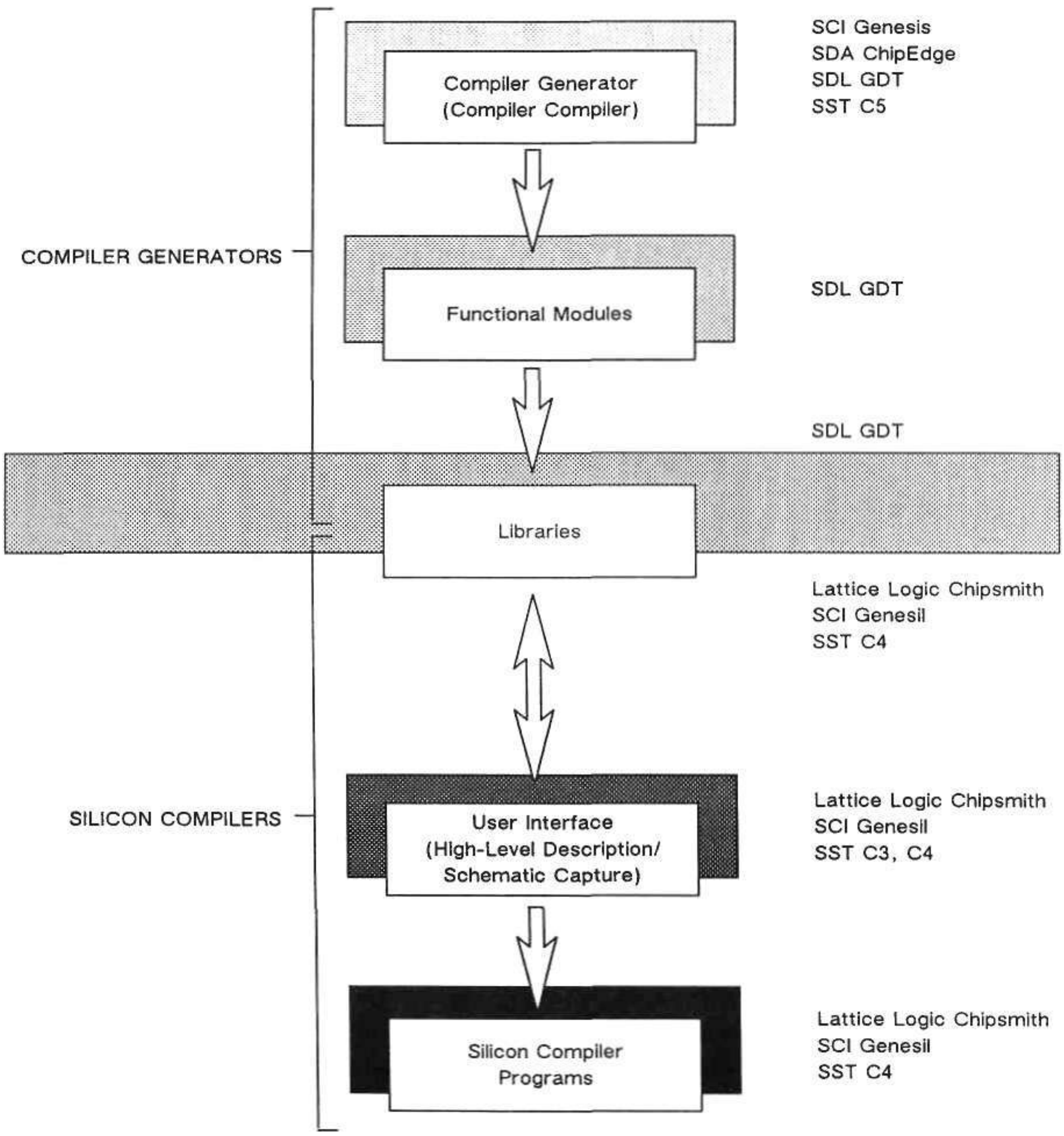
COMPILER GENERATORS AND SILICON COMPILATION



Source: Dataquest
January 1987

Figure 2

SILICON COMPILATION VENDORS AND PRODUCTS



Source: Dataquest
January 1987

Table 1

LATTICE LOGIC LIMITED

Headquarters:	Edinburgh, Scotland (U.K.)
Founded:	1982
Origins:	University of Edinburgh
Funding:	Not disclosed
Participants:	East of Scotland Investors (ESII), Investors In Industry (III)
Compiler Products:	Chipsmith
Delivery:	Turnkey or unbundled
CAD Alliances:	VIA Systems
IC Alliances:	European Silicon Structures (ES2), FELA (Switzerland), Ferranti, Hughes (U.K.), IMP, Lasarray, Newmarket Micro Systems
Hardware Platforms:	Apollo, Digital, IBM, Sun, Whitechapel
1985 Revenue:	$1 million

Source: Dataquest
January 1987

Table 2

SDA SYSTEMS

Headquarters:	Santa Clara, California
Founded:	1983
Origins:	National Semiconductor and University of California at Berkeley
Funding:	1983--$6 million (industrial sponsors), $4.5 million 1986--$8.3 million
Participants:	Alain Patricof and Associates, Applied Technology Partners, Continental Capital Ventures, Sand Hill Financial Company
Industrial Sponsors:	General Electric, Harris Corporation, L. M. Ericsson Telephone Company, National Semiconductor
Compiler Products:	ChipEdge
Delivery:	Turnkey or unbundled
CAD Alliances:	None
IC Alliances:	None
Hardware Platforms:	Apollo, Digital, Hewlett-Packard, Masscomp, Sun
1985 Revenue:	$2 million (includes all products)

Source: Dataquest
January 1987

Table 3

SEATTLE SILICON TECHNOLOGY (SST)

Headquarters:	Bellevue, Washington
Founded:	1983
Origins:	Boeing Aerospace
Funding:	Through 1984--$7 to $8 million Through 1985--$6.2 million Through 1986--$6 million*
Participants:	Canadian Enterprise Development Corporation, Hambrecht and Quist, the Hill Partnership, Norwest Venture Capital, Paragon Partners, Prudential-Bache High Technology Research Fund*, Rainier Venture Partners
Compiler Products:	Concorde Blue Chip Series: C3 (design entry), C4 (compiler), and C5 (compiler generator); First Silicon design services
Delivery:	Software only
CAD Alliances:	Mentor Graphics, Tektronix-CAE, Valid Logic
IC Alliances:	IMP, Motorola, NCR, Orbit, VTI
Hardware Platforms:	Apollo, Digital, Sun
1985 Revenue:	$1 million (includes OEM and design services)

*R&D funding; nonequity position

Source: Dataquest
January 1987

Table 4

SILICON COMPILERS INCORPORATED (SCI)

Headquarters:	San Jose, California
Founded:	1981
Origins:	Intel, California Institute of Technology, Scientific Calculations
Funding:	1981--$1 million 1983--$13 million 1985--$6.3 million
Participants:	General Electric Venture Capital, Kleiner Perkins Caulfield and Byers, L. F. Rothschild, Morgan Stanley, Robertson Colman Stephens
Compiler Products:	Genesil (compiler), Genesis (compiler generator)
Delivery:	Turnkey
CAD Alliances:	Daisy Systems, Mentor Graphics
IC Alliances:	U.S.--General Electric, Gould-AMI, Honeywell, IMP, Mosis, Motorola, National Semiconductor, NCR, SEEQ, VTC, VTI Europe--AMI-Austria, Matra, SGS Japan--Ricoh
Hardware Platforms:	Apollo, Digital
1985 Revenue:	$10 million (includes design services)

Source: Dataquest
January 1987

Table 5

SILICON DESIGN LABS (SDL)

Headquarters:	Liberty Corner, New Jersey
Founded:	1984
Origins:	ATT/Bell Laboratories
Funding:	$10.9 million
Participants:	Menlo Venture Partners, Welsh Carson Anderson and Stowe, Technology Venture Investors, Battery Ventures, Merrill-Lynch Venture Capital, Technology Funding Inc., Crown Advisors
Compiler Products:	GDT (compiler generator development tools), SDL2000 (microprocessor compiler)
Delivery:	Turnkey or unbundled
CAD Alliances:	Daisy Systems, Mentor Graphics, Tangent (Intergraph)
IC Alliances:	Not applicable
Hardware Platforms:	Apollo, Digital, Sun
1985 Revenue:	Less than $1 million

Source: Dataquest
January 1987

Table 6

VLSI TECHNOLOGY INCORPORATED (VTI)

Headquarters:	San Jose, California
Founded:	1979
Origins:	Synertek
Funding:	$10 million (publicly held)
Participants:	Bendix, Hambrecht and Quist, Olivetti, Rothschild
Compiler Products:	Datapath, logic, and cell compilers; megacell libraries
Delivery:	Software only
CAD Alliances:	Mentor, Daisy, Hewlett-Packard, SCI
IC Alliances:	Fairchild, VTI
Hardware Platforms:	Apollo, Digital, ELXSI, Hewlett-Packard, Ridge, Sun
1985 Revenue:	$20 million (includes design services and NRE)

Source: Dataquest
January 1987

Dataquest

Product Offerings

Industry Services

Business Computer Systems

CAD/CAM

Computer Storage—Rigid Disks

Computer Storage—Flexible Disks

Computer Storage—Tape Drives

Copying and Duplicating

Display Terminal

Electronic Printer

Electronic Publishing

Electronic Typewriter

Electronic Whiteboard

European Semiconductor*

European Telecommunications

Gallium Arsenide

Graphics

Imaging Supplies

Japanese Semiconductor*

Office Systems

Personal Computer

Personal Computer—Worldwide Shipments and Forecasts

Robotics

Semiconductor*

Semiconductor Application Markets*

Semiconductor Equipment and Materials*

Semiconductor User Information*

Software—Artificial Intelligence

Software—Personal Computer

Software—UNIX

Technical Computer Systems

Technical Computer Systems—Minisupercomputers

Telecommunications

Western European Printer

Executive and Financial Programs

Corporate Alliance Program

Coporate Technology Program

Financial Services Program

Strategic Executive Service

Newsletters

European PC Monitor

First Copy

Home Row

I.C. ASIA

I.C. USA

Focus Reports

The European PC Market 1985–1992

European PC Retail Pricing

PC Distribution in Europe

PC Software Markets in Europe

PC Local Area Networking Markets in Europe

The Education Market for PCs in Europe

Japanese Corporations in the European PC Markets

Home Markets for PCs in Europe

Integrated Office Systems—The Market and Its Requirements

European Market for Text Processing

Image Processing in the Office

Work Group Computing

Translation Systems

Vendor Support

The IBM 3270 Market: 1986 and Beyond

Korean Semiconductor Industry Analysis

Diskettes—The Market and Its Requirements

Directory Products

I.C. Start-Ups—1987

SpecCheck—Competitive Copier Guide

SpecCheck—Competitive Electronic Typewriter Guide

SpecCheck—Competitive Whiteboard Guide

Who's Who in CAD/CAM 1986

Future Products

- Industry Services
  - Manufacturing Automation
  - Computer Storage—Optical
  - Computer Storage—Subsystems
- Focus Reports
  - Japanese Printer Strategy
  - Japanese Telecommunications Strategy
  - Canon CX Laser—User Survey
  - Digital Signal Processing
  - PC-based Publishing
  - Taiwan Semiconductor Industry Analysis
  - China Semiconductor Industry Analysis
  - PC Distribution Channels
- Directory Products
  - SpecCheck—Competitive Facsimile Guide
  - SpecCheck—Competitive Electronic Printer Guide

*On-line delivery option available

For further information about these products, please contact your Dataquest sales representative or the Direct Marketing Group at (408) 971-9661.

Dataquest

Conference Schedule

1986

Semiconductor	October 20-22	Hotel Inter-Continental San Diego, California
Technical Computer	November 3-5	Silverado Country Club Napa, California
Asian Peripherals	November 5-7	Hotel Okura Tokyo, Japan
Semiconductor Users/ Semiconductor Application Markets	November 10	Sheraton Harbor Island San Diego, California
Electronic Publishing	November 17-18	Westin Copley Place Boston, Massachusetts
CAD/CAM EDA	December 4-5	Santa Clara Marriott Santa Clara, California

1987

Semiconductor Users/ Semiconductor Application Markets	February 4-6	Saddlebrook Resort Tampa, Florida
Copying and Duplicating	February 23-25	San Diego Hilton Resort San Diego, California
Electronic Printer	March 23-25	Silverado Country Club Napa, California
Japanese Semiconductor	April 13-14	The Miyako Kyoto, Japan
Telecommunications	April 13-15	Silverado Country Club Napa, California
CAD/CAM	May 14-15	Hyatt Regency Monterey Monterey, California
Display Terminals	May 20-22	San Diego Hilton Resort San Diego, California
European Semiconductor	June 4-5	Palace Hotel Madrid, Spain
European Copying and Duplicating	June 25-26	The Ritz Hotel Lisbon, Portugal
Financial Services	August 17-18	Silverado Country Club Napa, California
Western European Printer	September 9-11	Palace Hotel Madrid, Spain
European Telecommunications	October 1-2	Monte Carlo, Monaco
Semiconductor	October 19-21	The Pointe Resort Phoenix, Arizona
Office Equipment Dealers	November 5-6	Hyatt Regency Monterey, California
Electronic Publishing	November 16-17	Stouffer Hotel Bedford, Massachusetts
CAD/CAM EDA	December 10-11	Santa Clara Marriott Santa Clara, California

1986 Newsletters

1986–1987 SUIS Newsletter Index

The 1986-1987 SUIS Newsletter Index is a quick reference guide to the SUIS newsletters. It is structured as follows:

- Titles are organized by both keyword and company.
  - Pages 2 to 3 are a company list, e.g., Intel Corp.
  - Pages 4 to 6 are a subject list, e.g., Pricing.
- The newsletter type, month, and year follow each title listing in the index. Refer to the month and year to locate a specific newsletter.

This index will be updated quarterly.

1986–1987 SUIS Newsletter Index

Company / Newsletter		Date
ADVANCED MICRO DEVICES		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
FUJITSU LTD.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
HITACHI LTD.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
IBM		
IBM's Personal System/2: Doors are Still Open for DRAM Merchant Vendors	SUIS	Apr. 87
INTEL CORP.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
MATSUSHITA ELECTRONIC INDUSTRIES		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
MITSUBISHI ELECTRIC CORP.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
MOTOROLA INC.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
NATIONAL SEMICONDUCTOR CORP.		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
NEC CORPORATION		
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87
SGS-ATES SEMICONDUCTOR		
Thomson-SGS Merger	SUIS	May 87

1986-1987 SUIS Newsletter Index

Company	Newsletter	Date
SILICON COMPILERS INC.		
Silicon Compiler Companies Merge--Sign of Methodology Taking Off	SUIS	May 87
SILICON DESIGN LABS, INC.		
Silicon Compiler Companies Merge--Sign of Methodology Taking Off	SUIS	May 87
THOMSON CSF		
Thomson-SGS Merger	SUIS	May 87
TOSHIBA ELECTRIC CO.		
Toshiba's Emerging ASIC Strategy: Going for the Top	SUIS	May 87
Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS	Apr. 87

1986–1987 SUIS Newsletter Index

1986–1987 SUIS Newsletter Index

1986–1987 SUIS Newsletter Index

Subject	Newsletter	Date
SILICON COMPILERS		
Silicon Compiler Companies Merge--Sign of Methodology Taking Off	SUIS	May 87
The Silicon Compilation Maze: Where Does It Lead and Who's in It?	SUIS	Jan. 87
U.S./JAPAN		
The American-Japanese Trade War and Its Effect on the Asian Electronics Industry	SUIS	June 87
Dataquest's User Conference Reviews Partnering Opportunities in the Global Electronic Industry	SUIS	Feb. 87

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	Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS Apr. 87
IBM		
	IBM's Personal System/2: Doors are Still Open for DRAM Merchant Vendors	SUIS Apr. 87
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	Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS Apr. 87
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	Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS Apr. 87
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NATIONAL SEMICONDUCTOR CORP.		
	Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS Apr. 87
NEC CORPORATION		
	Preliminary 1986 Microcomponent Manufacturer Rankings	SUIS Apr. 87
SGS-ATES SEMICONDUCTOR		
	Thomson-SGS Merger	SUIS May 87

1986–1987 SUIS Newsletter Index

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1986–1987 SUIS Newsletter Index

SUIS Code: Newsletters
1986-M1

MILITARY SEMICONDUCTOR OUTLOOK
1986-1987

SUMMARY

On November 10, Dataquest presented its outlook for military semiconductors at a one-day Military IC Procurement Conference sponsored by the Semiconductor User Information Service and Semiconductor Application Markets. This newsletter summarizes the major points covered in the presentation and includes additional information on Congressional action regarding the DoD budget. Topics covered include:

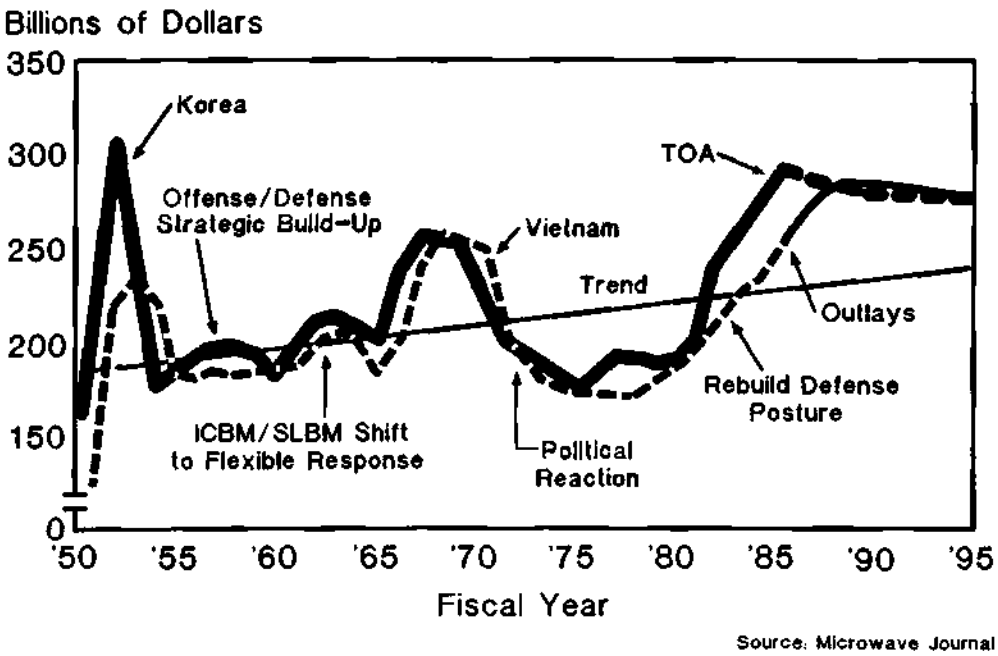
- Government programs
- DoD funding and budgeting
- Technology trends
- Semiconductor trends
- QPL suppliers and products
- 1985-1986 military semiconductor consumption
- 1987 forecast

DEFENSE BUDGET AND PROGRAMS

The Defense Department's budget continues to be driven by major program requirements, such as the Strategic Defense Initiative. Defense outlays have lagged significantly behind overall budget authorizations by as much as 15 percent, in any given year since 1982. The long-term trend line for the U.S. Defense budget has a slope of approximately 1 percent per year (in constant dollars). However, authorizations and outlays have varied substantially from this trend line depending on the state of world affairs (reference Figure 1).

Figure 1

DEFENSE BUDGET TREND



In FY'86, the estimated Defense RDT&E (Research Development Test & Evaluation) was $35.4 billion, 14.9 percent above FY'85. DoD's estimate for FY'87 is for further growth of more than 18 percent, to $42.1 billion. The major benefactor of this increase is advanced technology development (reference Table 1).

Because of the trend in recent years toward increased defense spending, numerous programs were exempted from budget cutbacks in FY'86 (see Table 2). The Strategic Defense Initiative (SDI) remained unchanged at $2.76 billion.

Table 1

DEFENSE RDT&E
(Billions of Dollars)

	FY'85	FY'86	% Chg.	FY'87	% Chg.
Technology Base	$ 3.1	$ 3.4	10.5%	$ 3.6	3.9%
Advanced Technology Development	2.8	4.2	54.0%	6.6	55.3%
Strategic Programs	8.2	8.1	(1.4%)	9.4	17.1%
Tactical Programs	9.1	10.9	20.3%	12.8	16.2%
Intelligence & Communications	3.9	4.7	19.0%	5.1	8.5%
Defense-wide Mission Support	3.8	4.1	8.1%	4.6	10.7%
Total RDT&E	$30.9	$35.4	14.9%	$42.1	18.2%

Source: Department of Defense

Table 2

PROGRAMS EXEMPTED FROM CUTBACKS
IN FY'86
(Millions of Dollars)

Program	Amount
Strategic Defense Initiative	$2,760
Mobile Subscriber Equipment	$ 335
A-6F Upgrade	$ 239
F-14 Upgrade	$ 348
EA-6B R&D	$ 78
Navstar Satellite	$ 197
DSCS-3 Communications satellite	$ 142
Nuclear Detection Satellite	$ 44
T-45 Trainer	$ 116
AV-8B R&D	$ 65
T-56 Engine R&D	$ 45
VH-60 Presidential Aircraft	$ 103

Source: Electronic News

C^3I

Command, control, communications, and intelligence (C^3I) is a growing component of the DoD budget, receiving increasing attention by Congress. DoD estimates that this part of its budget will grow to $17.4 billion in FY'87, up almost 22 percent. Table 3 summarizes the FY'86 and FY'87 C^3I budget figures at the major department level.

Table 3

C^3I BUDGET SUMMARY
(Billions of Dollars)

	FY'86	FY'87	% Chg.
Defense Agencies RDT&E	$ 2.3	$ 2.7	19.6%
Army Procurement	2.3	3.1	35.6
Army RDT&E	0.7	0.6	(8.5)
Navy Procurement	1.1	1.5	29.0
Navy RDT&E	2.1	2.4	12.4
Air Force Procurement	3.0	4.2	41.2
Air Force RDT&E	2.8	2.9	3.4
Totals	$14.3	$17.4	21.7%

Source: Department of Defense

HOUSE/SENATE BUDGET ACTIONS

For FY'87, the U.S. House of Representatives Armed Services Committee (HASC) favored cutting $1 billion in EW programs, cancelling the Army's SHORAD and Aquila RPV programs and the Navy's ASPJ and airborne EW, cutting the Air Force's JSTARS to $0 and NAVSTAR to half, and setting SDI at $3 billion. However, much funding was restored in conferences with the Senate Armed Services Committee (SASC) (see Table 4).

Table 4

FY'87 BUDGET AUTHORIZATIONS
CONGRESSIONAL COMMITTEE AGREEMENTS FOR MAJOR DoD PROGRAMS
(Millions of FY'87 Dollars)

Program	DoD Request R&D $	DoD Request Proc. $	House Auth. R&D $	House Auth. Proc. $	Senate Auth. R&D $	Senate Auth. Proc. $	Conf. Agrmnt. R&D $	Conf. Agrmnt. Proc. $
SDI	5,347		3,125		3,953		3,530	
F-16	81	3,842	54	2,668	81	3,481	65	3,121
F/A-18	59	3,406	35	2,399	59	2,443	59	2,495
Trident II Missile	1,632	1,426	1,500	1,426	1,632	1,426	1,595	1,426
DDF-51	107	2,527	82	951	107	2,545	102	2,470
SSN-688	4	2,332	0	2,332	4	2,332	0	2,250
F-15	209	2,027	139	1,152	209	2,02	179	1,816
M-1	35	2,116	25	2,050	35	2,116	30	2,050
CG-47 Aegis	38	1,924	28	2,725	38	1,924	38	2,725
C-5B	0	1,954	0	1,954	0	1,937	0	1,935
M-X Peacekeeper	352	1,473	200	1,146	322	1,418	290	1,146
Trident Submarine	51	1,509	41	0	51	1,509	41	1,446
Midgetman/SICBM	1,375	0	1,375	0	675	675	1,200	0
AH/64	13	1,342	13	1,184	13	1,103	13	1,166
Bradley IFV	20	1,200	10	890	20	1,005	15	974
Patriot	40	1,033	0	1,002	40	965	40	997
F-14A/D	268	696	240	506	268	696	260	675
Tomahawk	68	790	68	712	68	735	68	735
MSE	0	903	0	853	0	903	0	903
KC-135 Engines	0	865	0	836	0	997	0	997
C-17	612	217	587	180	547	217	547	180
LANTIRN	40	784	10	784	40	784	40	784
AV-8B	48	762	65	762	48	762	56	762
AMRAAM	58	756	39	431	58	756	58	617

Source: Dataquest
December 1986

TECHNOLOGY TRENDS

As in the past, defense electronics technology, including military semiconductors, continues to be driven by major program requirements. These include SDI; smart-skin aircraft; compact radar; VHSIC insertion;

increased demands for DSP, AI, and RISC architectures; and application of photonics to replace electronics where practical. Projected 1990 military signal processing improvements needed beyond today's technologies are shown in Table 5.

Table 5

PROJECTED 1990 MILITARY
SIGNAL PROCESSING REQUIREMENTS

Application	Processing Improvement	Volume x Power Reduction	Reliability Improvement
Signal Intelligence	100x	3x	>10x
Radar	50-100x	4-10x	2-10x
Weapons Targeting	100x	16x	10x
Image Processing	200-500x	-	-
Wideband Communications	50-70x	4x	100x
ASW-Global Search	4,000x	-	-
Electronic Warfare	1,000x	-	-

Source: Naval Research Laboratory

The M^3I (monolithic microwave/millimeter wave initiative) is a concerted effort by DoD to bring new high-speed GaAs IC technology to production status in military programs, in response to many of the demands listed in Table 5. Table 6 summarizes the major aspects of this initiative.

Table 6

M^3I/MIMIC
MONOLITHIC MICROWAVE AND MILLIMETER-WAVE INITIATIVE

- Similar to VHSIC; GaAs instead of Si
- Four Phase program
  - Feasibility studies
  - Development
  - Pilot production
  - CAD/CAE, packaging, test technology
- Technology insertion
  - ATF, MILSTAR, etc.
- Budget request exceeds $130 million

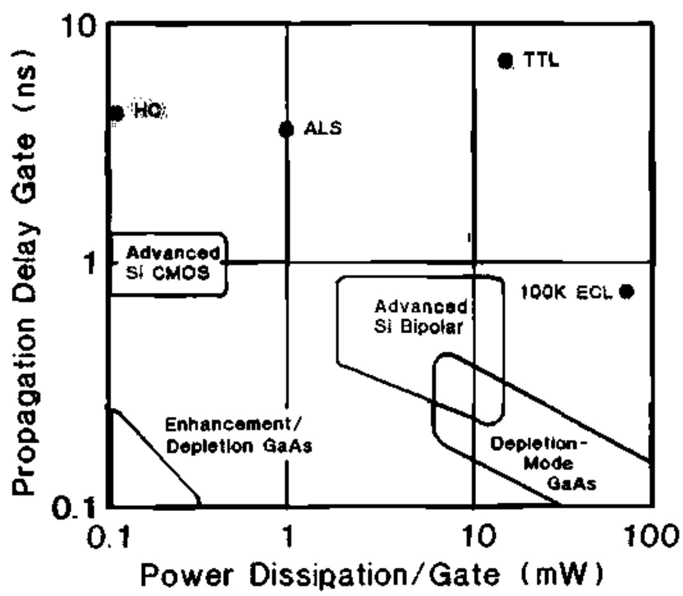
Source: DoD

SEMICONDUCTOR TRENDS

The move to photonics and integrated photonics/electronics in military hardware design is putting tremendous speed demands on the ICs involved. Figure 2 shows the present speed-power relationships of existing production IC technologies. These data, coupled with the demands of Table 5, imply increasing demand for GaAs IC technology in new designs. We believe that the more mature D-MESFET GaAs process will be quickly displaced by enhancement/depletion (E/D) processing because of the superior speed-power product of E/D devices.

Figure 2

IC TECHNOLOGY COMPARISON



Source: Vitesse Electronics Corp.

QPL IC SUPPLIERS

At least 16 companies are qualified parts list (QPL) suppliers of MIL-M-38510 ICs. However, the cost of achieving QPL status for a given product is such that none of these companies offer the full range of standard ICs (see Table 7). This situation implies a major role for IC distributors in satisfying particular customers' needs. It also contributes to continuing cost problems in military electronics systems. IC users must make careful choices in selecting alternative sources. The recent announcement of Fujitsu's intent to buy a major stake in Fairchild has raised additional concerns in this area.

Table 7

MIL-M-38510 QPL SUPPLIERS AND PRODUCTS

Company	Logic-Memories TTL	ECL	CMOS	NMOS	uPs	A/Ds, D/As	Other Linear
AMD	X						
Analog Devices						X	
Fairchild	X					X	X
GE/RCA			X				
Harris			X				
Intel				X	X		
Linear Tech.							X
MMI	X						
Motorola		X	X				
NSC	X		X				X
PMI						X	X
Raytheon	X					X	X
Signetics	X						
Thomson/Mostek				X	X		
TI	X		X				
Zilog					X		

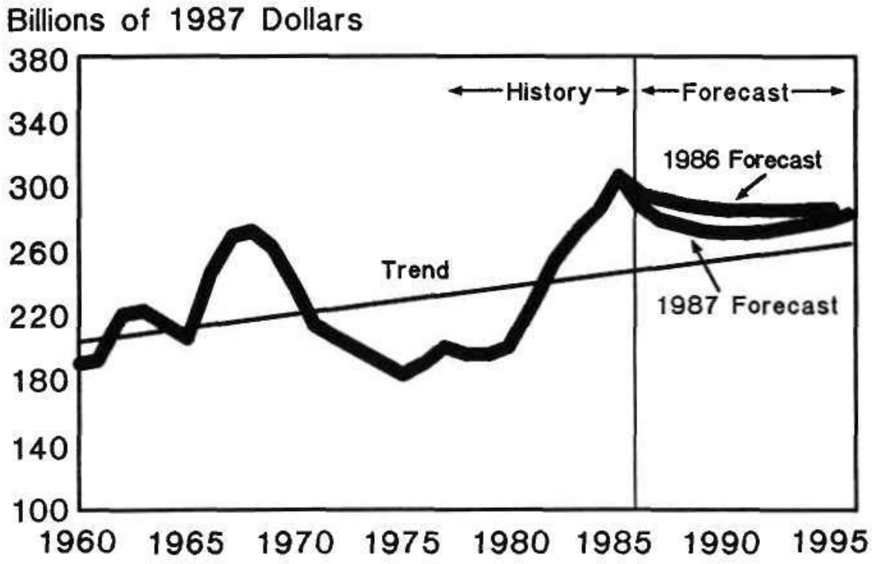
Source: Dataquest
December 1986

DoD BUDGET FORECAST

The present forecast of DoD budget authority is for spending (in constant 1987 dollars) to decline for the next three fiscal years (see Figure 3). Figures 4 and 5 break out the DoD total procurement and RDT&E budget authority forecasts extended to 1995. While the RDT&E budget is forecast to continue declining for the next decade, it remains well above the long-term trend throughout the period. Details of the EIA 1987 forecast of budget authority through 1996 are in Tables 8 and 9.

Figure 3

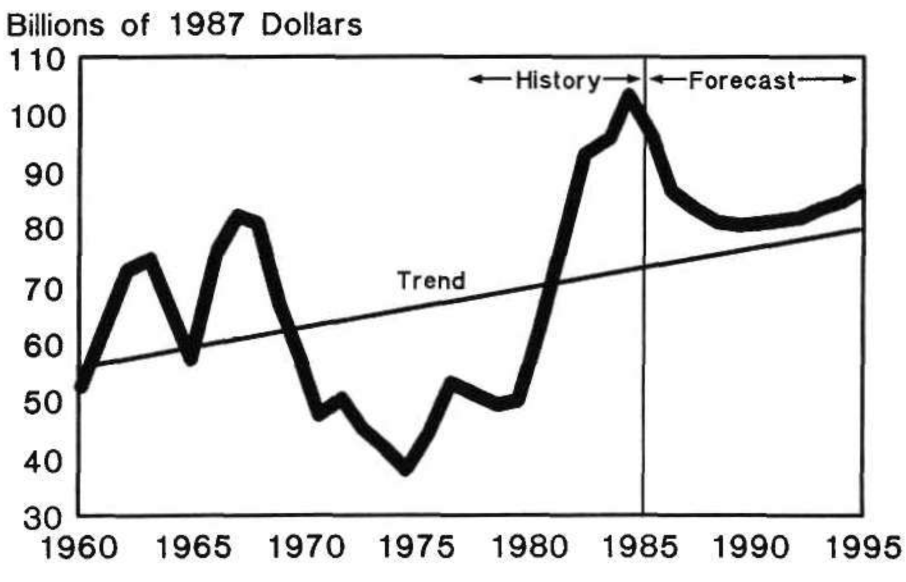
EIA DoD BUDGET AUTHORITY FORECASTS
1986 versus 1987



Source: EIA

Figure 4

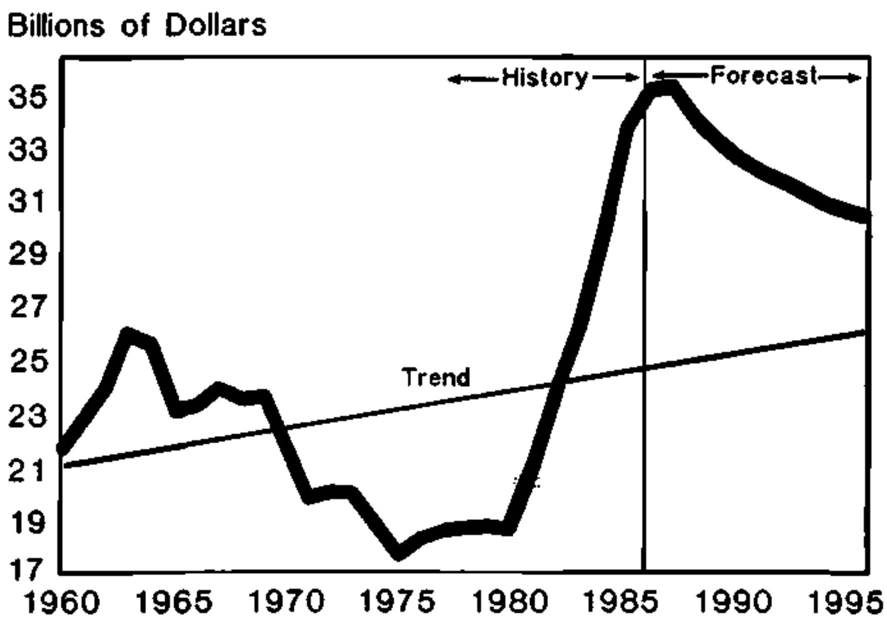
DoD PROCUREMENT BUDGET AUTHORITY FORECASTS



Source: EIA

Figure 5

DoD RDT&E AUTHORITY FORECASTS



Source: EIA

Table 8

ELECTRONIC CONTENT SUMMARY
TOTAL PROCUREMENT FORECAST
BY MAJOR PROGRAM
(In Constant FY 1987 Billions of Dollars)

Program	1985	1986	1987	1988	1989	1990
Aircraft	$11.5	$10.0	$ 8.3	$ 8.4	$ 8.3	$ 8.3
Missiles	4.9	6.0	6.1	5.9	5.7	5.6
Space	2.6	2.6	2.6	2.7	2.8	2.9
Ships	4.4	3.8	3.2	3.0	3.0	3.0
Ordnance & Weapons	1.3	1.2	1.1	1.1	1.1	1.1
Vehicles	1.1	0.9	0.9	0.9	0.9	0.9
Electronics & Communications	6.5	7.2	7.1	7.2	7.2	7.2
All Other	0.9	0.9	0.9	0.8	0.8	0.8
Total	$33.3	$32.6	$30.2	$30.0	$29.6	$29.7
Percent Change	–	(2.2)	(7.3)	(0.7)	(1.2)	0.3

Program	1991	1992	1993	1994	1995	1996
Aircraft	$ 8.4	$ 8.5	$ 8.8	$ 9.0	$ 9.2	$ 9.5
Missiles	5.6	5.5	5.5	5.5	5.5	5.4
Space	3.2	3.4	3.7	4.0	4.4	4.8
Ships	3.0	3.0	3.1	3.1	3.1	3.1
Ordnance & Weapons	1.1	1.2	1.2	1.2	1.3	1.3
Vehicles	0.9	1.0	1.0	1.0	1.0	1.0
Electronics & Communications	7.2	7.3	7.6	7.9	8.1	8.4
All Other	0.8	0.8	0.8	0.8	0.9	0.9
Total	$30.2	$30.8	$31.7	$32.7	$33.5	$34.3
Percent Change	1.5	2.0	2.9	3.1	2.5	2.5

Note: Columns may not total due to rounding.

Source: EIA

Table 9

ELECTRONIC CONTENT SUMMARY
TOTAL RDT&E FORECAST
BY MAJOR PROGRAM
(In Constant FY 1987 Billions of Dollars)

Program	1985	1986	1987	1988	1989	1990
Aircraft	$ 1.7	$ 1.7	$ 1.6	$ 1.6	$ 1.6	$ 1.5
Missiles	5.1	5.4	5.4	5.0	4.7	4.6
Space	2.5	3.0	3.3	3.6	3.8	4.0
Ships	0.6	0.6	0.6	0.5	0.5	0.5
Ordnance & Weapons	0.2	0.3	0.3	0.3	0.3	0.3
Vehicles*	0	0	0	0	0	0
Electronics & Communications	5.5	5.7	5.6	5.4	5.2	5.2
All Other	0.4	0.4	0.4	0.4	0.4	0.4
Total	$16.1	$17.1	$17.3	$16.9	$16.6	$16.5
Percent Change	-	6.4	1.0	(2.2)	(1.8)	(0.7)

Program	1991	1992	1993	1994	1995	1996
Aircraft	$ 1.5	$ 1.5	$ 1.4	$ 1.4	$ 1.4	$ 1.5
Missiles	4.5	4.4	4.1	3.9	3.8	3.8
Space	4.2	4.2	4.2	4.4	4.5	4.5
Ships	0.5	0.4	0.4	0.4	0.4	0.4
Ordnance & Weapons	0.3	0.2	0.2	0.2	0.2	0.2
Vehicles*	0	0	0	0	0	0
Electronics & Communications	5.3	5.3	5.3	5.3	5.5	5.4
All Other	0.4	0.4	0.4	0.4	0.4	0.4
Total	$16.5	$16.4	$16.0	$16.0	$16.3	$16.2
Percent Change	0	(0.5)	(2.7)	0.2	1.9	(0.4)

*Less than $0.05 billion per year
Note: Columns may not total due to rounding.

Source: EIA

NORTH AMERICAN SEMICONDUCTOR CONSUMPTION

Dataquest forecasts semiconductor consumption growth in North America at 12.4 percent through 1991 (reference Table 10). IC consumption is expected to grow slightly faster at 13.9 percent CAGR. These data include all merchant consumption, both commercial and military.

Table 10

NORTH AMERICA
SEMICONDUCTOR CONSUMPTION FORECAST
(Millions of Dollars)

	1985	1986	1987	1991	CAGR 1986-1991
Total Semiconductor	$9,607	$10,219	$11,445	$18,329	12.4%
Total Integrated Circuit	$7,710	$ 8,214	$ 9,414	$15,735	13.9%
Bipolar Digital	2,006	2,143	2,302	3,442	9.9%
MOS	4,247	4,438	5,377	9,799	16.9%
Linear	1,457	1,634	1,735	2,593	9.7%
Total Discrete	$1,528	$ 1,599	$ 1,612	$ 2,008	4.7%
Total Optoelectronic	$ 369	$ 406	$ 419	$ 586	7.6%

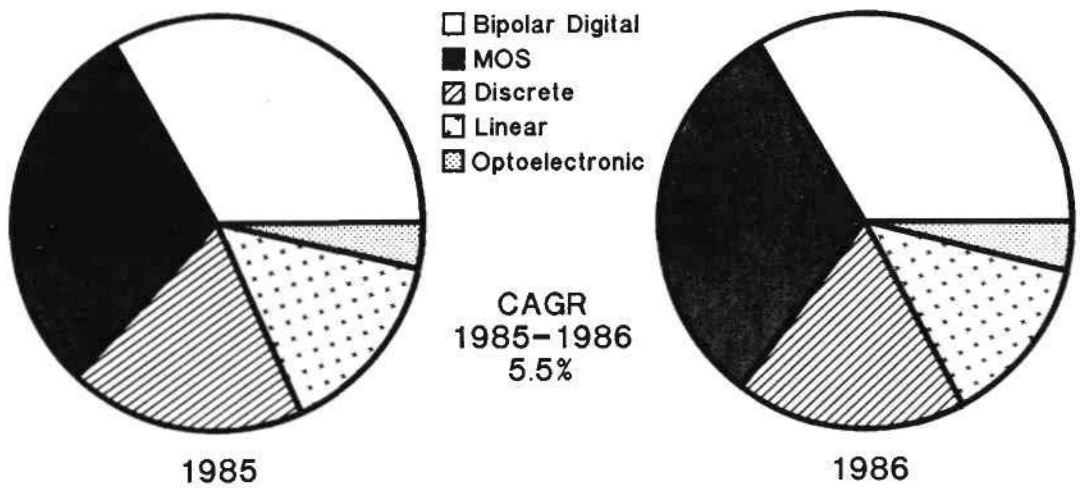
Source: Dataquest
December 1986

MILITARY SEMICONDUCTOR CONSUMPTION

Military semiconductor consumption is estimated at $1,567 million in 1986. It is expected to grow to $1,803 million in 1987, a gain of 15.1 percent. Significantly, MOS IC shipments are forecast to exceed bipolar for the first time in 1987. Figure 6 and Table 11 show the forecast details.

Figure 6

MILITARY SEMICONDUCTOR CONSUMPTION FORECAST



Source: Dataquest
December 1986

Table 11

MILITARY SEMICONDUCTOR
CONSUMPTION FORECAST
(Millions of Dollars)

	1985	1986	1987	Percent Chg. 1986-1987
Total Semiconductor	$1,486	$1,567	$1,803	15.1%
Total Integrated Circuit	$1,160	$1,225	$1,394	13.8%
Bipolar Digital	498	529	571	7.9%
MOS	442	487	578	18.7%
Linear	220	209	245	17.2%
Total Discrete	$ 278	$ 284	$ 330	16.2%
Total Optoelectronic	$ 51	$ 58	$ 79	36.2%

Source: Dataquest
December 1986

DATAQUEST CONCLUSIONS

Despite the fact that many military-range semiconductor distributor locations are well stocked, currently causing downward price pressure, the 1987 military market is expected to be one of the strongest segments of the North American semiconductor market. Because DoD outlays still lag authorizations, this segment is expected to enjoy improved growth in the near term.

U.S. military IC suppliers have cause for concern as non-U.S. firms such as Fujitsu (Fairchild), Philips (Signetics), Siemens (MSC and others), Thomson (Mostek), and possibly others attempt to grow their shares of the military market through their U.S. subsidiaries. Although Dataquest believes that DoD and the Department of Commerce will attempt to prevent the transfer of key IC technology from Fairchild to Fujitsu, it is not clear that the U.S. government shares the concern of the IC suppliers across the board.

Gene Miles

SUIS Code: Newsletters
1986-M2

JAPAN'S EXPANDING SPACE PROGRAMS DEMAND HI-REL ICs

SUMMARY

Dataquest expects Japan to increase emphasis on high-reliability (hi-rel) GaAs and Si ICs in support of its expanding space programs. While Japan claims to have a zero military budget, it has massed tremendous capabilities in aerospace hardware in recent years, and has aggressive plans for the next decade. This bulletin details some of Japan's capabilities and plans in this area.

Japan's space activities include the following programs, which require mil range and, in many cases, radiation-hardened (rad-hard) ICs and discrete semiconductors:

- Three new expandable boosters: H-I, M-38-2, and H-II
- More than ten advanced satellites
- Space platforms
- A space shuttle
- Participation in a U.S. shuttle mission
- Participation in the U.S./international space station
- Moon and Venus probes

Japan's space activities represent an increasing threat to Western leadership in satellites, platforms, and shuttles. Dataquest believes that there will be increased international interest in Japan's satellite launch capability as a result of 1986's shuttle, Ariane, and other launch failures.

DISCUSSION AND ANALYSIS

Japan has two space agencies: NASDA (National Space Development Agency) and ISAS (Institute of Space and Astronautical Science). These agencies have been responsible for launching about one satellite per year since 1970. MITI (Ministry of International Trade and Industry) serves to create competitive pressures by funding specific payloads.

Japan's space agencies are developing more than 10 satellites and space probes, many designed for geosynchronous orbit (approximately 22,000 miles altitude). These satellites require state-of-the-art GaAs and Si ICs to accomplish the intended functions within launch payload constraints. In addition, rad-hard requirements are expected to impact the IC designs.

Thirteen Japanese companies are studying the MITI/ISAS platform concept for launch by the U.S. shuttle and Japan's H-II booster (developed by Mitsubishi). The H-II booster will support manned launches by 1995. A summary of Japan's spacecraft including launch dates, type of payload and other pertinent data is given in Table 1. These include four communications satellites and two meteorological satellites designed for geosynchronous orbit.

DATAQUEST CONCLUSIONS

Japan is developing a demand for low volumes of domestically produced hi-rel, rad-hard ICs. To achieve better economies of scale, the next logical step is to take these ICs to the international marketplace. Western suppliers of mil-range ICs may experience increased market pressure as a result of Japan's space efforts.

Japan's investment in its space efforts is resulting in far greater capacities in hi-rel semiconductors, satellite systems, and launch hardware than required to support the programs listed in Table 1. In view of recent Western launch failures, we believe that Japan will likely experience increasing difficulty in attempting to keep a low profile regarding its space programs.

Gene Miles

Table 1

JAPANESE SPACECRAFT

Launch Date	Type	Name	Company	Payload (Lbs.)	Orbit Height	Comments
8/1/86	EGP	Experimental Geodetic Payload	Kawasaki	1,500	900 miles	Laser target, first H-I payload
Mid-1987	ETS-5	Engineering Test Satellite #5	Mitsubishi	N/A	Geosync.	Mobile Satcom with ships, planes
1/87	MOS-1	Marine Observation Satellite	NEC	1,650	545 miles	Carrying CCDs and other multispectral detectors
Early 1988	CS-3A	Communications Satellite #3A	Mitsubishi	N/A	Geosync.	Third-generation, 6,000 voice channels plus K- and C-band transponders
Mid-1988	CS-3B	Communications Satellite #3B	Mitsubishi	N/A	Geosync.	Sister to CS-3A
Mid-1989	GMS-4	Geosync. Meteorological Sat.	NEC	N/A	Geosync.	Weather spacecraft; H-I launch vehicle
Mid-1989	GMS-5	Geosync. Meteorological Sat.	NEC	N/A	Geosync.	$185 million development cost; 3-axis stabilized; H-I launch vehicle
Mid-1990	BS-3A	Broadcast Satellite	NEC	N/A	Geosync.	Color TV--3 channels
Mid-1991	BS-3B	Broadcast Satellite	NEC	N/A	Geosync.	Sister to BS-3A
N/A	ERS-1	Earth Resources Satellite #1	NEC/Mitsubishi	3,000	N/A	Will carry synthetic aperture radar, visible and IR sensors
1/92	ETS-6	Engineering Test Satellite #6	Mitsubishi	N/A	N/A	First H-II payload
1994	N/A	Moon Probe	N/A	N/A	Inapplic.	H-II payload; seismic detection
Mid-1990s		Venus Probe	N/A	N/A	Inapplic.	H-II payload; magnetosphere probe

Geosync. = Geosynchronous orbit (approximately 22,700 miles above Earth's surface)
N/A = Not available at press time
Inapplic. = Inapplicable

Source: AZTEK Associates

SUIS Code: Newsletters
1986-41

PROGRAMMABLE LOGIC DEVICES: THE SYNERGISTIC INTERSECTION

INTRODUCTION

A unique combination of factors have come together in the world of programmable logic devices (PLDs). As application-specific IC (ASIC) users demand shorter and shorter turnaround of their products, more attention has been focused on finding a way to deliver custom ICs in the shortest possible time. Converging with this need is a synergistic combination of new process technologies and sophisticated CAD. The bottom line is that in our opinion, the PLD market is about to experience a growth spurt. With the intersection of these factors, we believe that PLDs will not only expand in diversity of products, but also in diversity of technology.

THE SUPPLIERS AND THE MARKET

Table 1 lists the five top PLD suppliers for 1985. While most of the 1985 revenue for these companies was from bipolar products, all suppliers are now expected to have major product offerings in CMOS, as well. These companies, along with a cadre of start-up companies, are about to change the character of the market. Since the early 1980s, PLDs were made using a bipolar TTL process, but today things have changed. With the emergence of sub-2-micron CMOS technologies, suppliers have started to offer products that compete with some of the more mature TTL products. This repositioning is not to say that the TTL is on its way out, but that we expect products using both bipolar and CMOS technologies to move to speeds that are beyond the reach of today's offerings.

Table 2 provides information about the top five PLD suppliers and their products

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Table 1

ESTIMATED 1985 REVENUE--TOP FIVE PLD SUPPLIERS
(Millions of Dollars)

Rank	Company	Revenue
1	Monolithic Memories	$123
2	Signetics	44
3	Advanced Micro Devices	23
4	National Semiconductor	22
5	Texas Instruments	12
Total		$224

Source: Dataquest
December 1986

Table 2

PRODUCTS AND FEATURES--TOP FIVE PLD SUPPLIERS

Company	Product Type	Process	Alternate Sources	Product Terms
MMI	PALs, HALs	TTL, ECL	AMD, TI	80 to 256
Signetics	PLD (IFL) PLD (PML)	TTL, CMOS	TI, AMD, National, Fairchild	5 to 72
AMD	PLD (AmPAL)	TTL, ECL	Signetics, Cypress, TI	64 to 132
National	PLD (PAL)	TTL, ECL	AMD, MMI, TI, Harris, National	16 to 64
Texas Instruments	PLD (TIFPLA)	TTL	Signetics, MMI, AMD, National	32 to 64

Source: Dataquest
December 1986

Monolithic Memories

Historically, MMI has been the worldwide leader in bipolar programmable logic devices. However, realizing the importance of having a competitive CMOS device, MMI has accomplished the following:

- Signed with Xilinx for the CMOS Logic Cell Array (LCA)
- Added CMOS gate arrays to supplement its product breadth
- Added more technical support centers

MMI has obtained a 16 percent interest in Seeq Technology giving it access to EE technology for future products.

Signetics

Signetics has introduced a new bipolar architecture called Programmable Macro Logic (PML). While Signetics is not currently a major CMOS vendor in this area, it is hoping that PML will provide a new alternative in the PLD product area with benefits beyond existing bipolar PLDs.

Advanced Micro Devices

To date, AMD has not announced a new PLD architecture. However, the company may be working on some advanced devices for the future, possibly using electrically erasable technology.

National Semiconductor

NSC has second sourced MMI's TTL PAL products and in addition, it is focusing on a new high performance ECL PLD for high speed applications.

Texas Instruments

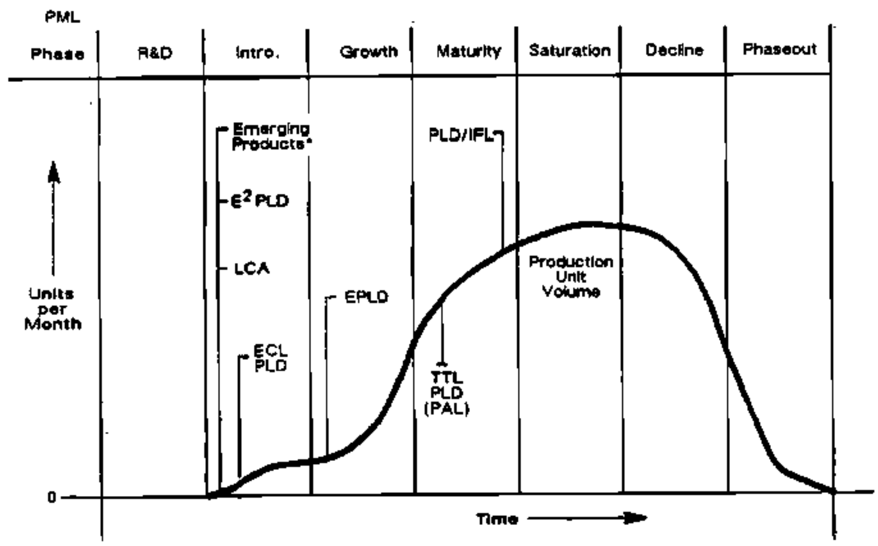
TI's strategy is to focus on the current leading PAL and FPLA devices. It considers these PLDs to be a portion of its Logic Consolidation category in ASICs. While these devices are TTL, TI is promoting ECL technology for future PLDs. The marriage of bipolar and CMOS technologies will birth BiCMOS PLDs for the best of both technologies.

Product Life Cycle

It is important to understand where these myriad devices sit in their relative life cycle. Figure 1 shows the general positioning of the major device types differentiated by technology and programming method.

Figure 1

PLD PRODUCT LIFE CYCLE



*Emerging Products: Erasic (Exel Microelectronics), ispGAL (Lattice Semiconductor), and PML (Signetics Corporation)

Source: Dataquest December 1986

What does this all mean?

It would seem that bipolar technology (in particular TTL) is far from dead. Certainly most vendors of PLDs understand the need to move into CMOS as more complex functionality and power requirements evolve. In contrast, many users still desire the speed that only bipolar, and specifically ECL technology can offer. Hence, while the demand for CMOS increases, suppliers will focus on performance oriented products that will cover the higher end applications.

What should users do?

First, users should be aware that there are two camps in PLDs. One is composed of the mature bipolar PLD products, and the other of the newer CMOS devices. PLD users who are firmly entrenched in bipolar devices shouldn't panic: The TTL devices are still viable solutions for many designs and there are numerous suppliers of those devices. Second, users who need the speed of ECL parts will see more suppliers bringing these devices to market as total throughput time is reduced to about two to three nanoseconds giving these devices an edge in performance.

A vital aspect to the PLD marketplace is the mounting variety of products in all technologies. Users should try to stay keenly aware of what products are manufactured, and by whom. Not only are there differing architectures in the form of emerging products, but also a variety of programming techniques. Without standardization, the proliferation of dissimilar devices will result in confusion for the user.

CMOS Suppliers

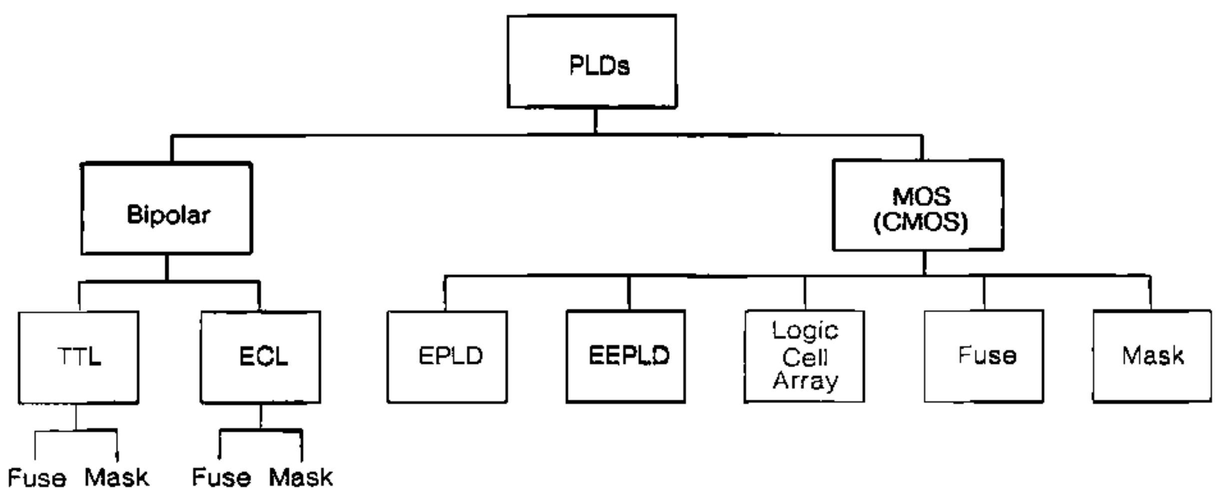
While the top five PLD suppliers discussed above are primarily manufacturers of bipolar devices, there is another set of vendors at the top of the CMOS product list. A follow-on newsletter in the near future will highlight these companies and their products.

THE PROGRAMMABLE LOGIC FAMILY AND DEFINITIONS

The family tree for programmable logic devices has grown considerably from a few years ago. This growth stems from evolution in both technology and architecture/programming methods. Figure 2 shows the current PLD product breakdown.

Figure 2

PROGRAMMABLE LOGIC FAMILY TREE



Source: Dataquest
December 1986

Definitions

- EPLD--Erasable programmable logic device
- EEPLD--Electrically erasable programmable logic device
- FPLA--Field-programmable logic array (IFL-type product)

- GAL--Generic Array Logic (trademark of Lattice)
- HAL--Hardwired Array Logic (trademark of MMI)
- IFL--Integrated Fuse Logic (trademark of Signetics)
- LCA--Logic Cell Array (trademark of Xilinx)
- PAL--Programmable Array Logic (registered trademark of MMI)
- PLD--Programmable logic device
- PML--Programmable Macro Logic (trademark of Signetics)

Table 3 shows our consumption forecast by technology for PLDs. We have divided the markets into one-time programmable (OTP) and reprogrammable products. Under each of these categories, we have estimated growth by process technology and by programming technology. It is important to note that all CMOS technologies, whether OTP or reprogrammable, are forecast to experience strong growth for the balance of the decade. In the bipolar segment, where speed is critical, we believe that there will be small but growing demand for ECL PLDs. While the majority of the demand is for OTP products, we believe that reprogrammable parts will reach consumption levels in the $350 million range by 1991.

This means that we will see a rapid expansion of new, very diverse products. As suppliers rush to introduce products, users can expect a variety of products that will:

- Increase speed
- Increase density
- Provide flexible architecture
- Use less power

Table 3

ESTIMATED WORLDWIDE CONSUMPTION OF PROGRAMMABLE LOGIC DEVICES
BY PRODUCT
(Millions of Dollars)

	1984	1985	1986	1991
Total Programmable Logic	$219.9	$234.4	$353.5	$1,263.8
MOS (CMOS)	2.7	9.4	58.5	665.2
Bipolar	217.2	225.0	295.1	598.6
One-Time Programmable (OTP)	$219.7	$230.3	$317.0	$ 914.9
MOS (CMOS)	2.5	5.3	21.9	316.3
EPLD	0	1.2	16.2	293.4
Fuse Link	2.5	3.1	4.5	15.0
Mask	0	1.0	1.2	7.9
Bipolar	$217.2	$225.0	$295.1	$ 598.6
TTL	217.2	225.0	291.4	525.4
Fuse Link	210.2	218.0	283.4	508.4
Mask	7.0	7.0	8.0	17.0
ECL	0	0	3.7	73.2
Fuse Link	0	0	3.6	70.0
Mask	0	0	0.1	3.2
Reprogrammable	$ 0.2	$ 4.1	$ 36.6	$ 348.9
MOS (CMOS)	0.2	4.1	36.6	348.9
EPLD	0.2	3.1	23.3	82.5
EEPLD	0	0.7	7.2	115.2
Cell Array	0	0.3	6.2	115.1

Source: Dataquest
October 1986

THE QUICKEST TURNAROUND

With the proliferation of new products, we expect more engineers to seek ways to customize products using PLDs. Our surveys of the engineering community show that many users are frustrated by the long development times encountered with gate arrays, cell-based ICs, and full custom. They see PLDs as a way to tailor ASICs at their desks. With the growing diversity of PLDs and the ability of the users to customize the products, we believe that demand for PLDs will be stimulated.

NEW CAD TOOLS

History has shown that first-rate CAD tools have fueled the growth of ASICs. In PLDs it is no different. Since the founding days, PLD suppliers have developed and refined CAD systems that have streamlined engineers' tasks. While most suppliers would prefer to leave the design of PLD-CAD to third-party companies, PLD manufacturers have often been the leaders in developing innovative systems to support their products. We believe that this trend will continue. As new products proliferate, we expect the PLD suppliers to offer the first PLD-CAD tools.

FAT CATALOGS

All of the above point to an exciting synergistic mix of factors that should make PLDs experience robust growth. Over the next five years, Dataquest believes that the intersection of technologies, CAD tools, and the need for quicker ASICs will drive the growth of PLDs. Users can expect to see a sharp increase in the number and diversity of products available.

Before the end of the decade, Dataquest expects to see PLD suppliers' catalogs that are as large as today's LS TTL catalogs.

(Portions of this newsletter were originally published by Dataquest's Semiconductor Industry Service.)

Brand Parks
Andrew M. Prophet

Dataquest

Conference Schedule

1986

Semiconductor	October 20-22	Hotel Inter-Continental San Diego, California
Technical Computer	November 3-5	Silverado Country Club Napa, California
Asian Peripherals	November 5-7	Hotel Okura Tokyo, Japan
Semiconductor Users/ Semiconductor Application Markets	November 10	Sheraton Harbor Island San Diego, California
Electronic Publishing	November 17-18	Westin Copley Place Boston, Massachusetts
CAD/CAM EDA	December 4-5	Santa Clara Marriott Santa Clara, California

1987

Semiconductor Users/ Semiconductor Application Markets	February 4-6	Saddlebrook Resort Tampa, Florida
Copying and Duplicating	February 23-25	San Diego Hilton Resort San Diego, California
Electronic Printer	March 23-25	Silverado Country Club Napa, California
Japanese Semiconductor	April 13-14	The Miyako Kyoto, Japan
Telecommunications	April 13-15	Silverado Country Club Napa, California
CAD/CAM	May 14-15	Hyatt Regency Monterey Monterey, California
Display Terminals	May 20-22	San Diego Hilton Resort San Diego, California
European Semiconductor	June 4-5	Palace Hotel Madrid, Spain
European Copying and Duplicating	June 25-26	The Ritz Hotel Lisbon, Portugal
Financial Services	August 17-18	Silverado Country Club Napa, California
Western European Printer	September 9-11	Palace Hotel Madrid, Spain
European Telecommunications	October 1-2	Monte Carlo, Monaco
Semiconductor	October 19-21	The Pointe Resort Phoenix, Arizona
Office Equipment Dealers	November 5-6	Hyatt Regency Monterey, California
Electronic Publishing	November 16-17	Stouffer Hotel Bedford, Massachusetts
CAD/CAM EDA	December 10-11	Santa Clara Marriott Santa Clara, California

Dataquest

Product Offerings

Industry Services

Business Computer Systems

CAD/CAM

Computer Storage—Rigid Disks

Computer Storage—Flexible Disks

Computer Storage—Tape Drives

Copying and Duplicating

Display Terminal

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Electronic Publishing

Electronic Typewriter

Electronic Whiteboard

European Semiconductor*

European Telecommunications

Gallium Arsenide

Graphics

Imaging Supplies

Japanese Semiconductor*

Office Systems

Personal Computer

Personal Computer—Worldwide Shipments and Forecasts

Robotics

Semiconductor*

Semiconductor Application Markets*

Semiconductor Equipment and Materials*

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Software—Artificial Intelligence

Software—Personal Computer

Software—UNIX

Technical Computer Systems

Technical Computer Systems—Minisupercomputers

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Executive and Financial Programs

Corporate Alliance Program

Coporate Technology Program

Financial Services Program

Strategic Executive Service

Newsletters

European PC Monitor

First Copy

Home Row

I.C. ASIA

I.C. USA

Focus Reports

The European PC Market 1985-1992

European PC Retail Pricing

PC Distribution in Europe

PC Software Markets in Europe

PC Local Area Networking Markets in Europe

The Education Market for PCs in Europe

Japanese Corporations in the European PC Markets

Home Markets for PCs in Europe

Integrated Office Systems—The Market and Its Requirements

European Market for Text Processing

Image Processing in the Office

Work Group Computing

Translation Systems

Vendor Support

The IBM 3270 Market: 1986 and Beyond

Korean Semiconductor Industry Analysis

Diskettes—The Market and Its Requirements

Directory Products

I.C. Start-Ups—1987

SpecCheck—Competitive Copier Guide

SpecCheck—Competitive Electronic Typewriter Guide

SpecCheck—Competitive Whiteboard Guide

Who's Who in CAD/CAM 1986

Future Products

- Industry Services
  - Manufacturing Automation
  - Computer Storage—Optical
  - Computer Storage—Subsystems
- Focus Reports
  - Japanese Printer Strategy
  - Japanese Telecommunications Strategy
  - Canon CX Laser—User Survey
  - Digital Signal Processing
  - PC-based Publishing
  - Taiwan Semiconductor Industry Analysis
  - China Semiconductor Industry Analysis
  - PC Distribution Channels
- Directory Products
  - SpecCheck—Competitive Facsimile Guide
  - SpecCheck—Competitive Electronic Printer Guide

*On-line delivery option available

For further information about these products, please contact your Dataquest sales representative or the Direct Marketing Group at (408) 971-9661.

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1986-40
Rev. 12/2/86

PRICE UPDATE: REALITY STRUGGLING BACK INTO THE DRIVER'S SEAT

OVERVIEW

The results of Dataquest's third quarter price survey illustrate that although the market can be modified with agreements and foreign market value (FMVs), supply and demand pricing survives. The absence of an anticipated 1986 upturn has kept semiconductor prices relatively lower than our last survey. The effects of the semiconductor agreement on prices other than DRAMs and EPROMs remain to be seen. Standard logic prices are expected to remain relatively stable through next year as some production is reduced and forecast increases in demand firm prices in the second half of 1987. Microprocessor pricing is coming under some downward pressure in certain mature 8- and 16-bit devices. These devices are being used in low-cost PC clones coming from the Far East. Enhanced 16- and 32-bit processor prices have stabilized due to a lack of demand in the performance system market that precludes cost-related price cuts.

With the exception of 256K and 1Mb DRAMs and EPROMs, memory prices remain relatively stable since our last survey. The semiconductor agreement briefly raised affected DRAM and EPROM prices above the then ongoing trend, but prices have since smoothed out as methodologies and data input become more timely and homogeneous. Average prices for the affected memory devices in the United States range from 10 to 22 percent above the preagreement price estimates. Prices outside of the United States continue to be 10 to 25 percent less. This price disparity is expected to narrow as the U.S. and Japanese governments refine their monitoring methods.

ASIC pricing has stabilized in the workhorse 2-micron technology but the 1.5-micron process has become increasingly competitive since our last survey. The sharp price declines seen in the second quarter of this year came under the scrutiny of the U.S. Commerce Department, which has indirectly stabilized pricing.

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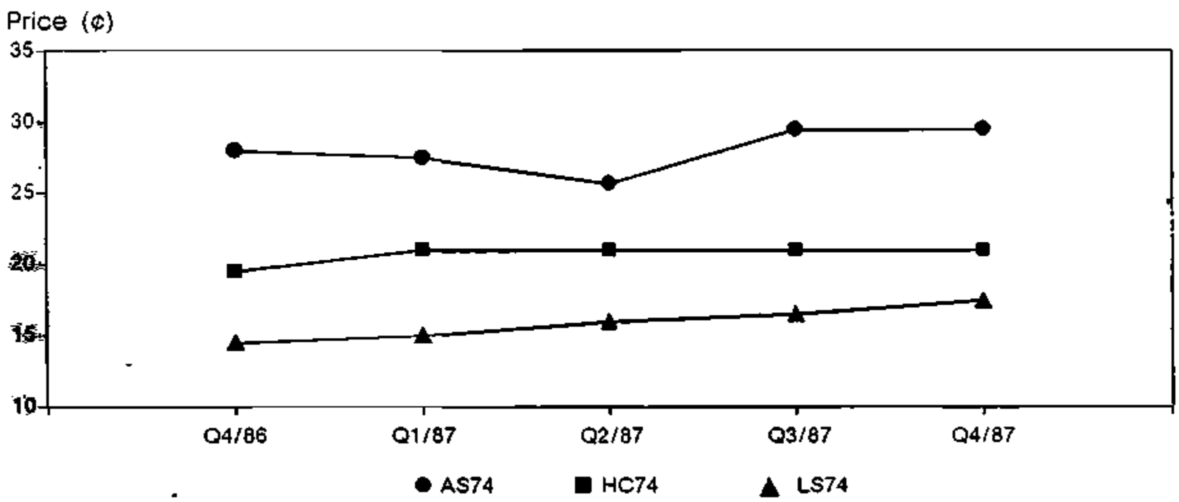
LOGIC TRENDS

Figure 1 shows the stability of the standard logic market using comparative devices in different technologies. The gradual price increases are a result of the cut backs in production levels that are being made after the long-awaited 1986 sharp upturn did not materialize. Underlying growth of 24 percent in the 1987 logic market will also reinforce this trend.

Figure 1

U.S. STANDARD LOGIC PRICE TRENDS



Source: Dataquest
November 1986

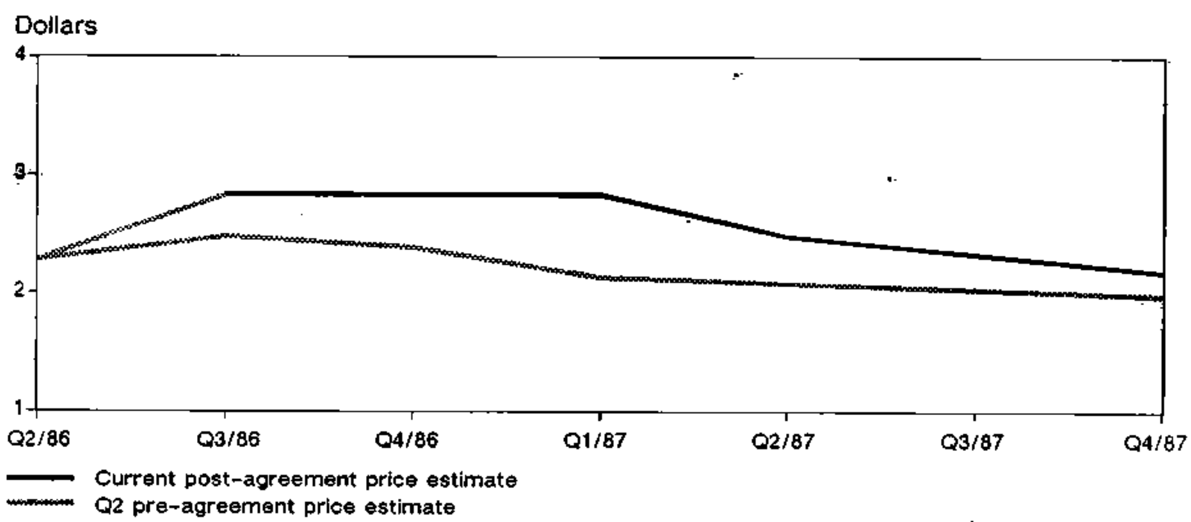
MEMORY TRENDS

At first, the semiconductor agreement added to the confusion of the volatile DRAM and EPROM market. The initial FMVs were based on a mixture of old and incomplete cost data. The second round of FMVs have come more into line with experience curve price trends and agree with our cost model. The next and future versions of memory FMVs and the monitoring of other parts by MITI are expected to more closely tie in with current costs and technology developments. This mandated stability will be welcomed by procurement managers in their long-term contract negotiations. Other than DRAMs and EPROMs, memory market pricing has not reflected any noticeable shift from our last survey. Although not included in FMVs, SRAMs are being closely watched by the Department of Commerce and their prices may stabilize or rise due to the DOC's interest alone.

Figures 2 and 3 show the semiconductor agreement long-term pricing effects on 256K and 1Mb DRAMs. As mentioned earlier in this newsletter, initial third quarter prices rose abruptly in response to uncertainty surrounding the initial FMVs. Fourth quarter prices centering around the latest FMVs are bringing prices more in line with preagreement trends.

Figure 2

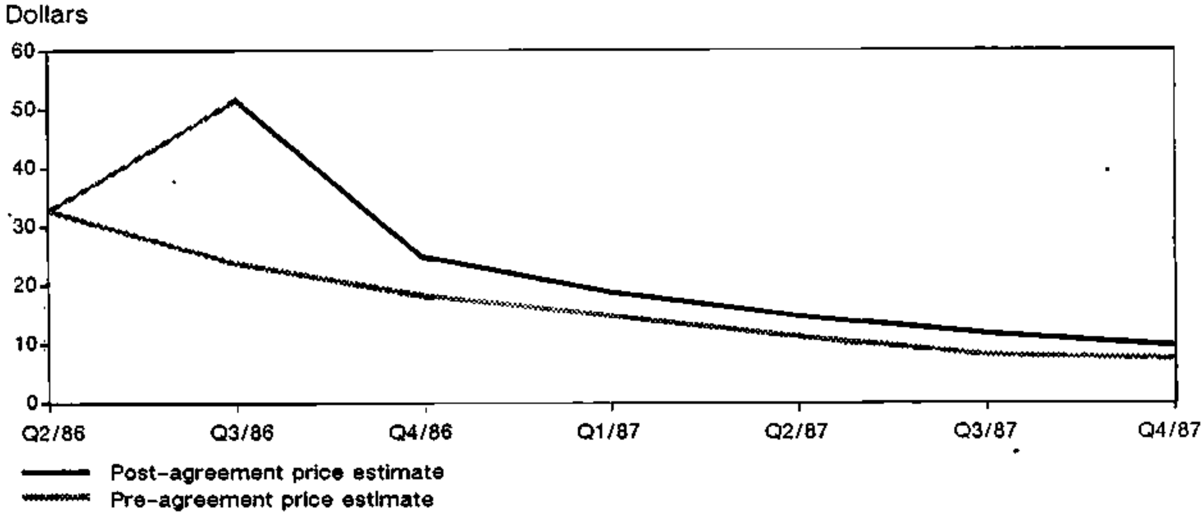
U.S. 256K DRAM PRE- AND POST-AGREEMENT PRICE COMPARISON



Source: Dataquest
November 1986

Figure 3

U.S. 1-MBIT DRAM PRE- AND POST-AGREEMENT PRICING



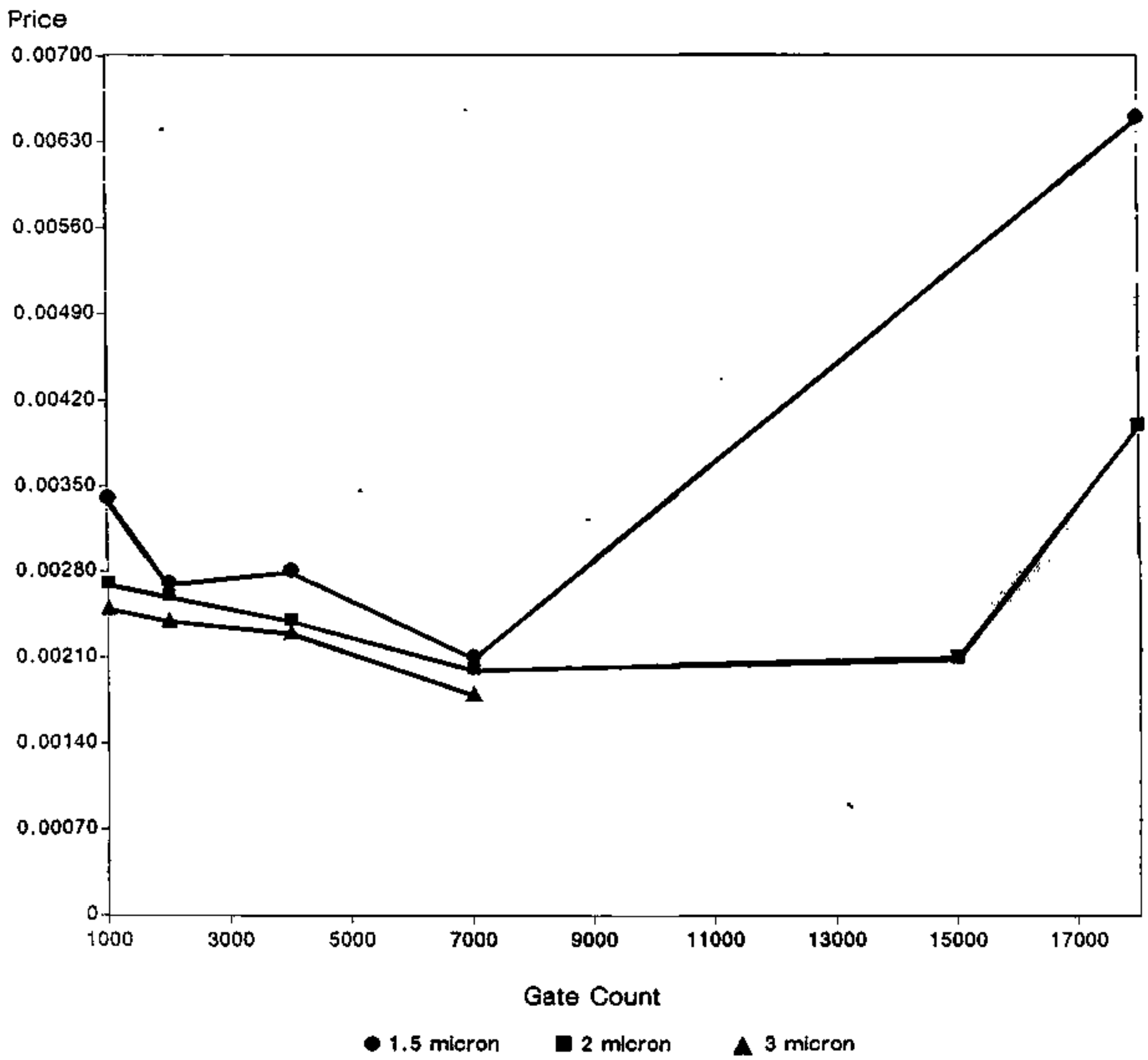
Source: Dataquest
November 1986

ASIC TRENDS

Of the two predominant ASIC design methods--cell-based designs and gate arrays--gate array prices per gate have shifted the most since our last survey. Figure 4 illustrates how the 1.5-micron CMOS process has come under strong price pressure in the 1,000 to 7,500 gate density range from the relatively mature and stable 2- and 3-micron processes. These price reductions are resulting from the ongoing price battle between Japanese and U.S. manufacturers as the emphasis shifts from the 2-micron prices, which dropped in the second quarter of this year, to the emerging 1.5-micron arena.

Figure 4

1986 U.S. GATE ARRAY PRICE TRENDS
(Pricing Per Gate)



Includes low-cost plastic package

Source: Dataquest
November 1986

DATAQUEST ANALYSIS AND RECOMMENDATIONS

Semiconductor price trends reflect the way the industry is headed. Dataquest's 1987 semiconductor industry forecast has been revised down to 12 percent from 19 percent. Likewise, prices reflect lower anticipated shipments with a corresponding generally depressed price trend. As the semiconductor industry matures, growth rates tend to decline relative to the past. The search for the "next PC" that is supposed to bring the industry back to life overlooks the fact that the industry is growing albeit slower than historic rates warrant. The volatile commodity memory pricing experienced over the past two years illustrates how exaggerated reactions to market conditions affect not only the semiconductor manufacturers but eventually the users as well as the pendulum swings from unwarranted low to higher prices.

The current price trends accommodate political involvement and industry hindsight of overly-optimistic growth projections. Slower price declines are expected across the board as production capacity adjusts to new demand levels and automation is assimilated into the manufacturing process. Procurement of semiconductors in this environment of global competition and, in some areas, two-tiered pricing requires flexibility. The strategic alliance concept that uses fewer vendors who offer the overall best total price (i.e., quality, timeliness, and ASP) can accommodate the changes to come as the electronics industry climbs a step in its growth progression. Structural as well as procedural changes in the market point to the government's desire for more consistent, gradual growth. Boom and bust cycles are not a thing of the past. They are being seen as a detriment to, and not a novelty of, a very important industry, and as such have recently received high-level attention.

Current price trends demonstrate a general malaise due to the lack of strong demand. The gradual 1987 price declines shown in our figures could reverse if demand increases quickly. Regional price differentials have and will continue to exist. MITI is targeting the price difference between domestic Japanese and exported foreign products at no more than 15 percent. Offshore procurement and manufacturing trends will continue as companies are forced to reduce their costs. This applies not only to the United States and Europe, but to Japan as well. The strategic partnering method of sourcing product when applied regionally on a worldwide basis can provide the flexibility required in the current economic environment. Although the logistics must be carefully thought out prior to sourcing product from overseas, a balance often can be achieved whereby the proximity of the vendor is matched with the total price of the raw material.

Mark Giudici

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1986-39
Rev. 11/19/86

THE SUPERALLIANCE: FUJITSU BUYS 80 PERCENT OF FAIRCHILD

SUMMARY

In a dramatic gesture, Fairchild/Schlumberger announced on October 23 that Fujitsu Limited will make a major equity investment in Fairchild. Under the agreement, Fujitsu will own approximately 80 percent and Schlumberger 20 percent of the new international company. Donald W. Brooks will remain president and CEO of the expanded Fairchild. We believe that the board of directors will consist of Fujitsu Semiconductor's Sadao Inoue, Donald Brooks, and several other Fujitsu and Schlumberger representatives. Consummation of the agreement awaits government approval.

A GLOBAL STRATEGY FOR THE 1990s

We believe that Fujitsu's investment in Fairchild is a strategic move to create a global company that will be a dominant player in the 1990s. By joining forces, Fujitsu (number 7 in 1985) and Fairchild (number 13) jump to fifth place in 1985 worldwide semiconductor ranking, as shown in Table 1. Moreover, the new Fairchild/Fujitsu company will be the largest supplier of emitter-coupled logic (ECL) devices, with $208 million in combined ECL sales in 1985 or 30.6 percent of worldwide market share. This ECL tie-up will strengthen Fujitsu, which currently sells its supercomputers through Amdahl, in the emerging supercomputer race with Cray, Control Data, Digital Equipment, Hitachi, IBM, and NEC.

CREATING SYNERGY BETWEEN COMPLEMENTARY TEAMS

The new company will benefit by combining the complementary product lines of both companies, as shown in Table 2. Fairchild is strong in bipolar devices (especially TTL and ECL), linear, military electronics, MPUs (32-bit Clipper) and smart power. Fujitsu offers TTL, ECL, linear, NMOS and CMOS memories, MPUs, ASICs (world leader in standard cells), standard logic, and Advantest (Takeda Riken) testers.

The arrangement will enable Fujitsu to sell its products worldwide under the Fairchild label and will allow Fairchild to enter the Japanese market through Fujitsu. Fairchild has a large customer base and an extensive distribution network in the United States, which will bolster U.S. sales of Fujitsu devices. Fairchild's main attraction is its U.S. plants, which will enable Fujitsu to circumvent the U.S.-Japan semiconductor agreement by producing memories in the United States at Fairchild's plants. The recent U.S.-Japan semiconductor agreement seriously hurt Fujitsu's MOS memory sales by forcing it to sell DRAMs and EPROMs at high fair market values (FMVs).

THE STRATEGIC IMPLICATIONS

Although many observers fear that Fairchild is giving away its technology to Fujitsu, we believe that this agreement not only enables Fairchild to stay in the game, but will enable both companies to become major global players in the 1990s by pooling their resources. Moreover, the U.S. Department of Defense will have access to Fujitsu's semiconductor and supercomputer technology through its procurement of Fairchild parts. The Japanese government recently agreed in principle to participate in the Strategic Defense Initiative (SDI). These agreements are the first in a series of closer U.S.-Japan commercial and military ties.

Stan Bruederle
Sheridan Tatsuno

Table 1

1985 WORLDWIDE RANKING OF SEMICONDUCTOR MAKERS
(Millions of Dollars)

Rank	Company	1985 Revenue
1	NEC	$1,984
2	Motorola	$1,830
3	Texas Instruments	$1,767
4	Hitachi	$1,671
(5)	Fujitsu/Fairchild	$1,512
5	Toshiba	$1,468
6	Philips/Signetics	$1,068
7/8	Fujitsu	$1,020
7/8	Intel	$1,020
9	National	$ 943
10	Matsushita	$ 906

Source: Dataquest
October 1986

Table 2

FAIRCHILD AND FUJITSU SEMICONDUCTOR REVENUE IN 1985
(Millions of Dollars)

Category	Fairchild	Fujitsu	Both	WW Share
Semiconductors	$492	$1,020	$1,512	6.2%
Integrated Circuits	451	940	1,391	7.5%
Bipolar Digital	329	267	596	15.9%
TTL	257	111	368	11.9%
ECL	68	140	208	30.6%
Other	4	16	20	12.7%
MOS	22	631	653	6.5%
Memory	4	412	416	10.8%
Micro Devices	10	106	116	4.3%
Logic	8	113	121	3.4%
Linear	100	42	142	3.0%
Discrete	39	37	76	1.6%
Optoelectronics	2	43	45	3.7%

Source: Dataquest
October 1986

SUIS Code: Newsletters
1986-38

NATIONAL'S TAPE PACK--A NEW SURFACE-MOUNT PACKAGE

OVERVIEW

National Semiconductor's new Tape Pack uses tape-automated bonding (TAB) technology. By combining this technology with a special molded body, Tape Pack offers a low-cost, space-efficient, prepackaged, and pretested IC in a format that lends itself to high-volume automation and surface mounting.

Tape Pack's impact on future packaging requirements will be determined by how well National can convince a significant cross section of the electronics industry to accept this package as the next-generation plastic molded package. In this newsletter, we will answer the following questions regarding Tape Pack and packaging problems in general:

- What is National's Tape Pack?
- What are some of the current packaging problems?
- Does Tape Pack offer a reasonable solution to these problems?
- What are some of the limitations of this method of packaging?
- What will it take for this package technology to become widely accepted?

WHAT IS NATIONAL'S TAPE PACK?

Since National first started using TAB in the 1970s, it has bonded more than 10 billion parts with its bumped tape process and has learned a great deal about handling taped parts. National first started using the tape bonding process on its TTL line of logic parts. Since these are typically low-cost, high-volume parts, the process had to be cost effective with wire bonding. The result was a single-layer copper tape on which the bumps were created with a carefully controlled etching process. The resulting tape has one of the lowest unit costs in the industry.

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Tape Pack incorporates a packaging method that uses bumped copper tape to make connection to an integrated circuit die. The taped IC is then molded to form an easily handled, easily tested product.

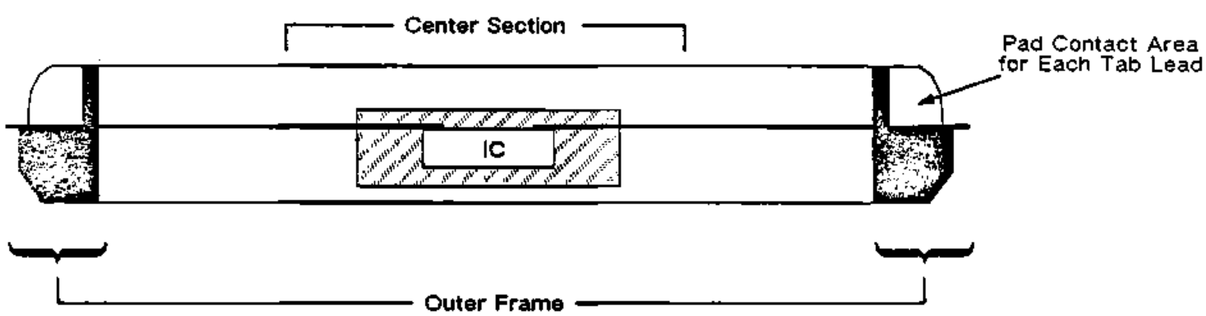
A sectional view of the completely molded package is shown in Figure 1. The center section contains the IC die bonded to the copper tape. As part of the molding process, a protective housing is formed that provides both physical and environmental protection to the die.

The second part of the device is the outside frame, which is also formed during the molding process and which performs the following key functions:

- Provides rigidity to the inside part during handling, testing, and shipping
- Protects the inside portion, including the thin leads, from damage prior to final placement
- Provides the test areas to each lead on standardized centers (typically 0.50 inch) so that conventional test equipment can be used

Figure 1

SECTIONAL VIEW OF THE TAPE PACK



Source: Dataquest
December 1986

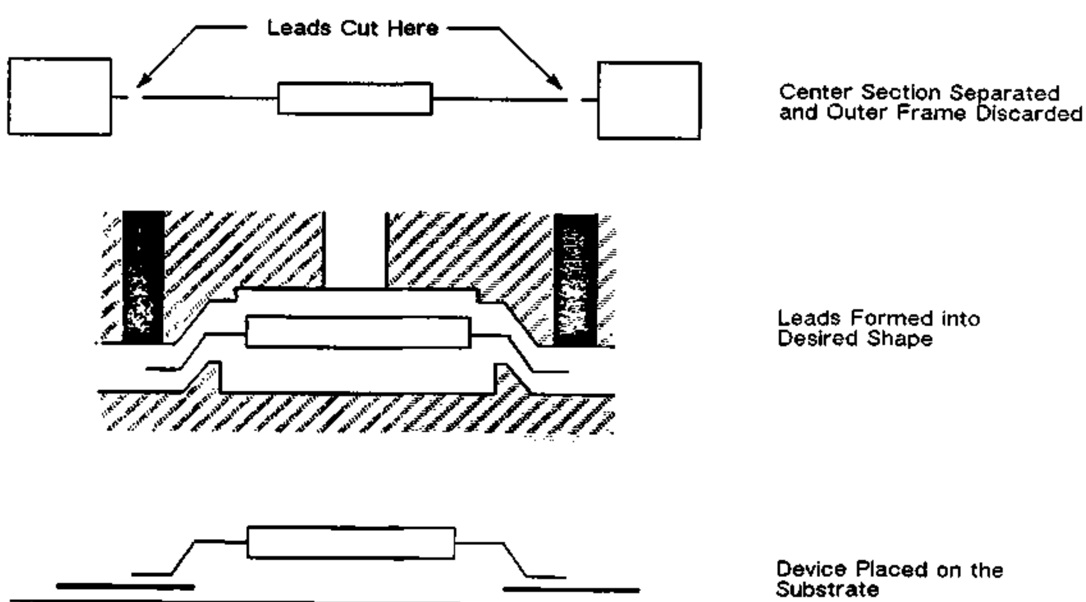
The outer frame protects the easily damaged center part during all of the handling and testing that the IC normally undergoes before it is assembled on a substrate or printed wiring board. It is critical that the thin, 0.0028-inch-thick copper foil leads are not damaged or positioned incorrectly prior to placement.

After the parts are molded, they are separated and loaded into a tube, like coins into a coin stacker. In this form they are fed through subsequent operations such as testing and marking.

In the assembly operation, a specialized placement machine removes each part from the supply tube. This assembly machine separates the inner die package from the outer frame, forms the leads to the desired share, and places the unit on the substrate or printed wiring board. The various steps are illustrated in Figure 2. Once the inner section has been separated, the outer frame, having served its purpose, is discarded.

Figure 2

BOARD ASSEMBLY PROCESS FOR THE TAPE PACK



Source: Dataquest
December 1986

WHAT ARE SOME OF THE CURRENT PACKAGING PROBLEMS?

The electronics industry is currently in a period of intense change, and electronic packaging is no exception. The industry currently faces the following problems (among others):

- A proliferation of package styles and formats. Not only is a wide range of package styles being introduced in surface-mount technology, but even conventional through-hole technology is seeing new package formats such as shrink DIP and ZIP.

- An increasing number of package leads required. For lead counts of more than 100 leads, the most viable packages are ceramic, which are quite expensive compared with molded plastic. High lead count plastic pin grid array packages are becoming available, but there is no comparable surface-mounted equivalent.

- Interconnect design becoming more complex. Higher lead count packages make the design of the next-level interconnect (in most cases a printed wiring board) more difficult. When the number of pin rows on a pin grid package reaches three or more, extra board layers are required to route the connecting traces, and this increases board cost.

- Package cost increasing with lead count. With some package types, the increase is exponential. The same is true for sockets for these high lead count packages. In some cases, the socket must be specially designed for the package, which results in a very costly socket.

- With increasing lead count, handling, testing, and repair becoming a problem. The increasing proliferation of packaging styles and formats is creating severe problems for designers of automatic component handling systems.

- Increasing signal speeds requiring improved package performance. Current package styles are performance limited. To meet this challenge, new substrate and conductor materials are being developed. These will be accompanied by new designs that will further aggravate the packaging situation.

IS TAPE PACK A REASONABLE SOLUTION TO THESE PACKAGING PROBLEMS?

Table 1 compares National's Tape Pack with currently existing package technologies in a number of areas. While not a perfect solution, Tape Pack offers a number of distinct advantages.

Proliferation of package formats has been a problem up to now because each approach has a limited range of applications. The exception to this statement is the pin grid package, but this package is not surface mountable. Tape Pack, with its ability to cover a wide lead count range, can reduce this proliferation of package formats.

Table 1

COMPARISON OF TAPE PACK AND OTHER PACKAGING TECHNOLOGIES

Parameter	PDIP	SOIC	ZIP	PLCC	Tape Pack
I/O Range	8-64	8-40	18-28	18-84	28-300
Board Area ($in.^2$) (28-Lead IC)	0.98	0.35	0.23	0.32	0.10
Single/Double Board Mounting	S	D	S	D	D
Interconnects per Square Inch	29	80	124	88	286
High-Speed Performance	Limited	Better	Limited	Better	Best
Average Cost per Lead*	$0.005	$0.006	$0.007	$0.01	$0.01
Lead Form Tooling	Moderate	Moderate	Moderate	High	Low**

*Package cost numbers can be misleading. A 64-pin plastic DIP costs disproportionately more than a 14-pin plastic DIP. The much larger volume of low lead count, lower-cost packages is reflected in a lower average cost.

**With Tape Pack, the lead form tooling is part of the assembly equipment fixturing, but is still much lower in cost than conventional tooling.

Source: Dataquest
December 1986

Package lead counts are increasing because more functions are being included in integrated circuit designs. Die with lead counts of more than 200 are already being fabricated, and some form of TAB appears to be the approach that offers the greatest promise as an alternative to using pin grid packages.

Incorporating high lead count packages into current board designs will increase board complexity as well as cost. Higher lead count pin grid packages make it difficult to route conducting traces to each pin on the printed circuit board. The solution is to add more layers to each board, but this is offset by an increased material cost and lower yield. With the National Tape Pack approach, more layers will not generally be required, but much smaller and finer traces will need to be patterned on each board. This will require much tighter process controls, but the cost increase can be significantly less if properly done.

Package costing is a very broad topic and we can only cover a small portion of it in this newsletter. To illustrate the potential cost savings of Tape Pack, assume a 1-inch square Tape Pack package. If we also assume a lead spacing of 0.025 inch, this size package will handle die with lead counts up to 160 pads. It will also handle die with as few as 80 leads. The key is that all die with I/Os between 80 and 160 would use this same package size. A one-inch square copper foil would be etched with 80, 160, or any lead count in between, and it would still be molded into this same size frame. The only element that would affect the cost of each die with a different lead count in the range between 80 and 160 leads is the artwork needed to generate each lead pattern in the copper foil. This is a very small cost.

An analogy that may help explain how Tape Pack can reduce package costs requires visualizing a stairway. Each step of the stairs represents a range of package lead counts (in the above example 80 to 160 leads). Once the tooling for that step is purchased, any lead count within that range can be made with essentially no additional cost.

Using this same analogy, testers and other handlers would be designed to handle the lead counts on a specific stairstep. This cannot be done with any of the current package formats.

In the last area, Tape Pack or some form of TAB will be required for handling the higher signal speeds currently under development. Nearly all methods of packaging except TAB significantly affect high-speed performance because of the inductance, capacitance, and resistance of the package leads.

WHAT ARE THE LIMITATIONS OF THIS PACKAGING METHOD?

Like many other things in this world, Tape Pack has a number of drawbacks. Some of these are currently being studied, while others have not been addressed because of resource limitations.

Dam Bars

Copper foil is very thin, and when it is etched into a pattern, the individual leads move and can easily become mispositioned. To minimize this lead movement, they are interconnected; these interconnections are called dam bars. After a part has been bonded and molded, these dam bars must be removed in order to electrically test the part. Removal of these dam bars is a problem. They are very thin, very close together, and to remove them with conventional tooling is very difficult and very expensive. National is considering using a laser to do this separation; this is currently under development.

Mold Tooling

Mold tooling of any sort tends to be expensive. The cost of mold tooling increases as the part size decreases and as the complexity increases. Since Tape Pack is both small and complex, mold tooling is very expensive. Unless this can be reduced, the only solution lies in running a sufficiently large volume of product so that the allocated cost becomes minimal.

Nonstandard Lead Pitch

While Tape Pack's lead-to-lead spacing is uniform and standard at the outside ring, when the inner part is separated the leads may be on some nonstandard lead pitch. While not a major problem, CAD systems will need to be able to provide routing and bond pads on these nonstandard values.

Separating, Forming, and Bonding

For low lead count parts (less than 160), separating, forming, and bonding appear to be straightforward. For parts with lead counts higher than this, no one knows what problems might be encountered because these processes have not been done yet. Any one of these processes could become a problem at very high lead counts, and much work remains to be done in this area.

Handling One Unit After Separation

While each part can be handled with the outer frame attached, there is no way of manually handling these parts after frame separation. Just like conventional TAB, the parts can only be handled when they are mounted in a carrier, and like TAB, they can only be bonded using a specialized machine. You cannot use a small soldering iron and solder them in place. This can only be done using a specially designed bonder, either automatic or manual.

WHAT WILL IT TAKE FOR THIS PACKAGE TO BECOME WIDELY ACCEPTED?

For any new package to become widely accepted, it must offer a number of advantages over current packaging methods. We have shown that Tape Pack appears to offer a number of advantages. It also has a number of disadvantages. We believe that National's goal should be to continue to address these limitations with the goal of either eliminating them or reducing them to acceptable levels.

One other factor not mentioned above and that might be considered a drawback is that National has patented this process and there is a license fee attached. We consider this reasonable because National has already made a substantial investment in this process. A benefit of this licensing is that it would result in products with standardized dimensions. However, a number of semiconductor companies will see this as a major drawback and some may attempt to develop their own package. It will be up to National to convince these companies that the package savings is sufficient to offset the license fee, or National will have to reduce or eliminate its fee.

One of the obvious benefits of this package is that it lends itself to automated assembly. For this reason, the success of this package is tied to the level of automated assembly that is present in manufacturing. While tremendous progress is being made in this area, only a few companies have truly developed the level of automation necessary to take advantage of this package. At the present time, only one company (Universal Instruments) has a module that will take a tube of these parts and mount them on a printed wiring board.

DATAQUEST ANALYSIS

Tape Pack appears to offer a reasonable solution to a number of the more pressing problems currently being encountered in the IC package area. While there are some drawbacks with this technology, progress is being made, and at some point in the future we expect that these will either be eliminated or reduced to an acceptable level.

Tape Pack's success depends on how well National can convince a sufficient number of users and other semiconductor companies to incorporate this package style into their product lines. So far, the only licensee has been Delco. This package style appears to be ideal for automotive applications because of the volume and the automation involved.

One semiconductor company that we believe National should approach is Fairchild. Fairchild has much the same background with TAB as National does, and it should be in a good position to evaluate this package technology.

A situation that we hope can be avoided is the proliferation of package styles that seem to affect every new package design. We are reaching a point in the manufacturing process where these vendor variations are creating major problems for board designers and assemblers. One way of preventing this is to tool an outside contract assembly company like Amkor or Indy, so that companies wishing to evaluate this package can obtain parts without making a substantial investment in up-front costs.

If these were the only problems, the job of developing the infrastructure for a new package would be relatively easy, but it is not. Handlers, testers, and other pick and place equipment is needed. Specialized repair stations will be needed, as will specialized soldering equipment.

The next few years will be critical for this package technology. If it is going to succeed, a number of companies will have to make a commitment to support it. This will require financial, as well as technical and material resources, all of which are in short supply. It will also require a focusing on how advanced package styles can be standardized. The alternative can best be described by the answers we recently received to a question asked a panel of packaging experts. The question was, "What package style do you see for commercial applications for die with I/Os over 200 and with no special heat dissipation requirements?" We received seven different answers and one abstention.

Stan Bruederle
Dave Francis

Dataquest

Conference Schedule

1986

Semiconductor	October 20–22	Hotel Inter-Continental San Diego, California
Technical Computer	November 3–5	Silverado Country Club Napa, California
Asian Peripherals	November 5–7	Hotel Okura Tokyo, Japan
Semiconductor Users/ Semiconductor Application Markets	November 10	Sheraton Harbor Island San Diego, California
Electronic Publishing	November 17–18	Westin Copley Place Boston, Massachusetts
CAD/CAM EDA	December 4–5	Santa Clara Marriott Santa Clara, California

1987

Semiconductor Users/ Semiconductor Application Markets	February 4–6	Saddlebrook Resort Tampa, Florida
Copying and Duplicating	February 23–25	San Diego Hilton Resort San Diego, California
Electronic Printer	March 23–25	Silverado Country Club Napa, California
Japanese Semiconductor	April 13–14	The Miyako Kyoto, Japan
Telecommunications	April 13–15	Silverado Country Club Napa, California
CAD/CAM	May 14–15	Hyatt Regency Monterey Monterey, California
Display Terminals	May 20–22	San Diego Hilton Resort San Diego, California
European Semiconductor	June 4–5	Palace Hotel Madrid, Spain
European Copying and Duplicating	June 25–26	The Ritz Hotel Lisbon, Portugal
Financial Services	August 17–18	Silverado Country Club Napa, California
Western European Printer	September 9–11	Palace Hotel Madrid, Spain
European Telecommunications	October 1–2	Monte Carlo, Monaco
Semiconductor	October 19–21	The Pointe Resort Phoenix, Arizona
Office Equipment Dealers	November 5–6	Hyatt Regency Monterey, California
Electronic Publishing	November 16–17	Stouffer Hotel Bedford, Massachusetts
CAD/CAM EDA	December 10–11	Santa Clara Marriott Santa Clara, California

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Korean Semiconductor Industry Analysis

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Directory Products

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SpecCheck—Competitive Electronic Typewriter Guide

SpecCheck—Competitive Whiteboard Guide

Who's Who in CAD/CAM 1986

Future Products

- Industry Services
  - Manufacturing Automation
  - Computer Storage—Optical
  - Computer Storage—Subsystems
- Focus Reports
  - Japanese Printer Strategy
  - Japanese Telecommunications Strategy
  - Canon CX Laser—User Survey
  - Digital Signal Processing
  - PC-based Publishing
  - Taiwan Semiconductor Industry Analysis
  - China Semiconductor Industry Analysis
  - PC Distribution Channels
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USER UPDATE

SUIS Code: Newsletters
1986-37

JAPANESE SEMICONDUCTOR MARKET QUARTERLY UPDATE: HIGH YEN MASKS A DEPRESSED MARKET

SUMMARY

Nearly everything we said in our August market update newsletter (JSIS Number 1986-33, "Japanese Semiconductor Market Quarterly Update: High Yen Wreaking Havoc on Japanese Consumption") is still true. However, we are sufficiently pessimistic about what those things mean that we have revised our third and fourth quarter 1986 and most of 1987 projections downward from the last forecast.

We believe that the Japanese semiconductor market will grow 40.6 percent in dollars, this year, followed by a 19.4 percent increase in 1987. In terms of yen, however, the Japanese market--which grew only 1.1 percent in first quarter 1986 and 1.4 percent in second quarter 1986--will experience negative growth in both third and fourth quarter 1986, resulting in a decline of 2.0 percent for the year.

We have used actual exchange rates for the first three quarters of 1986: ¥188, ¥170, and ¥155 per dollar, respectively. The ¥155 exchange rate is carried forward through fourth quarter 1986 and through the four quarters of 1987.

Figure 1 shows quarter-to-quarter percent growth in yen for the Japanese semiconductor market from the first quarter of 1985 through the fourth quarter of 1987. Figure 2 presents the same data in dollars. A comparison of these two graphs shows that the dramatic ascent of the yen makes a depressed industry appear to be undergoing strong growth when expressed in dollars.

FORECAST

Our quarterly forecast, in both yen and dollars, is shown in Tables 1 through 4.

We expect to see a healthier market in 1987, as the painful adjustment period accompanying the yen's rise ends and the market begins to stabilize. We believe that the total Japanese semiconductor market will grow 11.4 percent in yen in 1987, or 19.4 percent in dollars.

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Our revised forecast is based on the following:

- The strength of the yen against the dollar is causing end-equipment production to sag in third and fourth quarter 1986. We believe that this situation will continue in the first two quarters of 1987. Japanese industry is beginning to adjust to the age of the high yen, but we believe that the complete adjustment process will take at least one year. The movement of end-equipment production offshore from Japan has caused us to lower the 1987 growth forecast to only 11.4 percent in yen.

- Increasing competition among semiconductor suppliers in Japan is causing continued pricing pressure. We believe that price decreases will continue through second quarter 1987. Unit growth may be high, but in value it will be very tough for the Japanese semiconductor industry to have a high growth rate. There is still a good deal of overcapacity in the industry; therefore, the impetus is still to sell as much as possible at low prices in order to keep factories running.

- The effects of the price monitoring and demand forecasting provisions of the U.S.-Japan Semiconductor Trade Arrangement have not yet been felt. MITI is now in the process of establishing new pricing systems for Japanese companies in Japan and third countries. We believe that the effects of these efforts will contribute to a healthier market beginning early in 1987.

DATAQUEST CONCLUSIONS

The Japanese market will surpass the U.S. market as the world's largest semiconductor market in 1986, with total consumption of $12.1 billion. Because of the U.S.-Japan Semiconductor Trade Arrangement and pricing pressure caused by the ascent of the yen versus the dollar, we expect this always intensely competitive market to become even more fiercely competitive.

The structure of the Japanese semiconductor industry is going through its biggest upheaval in history. For the first time since the 1975 industry recession--when the Japanese market was only slightly larger than the European semiconductor market--the Japanese industry is taking drastic cost-cutting measures. Executive salaries and bonuses are being slashed and temporary workers are being let go in droves. The export-driven Japanese economy is being threatened by pressure from Japan's international trading partners to increase domestic consumption. The mood in Tokyo is grim, but we believe that stability will be recaptured in the second half of 1987 and that the Japanese semiconductor market will remain a major opportunity for suppliers.

Stan Bruederle
Patricia S. Cox

Figure 1

JAPANESE SEMICONDUCTOR MARKET
QUARTER-TO-QUARTER PERCENT GROWTH IN YEN

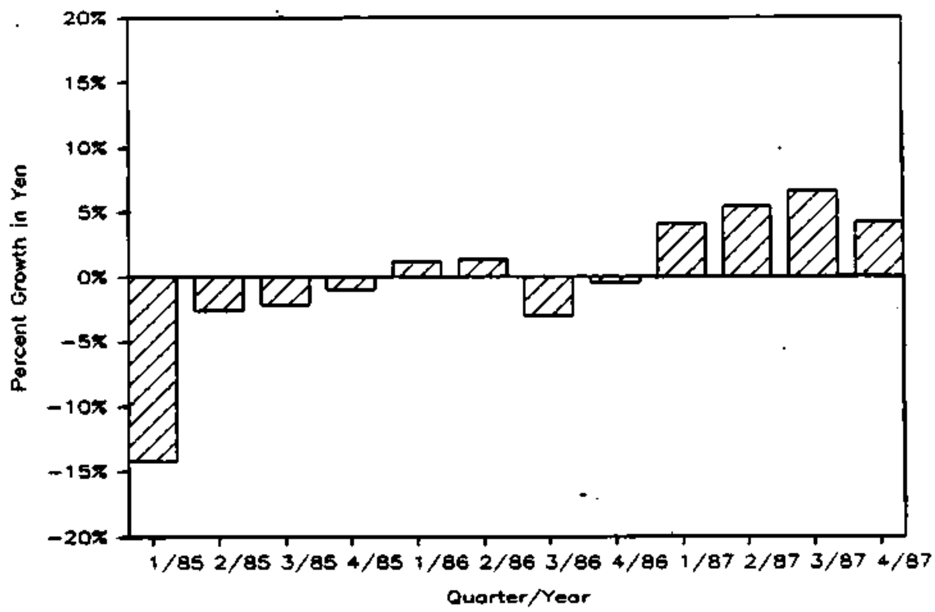
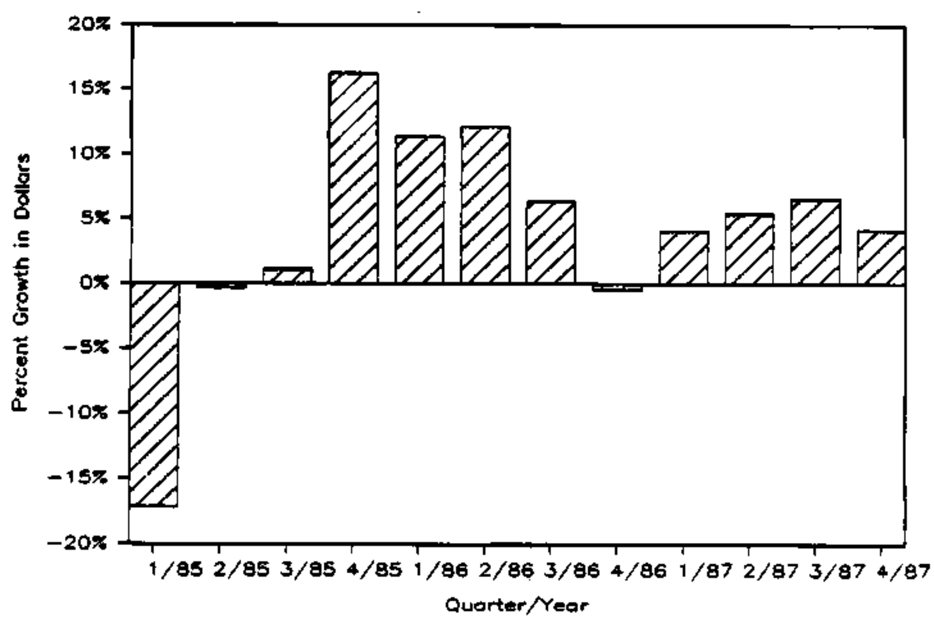


Figure 2

JAPANESE SEMICONDUCTOR MARKET
QUARTER-TO-QUARTER PERCENT GROWTH IN DOLLARS



Source: Dataquest
October 1986

Table 1

FORECAST QUARTERLY JAPANESE SEMICONDUCTOR CONSUMPTION
PERCENT GROWTH
1985-1987
(Percent of Yen)

	Q1/85	Q2/85	Q3/85	Q4/85	1985
Total Semiconductor		-2.6%	¥-2.2%	¥-1.0%	¥-2.3%
Total IC		-2.7%	-3.0%	-2.0%	-1.5%
Bipolar Digital		-10.5%	-8.3%	-0.6%	-3.8%
Memory		-10.3%	-10.3%	-8.6%	-4.5%
Logic		-10.6%	-8.0%	0.7%	-3.7%
MOS		-3.7%	-4.4%	-5.2%	-3.2%
Memory		-12.8%	-17.7%	-5.5%	-19.5%
Micro Device		10.9%	10.9%	4.6%	2.2%
Logic		-1.1%	-0.1%	-12.2%	17.2%
Linear		3.9%	2.4%	3.1%	2.9%
Discrete		-3.8%	-2.2%	1.5%	-5.8%
Optoelectronic		2.8%	10.0%	4.5%	-1.3%

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	1.1%	1.4%	-3.0%	-0.4%	-2.0%
Total IC	2.3%	1.9%	-2.8%	1.4%	-1.2%
Bipolar Digital	-1.0%	6.3%	2.2%	4.6%	-1.9%
Memory	0.0%	3.1%	3.0%	2.9%	-10.4%
Logic	-1.1%	6.8%	2.0%	4.8%	-0.7%
MOS	5.2%	0.7%	-2.9%	5.4%	-1.9%
Memory	1.9%	2.3%	-4.3%	0.0%	-15.7%
Micro Device	6.7%	-5.9%	-8.8%	5.0%	9.8%
Logic	7.1%	5.0%	2.8%	10.1%	4.3%
Linear	-1.0%	1.9%	-4.8%	-7.0%	0.5%
Discrete	-4.1%	-0.1%	-5.0%	-8.1%	-9.3%
Optoelectronic	2.7%	-0.6%	0.3%	-2.0%	10.9%

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	4.1%	5.4%	6.6%	4.2%	11.4%
Total IC	4.7%	6.3%	7.8%	4.8%	15.5%
Bipolar Digital	4.7%	4.5%	3.2%	1.3%	17.1%
Memory	1.4%	4.2%	5.4%	3.8%	13.4%
Logic	5.2%	4.6%	3.0%	1.0%	17.6%
MOS	6.5%	9.1%	9.3%	6.9%	24.5%
Memory	6.1%	9.9%	11.1%	7.6%	20.9%
Micro Device	7.8%	9.7%	12.0%	7.2%	21.9%
Logic	6.0%	8.0%	6.0%	6.2%	29.6%
Linear	1.3%	1.7%	7.1%	2.1%	-1.0%
Discrete	1.4%	2.3%	2.1%	2.0%	-4.3%
Optoelectronic	2.3%	1.3%	1.3%	0.9%	2.7%

Source: Dataquest
October 1986

Table 2

FORECAST QUARTERLY JAPANESE SEMICONDUCTOR CONSUMPTION
1985-1987
(Billions of Yen)

	Q1/85	Q2/85	Q3/85	Q4/85	1985
Total Semiconductor	529.1	515.3	504.2	499.3	2,047.9
Total IC	407.1	396.3	384.6	377.0	1,565.0
Bipolar Digital	64.5	57.7	52.9	52.6	227.7
Memory	8.7	7.8	7.0	6.4	29.9
Logic	55.8	49.9	45.9	46.2	197.8
MOS	228.5	220.1	210.4	199.4	858.4
Memory	99.5	86.8	71.4	67.5	325.2
Micro Device	47.8	53.0	58.8	61.5	221.1
Logic	81.2	80.3	80.2	70.4	312.1
Linear	114.1	118.5	121.3	125.0	478.9
Discrete	96.6	92.9	90.9	92.3	372.7
Optoelectronic	25.4	26.1	28.7	30.0	110.2
Exchange Rate	257.0	251.0	243.0	207.0	237.0
	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	504.9	511.8	496.4	494.2	2,007.3
Total IC	385.6	392.8	381.7	386.9	1,547.0
Bipolar Digital	52.1	55.4	56.6	59.2	223.3
Memory	6.4	6.6	6.8	7.0	26.8
Logic	45.7	48.8	49.8	52.2	196.5
MOS	209.8	211.3	205.1	216.1	842.3
Memory	68.8	70.4	67.4	67.4	274.0
Micro Device	65.6	61.7	56.3	59.1	242.7
Logic	75.4	79.2	81.4	89.6	325.6
Linear	123.7	126.1	120.0	111.6	481.4
Discrete	88.5	88.4	84.0	77.2	338.1
Optoelectronic	30.8	30.6	30.7	30.1	122.2
Exchange Rate	188.0	170.0	155.0	155.0	166.0
	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	514.3	542.1	577.8	602.1	2,236.3
Total IC	405.2	430.8	464.4	486.8	1,787.2
Bipolar Digital	62.0	64.8	66.9	67.8	261.5
Memory	7.1	7.4	7.8	8.1	30.4
Logic	54.9	57.4	59.1	59.7	231.1
MOS	230.2	251.1	274.4	293.3	1,049.0
Memory	71.5	78.6	87.3	93.9	331.3
Micro Device	63.7	69.9	78.3	83.9	295.8
Logic	95.0	102.6	108.8	115.5	421.9
Linear	113.0	114.9	123.1	125.7	476.7
Discrete	78.3	80.1	81.8	83.4	323.6
Optoelectronic	30.8	31.2	31.6	31.9	125.5
Exchange Rate	155.0	155.0	155.0	155.0	155.0

Source: Dataquest
October 1986

Table 3

FORECAST QUARTERLY JAPANESE SEMICONDUCTOR CONSUMPTION
PERCENT GROWTH
1985-1987
(Percent of Dollars)

	Q1/85	Q2/85	Q3/85	Q4/85	1985
Total Semiconductor		-0.3%	1.1%	16.2%	-2.8%
Total IC		-0.3%	0.3%	15.0%	-2.1%
Bipolar Digital		-8.4%	-5.2%	16.5%	-4.6%
Memory		-8.8%	-6.5%	6.9%	-5.3%
Logic		-8.3%	-5.0%	18.0%	-4.5%
MOS		-1.3%	-1.3%	11.2%	-3.9%
Memory		-10.6%	-15.0%	10.9%	-20.6%
Micro Device		13.4%	14.7%	22.7%	2.5%
Logic		1.3%	3.1%	3.0%	16.2%
Linear		6.3%	5.7%	21.0%	2.8%
Discrete		-1.6%	1.1%	19.3%	-6.2%
Optoelectronic		5.1%	13.5%	22.9%	-1.1%
	Q1/86	**Q2/86**	**Q3/86**	**Q4/86**	**1986**
Total Semiconductor	11.4%	12.1%	6.3%	-0.4%	40.6%
Total IC	12.7%	12.7%	6.5%	1.4%	41.9%
Bipolar Digital	9.1%	17.7%	12.0%	4.7%	41.7%
Memory	9.7%	14.7%	12.8%	2.3%	29.6%
Logic	9.0%	18.1%	11.8%	5.0%	43.5%
MOS	15.9%	11.4%	6.4%	5.4%	41.2%
Memory	12.3%	13.1%	5.1%	0.0%	22.0%
Micro Device	17.5%	4.0%	0.0%	5.0%	55.6%
Logic	17.9%	16.2%	12.7%	10.1%	50.8%
Linear	9.0%	12.8%	4.3%	-7.0%	43.4%
Discrete	5.6%	10.4%	4.2%	-8.1%	29.7%
Optoelectronic	13.1%	9.8%	10.0%	-2.0%	57.9%
	Q1/87	**Q2/87**	**Q3/87**	**Q4/87**	**1987**
Total Semiconductor	4.1%	5.4%	6.6%	4.2%	19.4%
Total IC	4.7%	6.3%	7.8%	4.8%	23.7%
Bipolar Digital	4.7%	4.5%	3.1%	1.4%	24.9%
Memory	2.2%	4.3%	4.2%	4.0%	21.0%
Logic	5.0%	4.5%	3.0%	1.0%	25.4%
MOS	6.5%	9.1%	9.3%	6.9%	33.3%
Memory	6.0%	10.0%	11.0%	7.6%	29.5%
Micro Device	7.9%	9.7%	12.0%	7.1%	31.0%
Logic	6.1%	8.0%	6.0%	6.1%	38.2%
Linear	1.3%	1.6%	7.2%	2.1%	6.3%
Discrete	1.4%	2.4%	2.1%	1.9%	2.8%
Optoelectronic	2.6%	1.0%	1.5%	1.0%	10.1%

Source: Dataquest
October 1986
Ref. #1086

Table 4

FORECAST QUARTERLY JAPANESE SEMICONDUCTOR CONSUMPTION 1985-1987 (Millions of Dollars)

	Q1/85	Q2/85	Q3/85	Q4/85	1985
Total Semiconductor	2,059	2,053	2,075	2,412	8,599
Total IC	1,584	1,579	1,583	1,821	6,567
Bipolar Digital	251	230	218	254	953
Memory	34	31	29	31	125
Logic	217	199	189	223	828
MOS	889	877	866	963	3,595
Memory	387	346	294	326	1,353
Micro Device	186	211	242	297	936
Logic	316	320	330	340	1,306
Linear	444	472	499	604	2,019
Discrete	376	370	374	446	1,566
Optoelectronic	99	104	118	145	466
Exchange Rate	257	251	243	207	237

	Q1/86	Q2/86	Q3/86	Q4/86	1986
Total Semiconductor	2,686	3,011	3,202	3,188	12,087
Total IC	2,051	2,311	2,462	2,496	9,320
Bipolar Digital	277	326	365	382	1,350
Memory	34	39	44	45	162
Logic	243	287	321	337	1,188
MOS	1,116	1,243	1,323	1,394	5,076
Memory	366	414	435	435	1,650
Micro Device	349	363	363	381	1,456
Logic	401	466	525	578	1,970
Linear	658	742	774	720	2,894
Discrete	471	520	542	498	2,031
Optoelectronic	164	180	198	194	736
Exchange Rate	188	170	155	155	166

	Q1/87	Q2/87	Q3/87	Q4/87	1987
Total Semiconductor	3,318	3,497	3,727	3,884	14,426
Total IC	2,614	2,779	2,995	3,140	11,528
Bipolar Digital	400	418	431	437	1,686
Memory	46	48	50	52	196
Logic	354	370	381	385	1,490
MOS	1,485	1,620	1,770	1,892	6,767
Memory	461	507	563	606	2,137
Micro Device	411	451	505	541	1,908
Logic	613	662	702	745	2,722
Linear	729	741	794	811	3,075
Discrete	505	517	528	538	2,088
Optoelectronic	199	201	204	206	810
Exchange Rate	155	155	155	155	155

Source: Dataquest
October 1986

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RESEARCH BULLETIN

SUIS Code: Newsletters 1986-36

NATIONAL CAPTIVATES ITS REPS

In a dramatic move on Monday, October 13, 1986, National Semiconductor made an offer to purchase its entire force of 150 to 200 U.S. sales representatives. Dataquest believes that this is an excellent move on the part of National and that it is also significant to the industry at large.

Currently, National's U.S. sales are almost exclusively through reps, while its European and Asian sales are handled by company employees. National is well along in its transition from a "jellybean" house to a firm with a broad line of proprietary products. Currently, more than 75 percent of National's new products are proprietary, and 18 of the top-selling 20 products are proprietary. National's component R&D expenditures have grown at a compound rate of 29 percent for the last three fiscal years and now stand at an estimated 19 percent of component revenue.

The acquisition of its North American sales force will permit National to better control its customer relations. This move represents a major push at National, where the corporate mission is to "provide service second to none--resulting in long-term National Semiconductor/customer partnerships." Under National, this sales force should be able to better support the increasing complexity of the company's proprietary products and more effectively work with customers during long design-in cycles. Additionally, this offer is well timed because many reps are currently somewhat disheartened with their businesses. National should be able to acquire a direct sales force for much less than it could recruit and train one.

This action by National is worthy of note by other semiconductor firms since reps that sell National products no longer will sell other firms' products. Dataquest believes that the semiconductor industry is becoming more "globalized," with U.S. firms striving to enter the Japanese market and Japanese and European firms striving to enter the North American market. Given this increasingly competitive situation, access to a captive sales force could be a major advantage.

Mark Giudici
Howard Z. Bogert

SUIS Code: Newsletters
1986-35

PUTTING OUT A FIRE WITH GASOLINE? THE SEMICONDUCTOR INDUSTRY LOOKS AT TAX REFORM

SUMMARY

With the passage of the tax reform bill, Congress will introduce the most significant change in the federal income tax structure since its inauguration in 1913. Once passed, the bill's most important immediate impact will be to end more than a year of uncertainty affecting the financial decisions of businesses and individuals--uncertainty that has been an added drag on domestic investment.

In this newsletter, Dataquest reviews the significance of the tax bill, its broad effects on the business sector, and, more specifically, its effects on the semiconductor industry. In gauging the bill's impact on semiconductor firms, Dataquest has reached a consensus of opinion among its semiconductor clients on the following key points:

- Contrary to initial press coverage, the semiconductor industry will not decrease capital spending as a result of the repeal of investment tax credits.
- Computer equipment manufacturers, who make up the largest end market for semiconductor devices, do not see the new tax bill adversely affecting their business in any significant way.
- The tax bill provides one more reason for semiconductor firms, and manufacturers in general, to make capital goods investments off shore.

EFFECTS AND SIGNIFICANCE

The new bill reverses a trend of nearly four decades during which business has taken on an increasingly smaller share of the federal tax burden. This share diminished from a high of 34 percent in the early

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1950s, to 8.4 percent in 1985. As a result of the tax reform, business contributions should now increase to about 13 percent of collected tax revenue. In addition, tax shelters, which have historically favored high-income earners, will be abolished. By 1988, the bill will also have eliminated a complex schedule of 15 tax rates on individual incomes, which range from 11 percent to 50 percent, replacing it with 2: 15 percent and 28 percent.

Over the next five years, the tax bill's framers hope to add an additional $122 billion to the pockets of U.S. consumers. While the maximum corporate tax rate will drop from 46 percent to 34 percent, business will, nonetheless, pay for the government's largesse to consumers through the elimination of cherished tax credits and the imposition of a minimum tax applied to all corporations. Businesses will feel the effects of the bill most keenly in the following areas:

- Investment tax credit--Companies will lose the 6 percent to 10 percent tax credit for their investments in capital goods. In addition, the repeal of the investment tax credit is retroactive to January 1, 1986. To further aggravate the situation, companies will only be able to apply 65 percent of unused investment tax credits to offset a maximum of 25 percent of their tax liability.

- Minimum tax rate--Tales of corporations paying less in taxes than some of their employees should become the stuff of future lore. All businesses will now be subject to a minimum tax rate of 20 percent. According to the new tax bill, not even the inability to turn a profit will keep companies beyond the long arm of the IRS. With the passage of the bill, net operating losses will only be able to offset 90 percent of minimum taxable income, rather than the 100 percent allowed under current tax law.

- Rate of depreciation--Companies may face a reduction of their depreciation allowances for capital goods, depending on how they file. According to Robert Perlman, director of tax and customs for Intel Corp., filing under the minimum tax provisions could result in a lower depreciation allowance due to differences in the method of calculation.

- Capital gains--Capital gains will no longer be given preferential treatment, but will be taxed at the same rate as regular income. This is expected to shrink available capital for investment in start-up businesses.

- R&D tax credit--Finally, some good news. The tax credit on research and development expenditures, which was to have expired at the end of 1985, has now been granted an additional three-year lease on life. The bad news is that the maximum credit allowed has been reduced from 25 percent to 20 percent, based on R&D costs that exceed average spending for the previous three years.

Overall, the Darwinian effect of the above changes suggests that somehow, capital-intensive companies are not as important as service companies in the eyes of Capitol Hill. Clearly, the companies that stand to benefit most from the tax bill are those that do not invest heavily in plant and equipment, and those whose profitability makes the lowering of the corporate tax rate more advantageous than the tax benefits that they lose. A maximum corporate rate of 34 percent is of little solace to ailing smokestack industries, although the bill's effects on steel producers will be mitigated by sizable "transition" payments to be made by the government over the next year.

Also bearing the brunt of tax reform are banking and real estate firms. While the banking industry may not share General Motor's concern over investment tax credits, banks face the loss of their deductions for bad debt reserves, which could cost them an estimated $4 billion in higher taxes over the next four years. This will no doubt force banks to foreclose more quickly on bad debt accounts in order to take a write-off. The banking industry could be helped, however, by the increased taxes on capital gains and the elimination of tax shelters, which may divert investors from the stock market to bank instruments. On the other side of this coin, America's $68 billion-a-year real estate industry will see a sharp drop in investments due to the elimination of tax shelter partnerships.

Effects on the Semiconductor Industry

Initial press reactions to the new bill have tended to exaggerate its effects on capital spending in the semiconductor industry. The realities of the tax bill do not alter the imperatives of the semiconductor business. In what remains a technology-driven industry, decisions to invest in new products and processes, and in the capital equipment that makes them possible, are not ruled by tax considerations. As a result, none of the semiconductor manufacturing clients surveyed by Dataquest have any intention of altering their capital spending plans. In the semiconductor industry, capital investment decisions are ruled by capacity, product and technology innovation, and manufacturing competitiveness. For the near future, any dampening of capital spending will have more to do with over-capacity and eroded profit margins than with the repeal of the investment tax credit.

For now, the bottom-line effect of investment tax credit repeal is a somewhat moot issue with the semiconductor industry, since the bottom line is red to begin with. During the two difficult years that the industry has been going through, however, this lack of profitability has resulted in the buildup of carry-over investment tax credits. National Semiconductor, for example, estimates its accumulated carry-over at between $40 million and $50 million. Over time, the 35 percent reduction in carry-over credit will cost the semiconductor industry an estimated $300 million.

Start-up semiconductor firms will find initial funding to be more difficult to come by under the new tax bill. By taxing capital gains at the same rate as regular income, venture capitalists may have difficulty in attracting investors to any but the safest investment avenues. To appreciate the possible impact this will have on funding, consider the effects of the 1978 reduction in the capital gains rate, which led to a boom in capital investment. In that year, only $216 million in venture capital was invested. In the seven years following the capital gains rate reduction, $12 billion was invested, for an average annual rate of $1.7 billion. When the new tax goes into effect, in addition to seeing the venture capital pool shrink, start-up companies may find themselves sending a check to the IRS under the minimum 20 percent tax requirement of the new bill, despite operating losses.

Fortunately, the new tax bill provides semiconductor companies with an additional incentive to invest in research and development. Tax credits for R&D, which were to have come to an end in 1985, have been preserved for three more years. In order to utilize these credits, a company will have to show R&D expenses that are higher than the average for the previous three years. If this criterion is met, 20 percent of R&D expenses may be applied against taxable income, as opposed to 25 percent under the old law. This credit is estimated to be worth about $100 million annually to the industry, which spends 10 to 20 percent of sales on R&D.

__Future Shock?__

At worst, the net effect of the tax bill will be to raise the cost of capital for the semiconductor industry. To its credit, the responses to Dataquest inquiries indicate that the industry is willing to weigh this consequence of the bill against whatever benefits it has on the U.S. economy. Inasmuch as the bill seeks tax burden equity and more productively invested capital, what is good for the economy will certainly benefit the semiconductor industry. If, as the chairman of the Council of Economic Advisers, Beryl Sprinkle, has suggested, shifting more than $120 billion in taxes from individuals to corporations will facilitate the consumer's role in economic expansion, the resulting rise in GNP will manifest itself in renewed capital spending. Historically, this has meant greater consumption of semiconductors. The logic behind this argument is one that the industry would be happy to embrace, except for some reservations gained through the bitter experience of recent years.

What concerns the semiconductor industry, and Dataquest, is the tax bill's seeming disregard for the lesson that semiconductor firms have had to learn the hard way: the U.S. must now effectively participate in a global economy. In this economy, the stimulation and protection of our own domestic market is a futile gesture if we cannot maintain a manufacturing competitiveness worldwide. Not only is the U.S. domestic market no longer solely the plum for our picking, it is not even, in the area of semiconductors, the biggest plum. That honor now goes to Japan. More money in the hands of consumers at the expense of the economy's manufacturing sector will not lead to greater economic growth if consumers simply spend more on Korean autos, Japanese VCRs, and Taiwanese ICs. Ignoring the importance of the U.S. manufacturing sector in reversing the current trade imbalance, in turn ignores the effects of this imbalance on the federal budget deficit.

Increasing the cost of capital will not blunt the semiconductor industry's investment in manufacturing. It will, however, influence where that investment is made. In keeping with a shift in the economic center of gravity toward the Pacific, large capital investments will more likely be made in Penang, Singapore, and Seoul, than in Santa Clara, Austin, and Kokomo. As the imperatives of global competitiveness force U.S. semiconductor firms to become multinational in character, it will ultimately matter less to them where goods are manufactured and who the consumers are. Such considerations, however, will matter very much to the American worker, and to the federal deficit.

During the final stages of the tax bill committee meetings, the House-Senate staff received a harbinger of future peril. A call was received from the Joint Committee on Taxation to report that, based on revised projections for economic growth, tax revenue from the business sector would cover only $114 billion of the originally planned $131 billion cut for individuals. While this $17 billion shortfall was resolved before reaching final agreement on the bill (by raising the maximum tax rate for individuals), a deadly flaw was nonetheless exposed. Under a functioning Gramm-Rudman Act, the effects of any future tax revenue shortfall on the federal deficit will have to be dealt with through budget cuts--that is, unless Congress is willing to commit the heresy of raising taxes in the wake of the landmark bill it is about to pass.

DATAQUEST CONCLUSIONS

The fundamental aims of the new tax bill are simplification, redistribution, and revenue neutrality. There are mixed messages from Washington, however, on the bill's long-term effects. On one hand, the current administration has claimed that tax legislation will no longer be an instrument of societal change or industrial policy. Instead, it will return to its more humble role of raising federal revenue in the most equitable way possible. On the other hand, Beryl Sprinkel, maintains that a redistribution of the tax burden will generate a 10 percent higher growth in productivity than would have occurred under the old tax structure. Thus, the bill is cast in the role of economic spark plug.

Whichever version of the tax bill's intent one chooses to believe, the fact remains that in the absence of an overall industrial policy, the bill's effects on the U.S. manufacturing sector take on a de facto significance. Looked at in this light, Dataquest believes that the tax bill contains the following flaws:

- The bill ignores the fact that the U.S. now competes in a global marketplace.

- The bill creates yet another disincentive for U.S. companies to invest in domestic manufacturing.

- As a result of the above, the bill may fail to raise enough revenue from the business sector to cover the cuts given to individuals--thereby adding to an alarming federal deficit that is the enemy of economic health for consumers and businesses alike.

Stan Bruederle
Michael J. Boss

SUIS Code: Newsletters
1986-34

EUROPEAN SEMICONDUCTOR RECOVERY FREEWHEELS THROUGH BALANCE OF 1986

EXECUTIVE SUMMARY

The previously expected second-half-year upswing in semiconductor demand in 1986 is now postponed--at least until the first half of 1987. The outlook for the rest of 1986 now looks slow and sluggish, as the continuing uncertainty in the worldwide economic and business environment favors a wait-and-see attitude. Our revised forecasts downgrade the 1986 local currency growth rate estimates from a positive 6.3 percent growth to a negative 7.3 percent. Due to the substantial decline of the U.S. dollar against all the European currencies, the growth rate measured in U.S. dollars actually increases from 6.3 percent to 14.8 percent.

Table 1 shows the latest forecast for European semiconductor consumption in U.S. dollars from 1984 through 1988, together with a restatement of the previous two forecasts for comparison. Table 2 gives the same three forecasts, but expressed in local currency terms.

Table 1

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION--TOTAL SEMICONDUCTOR
(Millions of U.S. Dollars)

Date of Forecast	1984	1985	1986	1987	1988
October 1985	$4,805	$4,700	$5,454	$6,856	$8,523
February 1986	$4,805	$4,632	$4,923	$6,391	$7,939
August 1986	$4,805	$4,720	$5,417	$6,200	$7,898

Source: Dataquest
October 1986

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Table 2

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION--TOTAL SEMICONDUCTOR
(Millions of European Local Currency Units)

Date of Forecast	1984	1985	1986	1987	1988
October 1985	8,453	8,268	9,595	12,061	14,994
February 1986	8,453	8,493	9,026	11,718	14,556
August 1986	8,453	8,655	8,024	9,184	11,699
Exchange Rate	1.7592	1.8335	1.4813	1.4813	1.4813

Source: Dataquest
October 1986

MARKET OUTLOOK

Dataquest now expects European dollar consumption of semiconductors to increase by 14.8 percent in 1986, representing an actual decline in local currency terms of a negative 7.3 percent. We believe that the current softness in the European semiconductor market reflects a timing problem as opposed to a lack of faith in the overall semiconductor industry. A major reason for this softness in demand is that since the spring of 1986, end-user demand has not improved. As a result, the anticipated reversal in the OEM inventory liquidation process did not occur. To the contrary, since early 1986 most OEMs have embarked on a program to purge inventories even further, fueled by concerns about the health of the economy and their end markets, especially those in the United States. As a result, new bookings slowed substantially. This slowdown, coupled with the traditionally weak third-quarter vacation period, effectively ended any real hopes of a strong second half year.

Semiconductor consumption in Europe grew at a compound annual growth rate (CAGR) of 7.7 percent in U.S. dollars, or 18.8 percent in local currencies, from 1979 to 1985. Dataquest believes that the CAGR from 1986 to 1991 will be approximately 17 percent in constant dollars, although we do expect a slowdown in 1988-1989 as semiconductor sales are affected by the next downward trend of the industry cycle.

The forecasts contained in ESIS Volumes I and II are now outdated and are in the process of being republished. Hard-copy printouts of the detailed tables are available on request by clients who require earlier access. The data are also available electronically either in floppy disk format, via the DESTINY Datadisks, issue 05, or via the on-line service.

Mark Giudici
Jennifer Berg

SUIS Code: Newsletters
1986-33

THE SEMICONDUCTOR AGREEMENT: INTENTIONS AND REALITY

SUMMARY

This newsletter concerns the near- and long-term pricing repercussions of the U.S.-Japan semiconductor agreement reached on July 31, 1986. It reviews the agreement's main points and the potential effects and resulting strategies for semiconductor manufacturers and users. It analyzes the agreement's intentions and potential near- and long-term effects and concludes with specific suggestions for how the situation can best be managed.

AGREEMENT OVERVIEW

The semiconductor agreement between the United States and Japan revolves around two key issues:

- Cost/price monitoring of semiconductor devices to insure that prices of semiconductors exported into the United States do not fall below costs
- Increased Japanese market access by U.S. semiconductor manufacturers

Cost/Price Monitoring

The agreement resulted in the suspension of dumping charges on all EPROMs and 256K and 1Mb DRAMs by the U.S. Department of Commerce (DOC). Instead, the DOC will monitor on a quarterly basis the prices and costs of certain Japanese-manufactured and exported semiconductor products.

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The DOC uses a formula to construct the quarterly Foreign Market Values (FMVs). This formula (A + B + C + D = Foreign Market Value) is made up of the following four parts:

- Material costs, including some R&D
- Fabrication costs
- General sales and administration expenses, including some R&D (not less than 10 percent of the above two costs)
- Profit (not less than 8 percent of the above three costs)

The formula is applied on a company-by-company basis using proprietary cost information to determine the minimum price of each company's products. This method uses real-time fabrication cost data in determining FMVs. The capacity utilization of a given company at a given time will determine in large part what that company's FMV will be. A company running at 80 percent capacity will have lower fabrication costs per unit than a company running at 50 percent capacity. The initial capacity utilization rate used can determine which companies will be continually competitive and which will continue to be uncompetitive, since a profit always has to be added to a higher manufacturing cost. Using these same guidelines, Japan's Ministry of International Trade and Industry (MITI) has agreed to monitor the following volume Japanese-exported semiconductors:

- MOS SRAMs
- ECL RAMs
- 8- and 16-bit microprocessors
- 8-bit microcontrollers
- ECL logic
- Gate arrays
- Standard cells

Market Access

The second part of the agreement facilitates greater access by U.S. semiconductor manufacturers to the Japanese market, which a Japanese governmental organization has been formed to support. The organization will:

- Provide sales assistance for foreign semiconductor producers as they attempt to penetrate the Japanese market
- Make quality assessments of foreign semiconductor products, upon request, and organize such things as research fellowship programs, seminars, and exhibitions for foreign firms

- Promote long-term relationships between Japanese semiconductor purchasers and foreign producers, including joint product development with Japanese customers

AGREEMENT EFFECTS

The effect of capacity utilization on price is illustrated by the cost model shown in Table 1.

The first round of FMVs created significant problems for Japanese semiconductor companies and for users in the United States. Larger users appeared to have managed to source product from U.S.-based suppliers or to be prebuying before the September 15, 1986, deadline. Many smaller users got caught in the crossfire.

Table 1

CONSTRUCTED PRICES FOR 256K DRAM

	Capacity			
	100%	75%	50%	25%
Processed-Wafer Cost	$178.00	$220.00	$280.00	$500.00
Cost/Chip	$ .27	$ .33	$ .42	$ .75
Test Cost/Hour	$ 27.00	$ 34.00	$ 54.00	$100.00
Wafer Probe Cost/Chip	$ .07	$ .10	$ .15	$ .28
Wafer Probe Yield	70%	70%	70%	70%
Cost/Good Chip	$ .49	$ .61	$ .81	$ 1.47
Assembly Cost	$ .14	$ .19	$ .24	$ .36
Assembly Yield	85%	85%	85%	85%
Assembly Chip Cost	$ .74	$ .94	$ 1.24	$ 2.15
Test Cost/Pkg.	$ .25	$ .36	$ .54	$ 1.01
Test Yield	90%	90%	90%	90%
Tested Device Cost	$ 1.10	$ 1.44	$ 1.98	$ 3.51
Mark, Pack, Ship	$ .20	$ .20	$ .20	$ .20
Total Mfg. Cost/Unit	$ 1.30	$ 1.64	$ 2.18	$ 3.71
R&D Expense (15%)	$ .20	$ .25	$ .33	$ .56
SG&A Expense (10%)	$ .15	$ .19	$ .25	$ .43
Profit (8%)	$ .13	$ .17	$ .22	$ .38
Foreign Market Value	$ 1.78	$ 2.25	$ 2.98	$ 5.08

Source: Dataquest
October 1986

Japan-based semiconductor companies have seen their exports to the United States decrease as prices based on yen have continued to drop in Japan, impacting company profits. The price for 256K DRAMs was ¥450 in 1985. Today the price is ¥289. The agreement has helped yen-based average selling prices increase to ¥375 or higher for sales made into the U.S. market.

It appears that the new FMVs that will become effective on October 15 will be much more palatable to customers. We expect 256K DRAMs to range in price from $2.50 to $4.00, and we expect 1Mb DRAMs to be in the $20 to $25 range for the lowest-cost suppliers. EPROM prices are outlined in our recent Research Newsletter number 1986-28, "Pricing and the Market at Odds: Revised EPROM and 256K DRAM Estimates."

Dataquest believes that the new FMVs will make life easier for U.S. buyers. The new prices indicate that buyers may expect prices to continue to decrease throughout 1987. By the end of 1987 we expect 256K DRAM prices to be close to $2.20, as shown below:

	1986		1987			
	Q3	Q4	Q1	Q2	Q3	Q4
256K DRAMs	$2.85	$2.85	$2.85	$2.50	$2.35	$2.20

We also expect 1Mb DRAMs to return to more competitive pricing than we had previously expected. We now believe that they will approach the crossover point by the end of 1987.

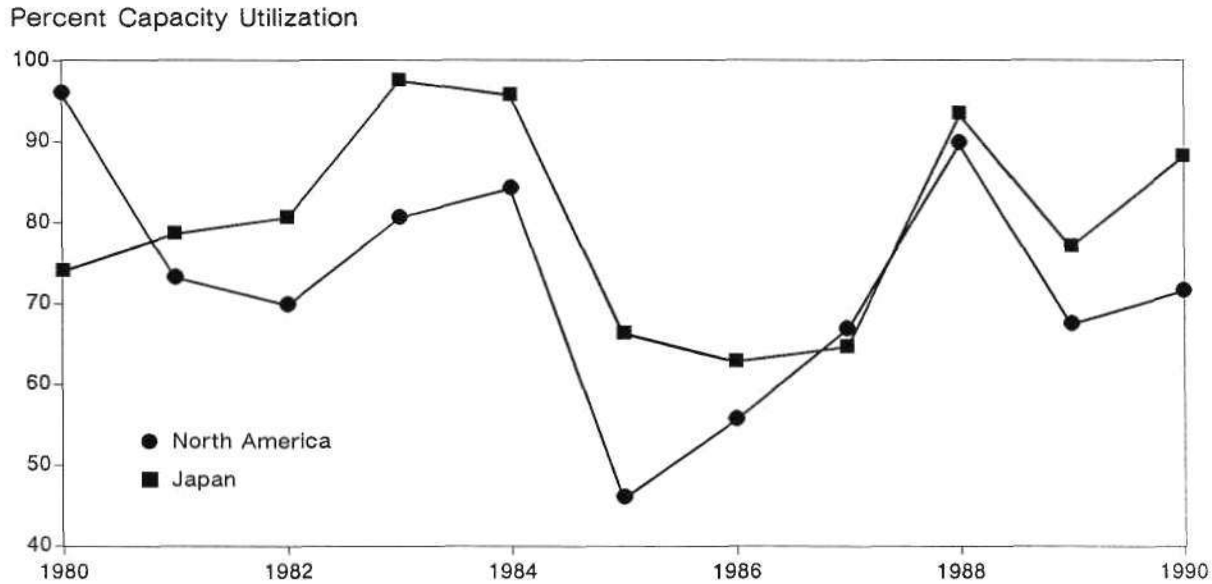
As prices in the United States reach more stable levels, the focus of the program is expected to move to other regions. We expect the Department of Commerce to take up this issue with MITI in the near future. Dataquest surveys prices in Europe, Japan, and Taiwan every two weeks, and prices in Europe and Taiwan have remained at $2.00 or less during the last month. However, our European research indicates that prices in Europe will increase from current levels in the next two quarters.

LONG-TERM IMPLICATIONS OF THE AGREEMENT

This agreement presents interesting opportunities for users and semiconductor manufacturers. Because the models used to determine the FMVs are based on capacity utilization, FMVs will decrease during market growth periods and increase during recessions when capacity utilization drops. Figure 1 shows our projection of capacity utilization for the industry for the next five years. By combining this with the data shown in Table 1, we can analyze the impact of the business cycle on FMVs. As capacity utilization drops, FMVs will tend to increase; this will effectively remove uneconomic foreign capacity from the U.S. market as demand declines and will direct more business toward U.S.-based suppliers who are not affected by the FMVs. Our current forecasts project that this will occur in 1989.

Figure 1

CAPACITY UTILIZATION--NORTH AMERICA VERSUS JAPAN



Source: Dataquest
October 1986

Another concern arising from the first round of FMVs was the price of new technologies--in this case, the 1Mb DRAM. Third quarter FMVs were double the prior market price. This had the impact of delaying the introduction of the latest technology into U.S.-manufactured equipment, giving Japanese companies a lead in this area. The long-term implications of this are far more important than any other action resulting from the agreement.

New technology has far greater impact on system cost than declining prices. Figure 2 shows how this works. Cost per function can decline by a factor of five or more for a much smaller decrease in price. Figure 3 shows how it works for memories. Each new level of cost occurs when the next generation of memory enters the market. Each new generation decreases the cost from the previous generation by a factor of five. A one-year lag in pricing causes a one-year lag in system technology. The anticipated 1Mb FMVs will prevent a near-term U.S. versus Japan system technology dichotomy.

The new FMVs of $20 to $25 for 1Mb DRAMs should correct this situation, but the impact on future generations of DRAMs remains to be seen. This is not a problem with EPROMs, however, because U.S. companies are leaders in introducing next-generation EPROMs.

Figure 2

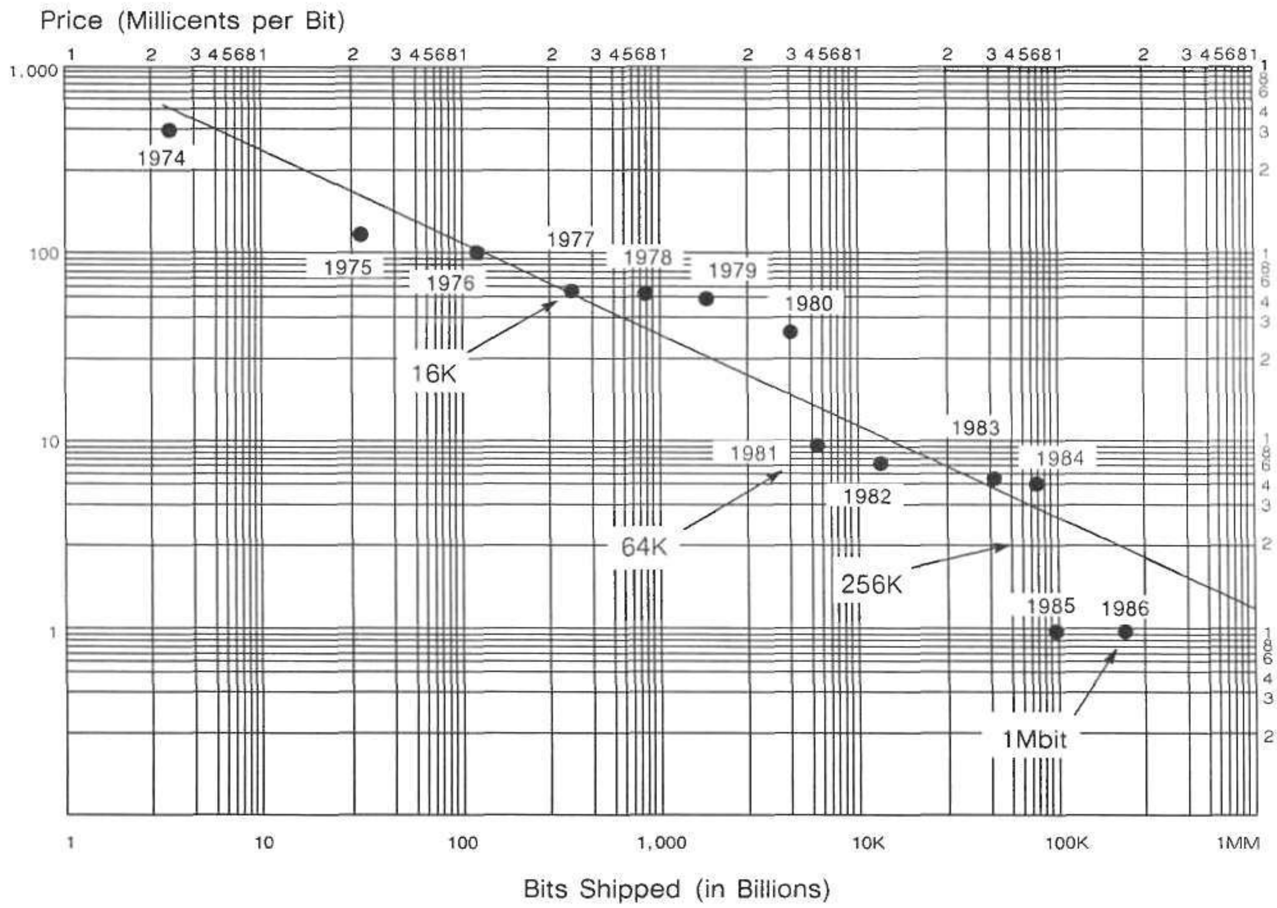
HYPOTHETICAL CHIP COST MODEL

	1984	1986
Minimum dimension	3 microns	2 microns
Wafer size	4 in.	6 in.
Processing cost	$140	$220
Chip size (mils per side)	200	250
Yield	30%	50%
Chip cost to product cost	4X	4X
Good chips	100	200
Finished chip cost	$1.49	$1.10
Finished package cost	$5.96	$4.40
Transistors/chip	50,000	211,000
Cost/transistor	9.9m¢	2.1m¢

Source: Dataquest
October 1986

Figure 3

DRAM EXPERIENCE CURVE



Source: Dataquest
October 1986

STRATEGIES FOR THE TRADE-AGREEMENT ENVIRONMENT

The trade agreement has precipitated a number of responses by semiconductor users. These responses and their implications are discussed in the following paragraphs.

Some U.S. companies are considering having memory PC boards manufactured in Japan and exported to the United States. Through this transformation of product, the FMVs are avoided. This is a good plan, but the government could close this loophole if it becomes a serious impediment to making the agreement work.

A number of users have benefited from agreements with NEC, which has manufacturing capacity in both the United States and Japan. The short-term effect obviously has been to lower prices. This will not appear to be so important with the new FMVs, but we believe that all users should develop a balanced U.S./Japanese supply base. It will enable them to shift sourcing during recessionary periods, when we expect the FMVs to increase as capacity utilization decreases. This will minimize the price impact on customers during down markets.

Moving to offshore manufacturing is another possible strategy. However, we believe that companies should be very careful with this, as the agreement could equalize prices worldwide (except in Japan) if it works as intended.

Korean suppliers offer another opportunity for lower prices, but this should be considered a short-term strategy. Korea currently supplies a small part of the market. If the U.S. government becomes interested in controlling Korean suppliers as a major source of DRAMs, we believe that Korean FMVs would be substantially higher than current prices.

DATAQUEST CONCLUSIONS

Procurement strategies under the trade agreement should remain extremely flexible. Companies should balance U.S. sources with foreign sources to be able to adjust to changes in the current business environment. Any actions taken to get around the agreement could be affected by government actions to close loopholes that could affect the intent of the agreement. We believe that the major negative effects of the agreement will subside when the new FMVs are released on October 15. The groundwork has to be done now for dealing with the long-term effects of the agreement.

Stan Bruederle
Mark Giudici

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RESEARCH BULLETIN

SUIS Code: Newsletters
1986-32

PRELIMINARY DRAM FMV PRICES RELEASED

The U.S. Department of Commerce has provided Japan-based manufacturers with a new set of preliminary FMV (fair market value) prices for DRAMs. These FMV prices are in keeping with the U.S.-Japan semiconductor trade arrangement in which dumping tariffs were suspended in exchange for a commitment by Japanese manufacturers to provide access to Japanese markets and monitor prices. The Japan-based manufacturers have the opportunity of commenting and appealing before the prices are finalized on October 11 and put into effect on October 16.

INDICATIONS OF THE NEW PRELIMINARY FMVs

Indications are that the new FMV prices will fall within the range of $2.50 to $4.00 for a 256Kx1 NMOS DRAM in a dual-in-line package. Current FMV prices for this product range from approximately $2.80 to $8.00. This decrease will lower the average FMV by more than 30 percent and narrow the price differences among the manufacturers.

For the 1Mb DRAM, the price differences among manufacturers are expected to remain wide, although the low point of the range of new FMV prices is anticipated to drop to between $20 and $25 from the current $50 to $60.

FMV prices will be different for each manufacturer. They will also differ by package (such as PLCC and SOJ) and by organization (such as x1 and x4). FMV prices will also include standard DRAM modules such as SIPs and SIMMs and one specialty memory, the video RAM.

DATAQUEST ANALYSIS

Dataquest believes that the potential impact of the new FMVs includes the following:

- We expect the trend toward offshore manufacturing and purchasing to continue, but at a more tempered rate. For users who have not yet done this, offshore manufacturing will remain a clear and viable option. Although the new round of FMV prices will narrow the gap between U.S. prices and those of Japan and Southeast Asia, the differences will still be significant.

- We expect purchasers to resume placing orders with more Japan-based manufacturers starting this month, but for more short-term requirements. Many buyers have been holding back orders because of the high FMV prices, in anticipation of new, lower FMVs in October.

- The 1Mb DRAM market is expected to resume its normal rate of development and should continue if future FMV prices follow the learning curve. Dataquest believes that the FMVs may result in diminishing the lead of the Japanese manufacturers over domestic and Korean suppliers. The current high 1Mb DRAM FMVs are a major concern of OEMs that have designed in the device. There are no viable commercial 1Mb DRAM suppliers other than the Japanese manufacturers.

Mark Guidici
Victor de Dios

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RESEARCH BULLETIN

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1986-31

ENTERING THE JAPANESE MARKET: NMB SEMICONDUCTOR AND NATIONAL SIGN FOUNDRY AGREEMENT

SUMMARY

NMB Semiconductor and National Semiconductor recently signed a long-term agreement to design, produce, and sell CMOS SRAMs in Japan. The initial agreement covers only 2Kx8 CMOS SRAMs but will be expanded to include three other configurations.

NMB Semiconductor currently produces CMOS DRAMs for Vitelic and Inmos and CMOS SRAMs for two undisclosed U.S. companies at its highly automated fab in Tateyama City, Chiba Prefecture. Completed in April 1985, the fab has two modules with 100 x 36-meter clean rooms, of which about 25 percent is Class 1 area. Module 1, which has a capacity of 20,000 to 24,000 wafers per month, handles 5-inch wafers. Module 2 handles 6-inch wafers. All wafer handling in the modules is fully automated.

DATAQUEST ANALYSIS

We believe that this agreement is significant for several reasons. Not only does it enable National to become a player in the Japanese SRAM market, but it helps NMB utilize its existing fab capacity. Moreover, it signals the growing use of Japanese foundries by major U.S. semiconductor makers. As shown in Table 1, many U.S. start-ups are already using Japanese foundries. Now major U.S. vendors are using Japanese foundries as a way to enter the Japanese market without having to make heavy capital investments up front. We see several emerging trends that will dramatically impact the semiconductor industry:

- More alliances between U.S. vendors and second-tier Japanese foundries to compete against the top 10 Japanese vendors

- The potential for major Japanese vendors to provide foundry to U.S. vendors to increase their capacity utilization, thereby lowering their fair market value for DRAMs and EPROMs (e.g., the recent Toshiba/Motorola DRAM agreement)

- The inclusion of second-tier Japanese foundries into the U.S.-Japan Semiconductor Arrangement

Strategic alliances are the key to survival. Companies may choose not to pursue an aggressive strategy, but they cannot afford to ignore the options available to them. In the long run, marketing strategy by omission is just as important as strategy by commission.

Stan Bruederle
Sheridan Tatsuno

Table 1

U.S.-JAPANESE FOUNDRY AGREEMENTS

Foundry	Company	Date	Products
Fuji Electric	Lattice	10/85	64K CMOS SRAMs
Kawasaki Steel	LSI Logic	09/85	ASIC joint venture fab
NMB	Inmos	06/84	256K CMOS DRAMs
	Vitelic	11/85	1Mb CMOS DRAMs
	U.S. Maker	1985	Fast 64K SRAMs
	National	09/86	CMOS SRAMs (four types)
	Unannounced yet	1986	CMOS SRAMs and DRAMs
Oki Electric	Silicon Systems	09/86	Single-chip modem LSIs (1,200 bps)
Ricoh	VTI	09/83	64K/128K/256K ROMs
	Silicon Compilers	09/86	Custom ICs (Ricoh CMOS n-channel)
Seiko Epson	Xilinx	12/85	Logic cell arrays
	Lattice	02/86	Fast 64K SRAMs (16Kx4)
	Lattice	09/86	Programmable logic (GAL)
Sharp	Wafer Scale	12/84, 10/85	64K/256K CMOS EPROMs
	Mosel	05/86	Fast 256K SRAMs
Sony	Vitelic	07/85	256K/1Mb/4Mb CMOS DRAMs
Suwa Seikosha	SMOS Systems	12/84	CMOS gate arrays
	AMCC	05/85	CMOS chips
Toshiba	Motorola	09/86	ASICs; later 64K/256K DRAMs

Source: Dataquest
September 1986

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RESEARCH BULLETIN

SUIS Code: Newsletters
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THE NEC/INTEL TRIAL: THE INDUSTRY WINS A VICTORY--OR DOES IT?

On Monday, September 22, 1986, U.S. District Court Justice William Ingram handed down the first court decision to come out of the NEC/Intel copyright lawsuit. In what has been hailed a landmark event in the protection of intellectual property, Judge Ingram declared that Intel possessed "good, valid, and existing copyrights on its 8086/8088 microcode."

Of greater significance to the semiconductor industry as a whole, and to manufacturers of microdevices in particular, is the court's stated position on the legal nature of that form of intellectual property known as microcode--the implementation of macroinstruction sets in silicon. In accordance with the 1980 amendment to the Copyright Act, which extends protection to computer software, Judge Ingram's decision included the following observations:

- "The loading of an 8086 program into a ROM is accomplished in the same manner as would attend upon the loading of an application program into a ROM."
- "The methodology employed in the creation of microcode is to the court indistinguishable from that employed in the creation of any computer program."

From Intel's point of view, Judge Ingram's decision marks a resounding victory in the war to protect intellectual property. Regardless of the outcome of its infringement suit over the use of 8088/8086 microcode in NEC's V-Series microprocessors (the V-20 through V-50), Intel maintains that the industry may now rest secure that its investments in microcode development are protected, in the words of its General Counsel, against the "predatory practice of copying."

It is Dataquest's position, however, that any major victory celebrations are premature on the part of either Intel or the industry. While the court has decided that microcode does indeed fall within the domain of copyright law, just how effectively it can be protected is difficult to assess until Judge Ingram decides on the infringement issue. In reaching a decision, the court will likely establish a criterion for infringement. This criterion will prove more crucial to the industry than the acknowledgment alone that copyright is applicable to microcode. However, such a decision may still be several months away.

To the semiconductor industry, the court's initial decision comes more as a confirmation than a revelation. Since the 1980 amendment to the Copyright Act and the passage four years later of the Semiconductor Chip Protection Act (SCPA), the semiconductor industry has operated under the assumption that microcode is copyrightable. The landmark nature of Judge Ingram's announcement is that it represents the first real test of this assumption in a court of law.

In the short term, the U.S. District Court's decision makes it unlikely that a microdevice manufacturer will produce a product that is software compatible and pin compatible with a competitor's product without first negotiating a license for that code. Assessment of the long-term effects of the decision await Judge Ingram's verdict on Intel's infringement claims against NEC. Looking at both ends of the possibility spectrum, Dataquest concludes the following:

- If the infringement criterion is rigidly interpreted to mean literal copying, successfully proving infringement will be very difficult for any copyright holder. With regard to the NEC/Intel trial, similarities between NEC's V-Series microcode and Intel's 8088/8086 code could be judged the result of "functional constraint" rather than copying. In this case, NEC would very likely be found innocent of infringement.

- If the infringement criterion is more loosely interpreted, any degree of similarity, whether the result of plagiarism or independent development, could be enough to constitute an infringement. Such a precedent would give copyright holders much greater influence in their markets through more effective control of alternate sources. With regard to the NEC/Intel trial, Intel would be more likely to win an injunction against the shipment of V-Series microprocessors into the United States, and/or the payment of royalties by NEC for V-Series devices sold.

Stan Bruederle
Michael Boss

SUIS Code: Newsletters
1986-29

GALLIUM ARSENIDE ICs--FACT OR FANCY?

It has been said that the quantity of paper published on gallium arsenide (GaAs) technology outweighs the shipments of chips, and this certainly holds true for GaAs ICs. Dataquest recently analyzed the industry to determine the extent of activity in this field and to gain insight into the reality of the emerging markets for GaAs semiconductors.

A CRITICAL MASS OF PLAYERS AND INVESTMENTS

Dataquest estimates the number of participants in the GaAs industry to be:

- 28 merchant market suppliers of GaAs ICs
- 26 additional companies supplying discretes
- 21 captive-only producers of GaAs chips
- More than 20 merchant suppliers of GaAs wafers, plus 10 or more suppliers of other III-V compound wafers such as InP
- 10 merchant foundries
- 11 IC start-ups not included above, with planned shipments starting in 1986 or 1987
- 30 Japanese companies in MITI-supported projects funded at $348 million

Additionally, more than 60 universities in the free world are involved in III-V compound semiconductor R&D, many with fabrication facilities. The number of professionals with degrees in this field is rapidly approaching 10,000. Analog GaAs ICs for TVRO applications are now available at ASPs

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of less than $20. Vitesse Electronics Corporation has announced a 2900-type bit slice family of digital ICs that includes a 1Kx4 SRAM and are based on a 1.2μ E/D MESFET process. Dataquest estimates that capital infusion into the GaAs IC field exceeded $330 million in 1985.

WHAT IS THE FUTURE OF THE GaAs IC INDUSTRY?

A recent Dataquest analysis of available high-speed ICs shows that silicon technology is evolving rapidly on several fronts. CMOS processes are now pushing critical dimensions (CDs) to less than 1.5μ and, in some cases, below 1.0μ, resulting in subnanosecond gate delays. ECL gate arrays based on sub-μ CDs are now in limited volume production and feature gate delays of less than 300 picoseconds. This progress, coupled with product schedule slippages at several major GaAs digital houses, has raised some doubt as to the viability of using GaAs digital ICs in new systems now being developed, especially at bottom-line-sensitive U.S. computer houses. This situation has also inspired many U.S.-based silicon IC supplier's to maintain the status quo of evolutionary progress in silicon as opposed to extending themselves by risking investment in GaAs.

Dataquest observed during this analysis that all of the Japanese GaAs IC suppliers are vertically integrated, supplying communications and EDP equipment; many also produce their own wafers. This contrasts sharply with the typical U.S. GaAs IC start-up, which is a "chips-only" company.

Despite the number of players in the GaAs arena, wafer defect densities are still excessive with respect to LSI chip fab requirements. This problem and the problem of gate threshold control have, to date, prevented the introduction of cost-effective GaAs chips into commercial systems. However, these problems are resolvable with the appropriate application of presently understood technology. The GaAs IC situation today is not unlike the Si NMOS situation in 1971, when the industry struggled to produce the standard 1K DRAM, the 1103. At that time, Burroughs, NCR, and others took leadership positions by designing the 1103 into systems and pressuring the U.S. industry to rise to the occasion, which it did. Today, to Dataquest's knowledge, only one U.S. systems house is applying similar pressure to potential GaAs RAM suppliers. If history is any indicator, the GaAs IC industry needs several more courageous champions within systems houses demanding tens of millions of GaAs LSI chips and backing their demands with purchase orders and multiyear schedules. It now appears that if such a situation evolves, it will do so in Japan, leading to a further demise of U.S. EDP houses in the world marketplace.

DATAQUEST CONCLUSIONS

While the U.S. Department of Defense appears to be pushing the U.S. industry very hard for viable merchant GaAs IC sourcing, many potential suppliers are limited by the lack of adequate additional demand from the commercial sector. This shortfall in demand is preventing a sufficiently rapid buildup of volume, making it difficult, if not impossible, to achieve the minimum efficiency of scale required for the success of the GaAs IC industry. The MITI-backed effort at vertically integrated Japanese firms does not face the same limitation; the net effect may be the eventual domination of the emerging worldwide GaAs IC market by Japanese firms. However, the race has just started, with only two Japanese suppliers of merchant GaAs ICs at present; a few courageous "drivers" in U.S. systems houses could have a major impact on the outcome.

Brand Parks
Gene Miles

Dataquest

a company of The Dun & Bradstreet Corporation

RESEARCH BULLETIN

SUIS Code: Newsletters
1986-28

PRICING AND THE MARKET AT ODDS: REVISED EPROM AND 256K DRAM PRICE ESTIMATES

The semiconductor agreement reached by the United States and Japan on July 31 has had a direct impact on all EPROM and 256K and 1Mb DRAM pricing. As a result of the agreement, the quarterly price estimates for these devices that we had published earlier in July require revision. We are currently conducting our third-quarter price survey, which will constitute a comprehensive pricing estimate for the next five quarters. Until that notebook section is completed, use this bulletin as an update to our July EPROM and DRAM contract price estimates.

Only Japanese manufactured and exported EPROMs and 256K and 1Mb DRAMs are covered by the agreement. Since the Japanese account for more than 80 percent of the 256K DRAM market and close to 50 percent of the EPROM market, Japanese exports greatly influence overall price trends. The price estimates in Tables 1 and 2 reflect information that has been gathered from both users and manufacturers, and they are in line with the Department of Commerce's Foreign Market Values. The price estimates are overall averages that include the prices of both foreign and domestic suppliers of the affected parts.

Although FMV ranges vary by company, on the average, prices initially have risen by a factor of two. Gradual price declines should follow as noted above if the current constructed cost formula used to create the FMVs remains intact. We are currently analyzing cost trends in relation to this agreement and its implications and will publish the results of this research when completed.

Mark Giudici

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Table 1

REVISED CONTRACT EPROM PRICE ESTIMATES

Family/Product	Q3/86	Q4/86	Q1/87	Q2/87	Q3/87	Q4/87
64K EPROM	$ 4.85	$ 4.00	$ 3.75	$ 3.50	$ 3.25	$ 3.00
128K EPROM	$ 5.90	$ 5.10	$ 4.85	$ 4.65	$ 4.30	$ 4.00
256K EPROM	$ 9.70	$ 8.00	$ 7.00	$ 6.00	$ 6.15	$ 4.60
512K EPROM	$24.00	$20.00	$17.50	$14.50	$12.00	$ 9.50
1Mb EPROM	$50.00	$35.00	$28.00	$24.00	$20.00	$18.00

Source: Dataquest
August 1986

Table 2

REVISED CONTRACT DRAM PRICE ESTIMATES

Family/Product	Q3/86	Q4/86	Q1/87	Q2/87	Q3/87	Q4/87
64K DRAM	$ 1.00	$ 1.00	$ 0.95	$ 0.95	$ 0.95	$ 0.95
256K DRAM	$ 5.00	$ 4.50	$ 4.00	$ 3.50	$ 3.00	$ 2.50
1Mb DRAM	$65.00	$55.00	$45.00	$35.00	$24.00	$18.00

Source: Dataquest
August 1986

SUIS Code: Newsletters
1986-27
Rev. 10/16/86

ASIC DESIGN CENTER CAD SURVEY

INTRODUCTION

As semiconductor users increase their design activity with ASICs, it is important to understand the direction that ASIC design centers are taking in serving the customer. Design tools are changing rapidly and users' requirements have a pronounced impact on what tools are put in place.

Clearly, ASIC vendors and the respective CAD vendors must provide the caliber of product and service necessary in today's market to maintain a quality relationship with the user. An important aspect to clarify in the following discussion is that of the role of the various hardware-based design platforms. That is, what portions of the design task are possible using the different hardware computing platforms.

This newsletter discusses the results of DATAQUEST's CAD/CAM Industry Service's design center survey. In compiling the results, we have identified three specific areas of controversy:

- Personal computers--engineering or office automation tool?
- Integrative design environment--is it possible in design centers?
- Bottlenecks--is the customer a bottleneck?

DEMOGRAPHICS

DATAQUEST polled 146 U.S.-based IC design centers, which is nearly 100 percent of the U.S. merchant ASIC design centers. Our survey tabulations represent a 50 percent response rate from 73 design centers.

Dataquest Incorporated, a company of The Dun & Bradstreet Corporation
1290 Ridder Park Drive / San Jose, CA 95131-2398 / (408) 971-9000 / Telex 171973

The respondents primarily consisted of three types of design centers:

- Semiconductor vendor affiliated
- Distributor affiliated
- Independent/unaffiliated

These types of design centers accounted for 90 percent of the total responses. The remaining 10 percent were vendor-affiliated centers that typically received their funding from private sources.

Designs

Cumulatively, there were 3,259 annual design starts in the sample, designed by 503 engineers. This translates into an average of seven design starts per engineer, and an average of seven engineers at each design center. Please refer to Figure 1 and Table 1 for information on the types of circuits being designed and the average number of gates.

PERSONAL COMPUTERS--ENGINEERING OR OFFICE AUTOMATION TOOL?

IBM PCs comprised nearly one-third of the nonturnkey-supplied CAD/CAM hardware. Yet, Figure 2 indicates that the PC's primary application is not engineering automation. PCs are used most often for office automation--even in such an intense engineering environment as an ASIC design center. Schematic capture represents the only engineering application for which the PC is used with any frequency.

We believe that the PC is so widely accepted because it also allows engineers to run office automation products. This suggests that vendors with PC or low-cost solutions must provide a path for end users to run general-purpose applications.

Purchase plans by product type are shown in Figure 3. Nearly 38 percent of the respondents indicated that they plan to purchase PCs. Standalone workstations plans, however, were even higher, at 46 percent.

We believe that engineers have a realistic attitude about the personal computer--by itself, it cannot run the computationally intensive applications that are typically run on a host or standalone computer. We expect personal computers to continue to be used for general-purpose applications and serve as a low-cost design entry nodes in networked engineering environments.

THE INTEGRATIVE DESIGN ENVIRONMENT

Software Perspective

Figure 4 shows the usage of analysis tools and the sources from which they were acquired. This figure suggests that in spite of the closed-door environment of ASIC software, there are a lot of commercially developed general-purpose analysis tools available on design center CAD systems. The most frequently cited analysis tool purchased from a software vendor is circuit simulation. This high response clearly contradicts the widespread myth that transistor-level simulation is not run on ASICs.

Although simulation tools are winning substantial design center acceptance, this is not the case with analysis tools addressing the manufacturability issues such as design rules check (DRC), electrical rules check (ERC), and layout-versus-schematic. Even though a significant number of design centers stated that they purchased these tools from outside sources, these applications were also cited most frequently as tools developed in-house, indicating that customization to a particular manufacturing process is frequently required.

We believe that ASIC design centers will continue to purchase analysis tools for their customers' use rather than for internal use. CAD vendors' products must be integratable with ASIC companies' in-house tools. Process-dependent tools must be easily customized to meet the process-specific requirements of individual manufacturers.

Turnkey Perspective

Figure 5 shows the installed bases of the five most frequently mentioned CAD vendors. These top five companies comprise 47 percent of all systems cited in the survey. Another 21 vendors comprise the remaining 53 percent of systems.

Figure 5 also illustrates buying plans and repeat purchases. Clearly, no respondent is so committed to any one CAD vendor that it excludes that vendor's competitors. The relatively low repeat business rates do not necessarily reflect dissatisfaction with any one vendor. Rather, they mirror the nature of the design center business itself--to avoid excluding potential ASIC customers, design centers must provide support and completion of customers' designs on corresponding CAD systems at the center. Therefore, systems purchased by design centers are an indication of general ASIC design community demands.

IS THE CUSTOMER A BOTTLENECK?

ASIC customers are strongly involved in the design process. Figure 6 shows that nearly half of the responding design centers' customers are responsible for their own designs. The survey also indicates that 44 percent of the customers are responsible for simulation.

Figure 7 shows the distribution of time spent on each design cycle phase. Nearly 60 percent of the time it takes to complete a design is spent on logic creation and simulation or the phases in which customers are directly involved. Yet design centers identify one of their biggest bottlenecks as the customer.

It appears that the design centers, as well as the CAD vendors, have not yet completed the end-user education process. CAD and ASIC vendors are not acknowledging customers' steep learning curves and are expecting expert results from novice users.

DATAQUEST CONCLUSIONS

Personal computers are only a platform; survey results show that PCs are not perceived in the end-user community as low-cost end-to-end design automation solutions. Although engineers use personal computers for schematic capture, the major application for PCs is office automation.

Dataquest believes that CAD vendors must concentrate on positioning PCs as design entry nodes that are easily integrated into networked design environments. The acceptance of PCs is dependent on networking and its ability to run general-purpose programs.

Dataquest believes that achieving the goal of widespread acceptance of ASICS will require semiconductor vendors to release their physical libraries and layout programs. As novice users become more proficient, they will want more control over their designs, and therefore need more information. This, in turn, will require a higher level of customer support.

What clearly emerges from the results of the survey is an end-user mandate for CAD vendors and ASIC vendors to take responsibility for supporting their customers. Dataquest believes that CAD vendors need to structure profitable and effective customer service so that all users get the experience necessary to make their systems produce.

If the CAD vendors' training ends with the design center engineers, they are ignoring the actual end-user market--the ASIC users--where penetration is still very low. Using a design center CAD system may be a customer's first opportunity for hands-on experience with ASIC design automation. In reality, the existing CAD systems in a design center are a sales opportunity in disguise; every time a design center customer uses a CAD system, it is actually a real-world demonstration of that system's capabilities. As prices continue to decrease and it becomes feasible for more engineers to purchase design automation systems, it behooves CAD vendors to ensure that every customer who uses that design center's system is adequately supported.

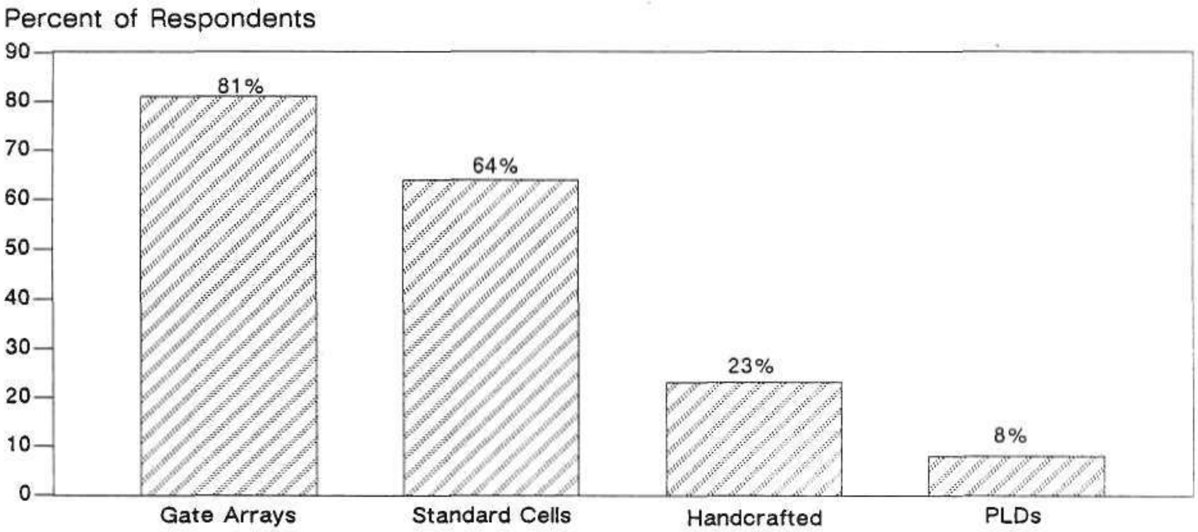
The ASIC design centers' perceptions of their customers as one of their biggest productivity bottlenecks is a example of the semiconductor industry's discrete parts mentality. For the relationship between the design centers and their customers to change, we believe that it is necessary for the relationship between the design centers and the CAD vendors to become a customer service partnership, with each assuming responsibility for their common customer--the ultimate end user.

(The majority of this newsletter was first published by Dataquest's CAD/CAM Industry Service and is reprinted with its permission.)

Brand A. Parks
Kelly D. Leininger

Figure 1

TYPES OF ASICs DESIGNED



Source: Dataquest
July 1986

Table 1

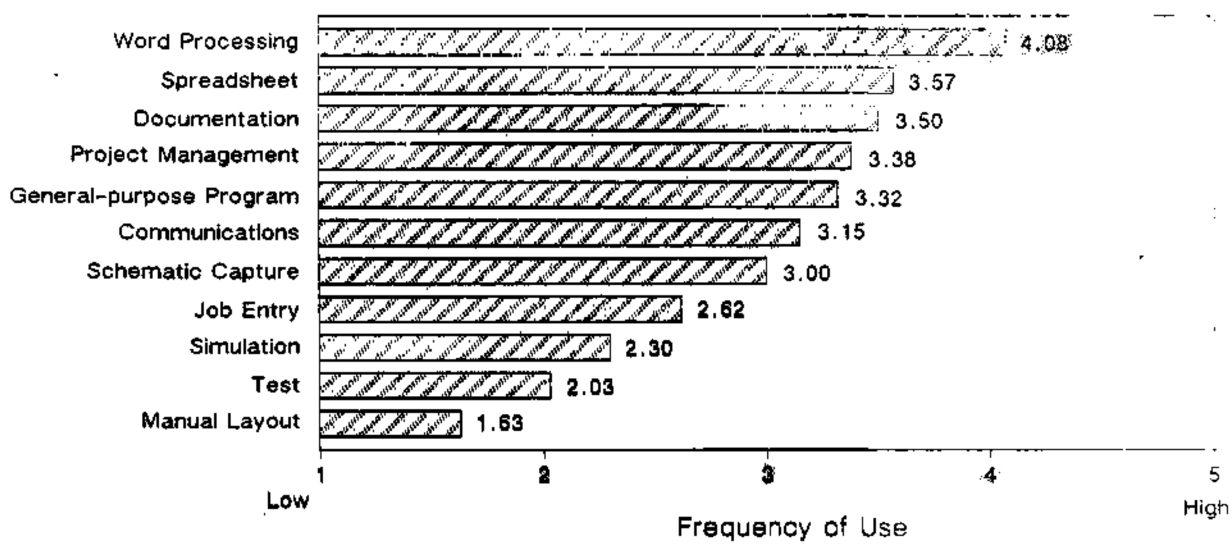
AVERAGE NUMBER OF GATES BY CIRCUIT TYPE

Type of Circuit	Average Number of Gates
Gate Arrays	1,930
Standard Cells	1,879
Handcrafted	1,058
PLDs	283

Source: Dataquest
July 1986

Figure 2

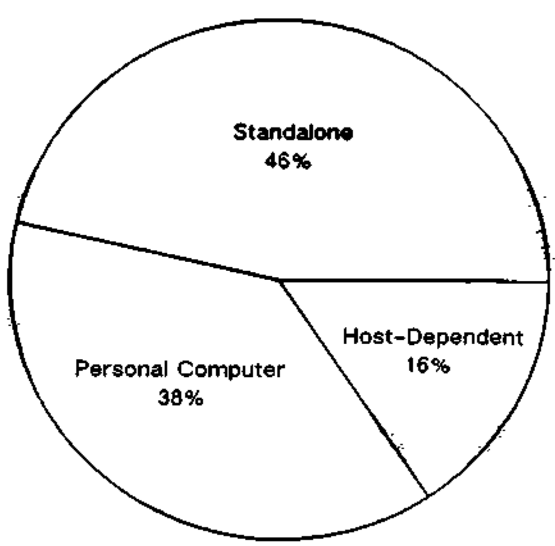
USE OF PERSONAL COMPUTER SOFTWARE TOOLS



Source: Dataquest
July 1986

Figure 3

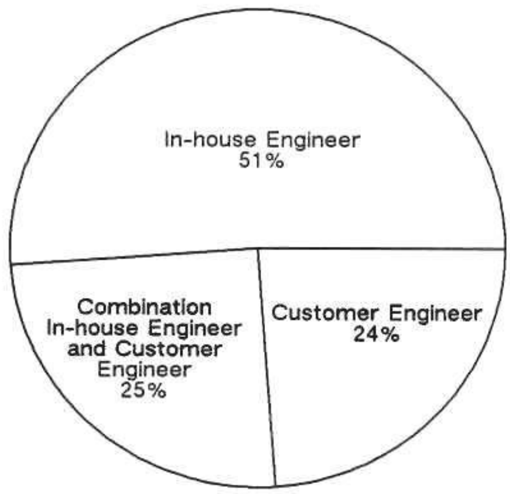
PURCHASE PLANS BY PRODUCT TYPE



Source: Dataquest
July 1986

Figure 4

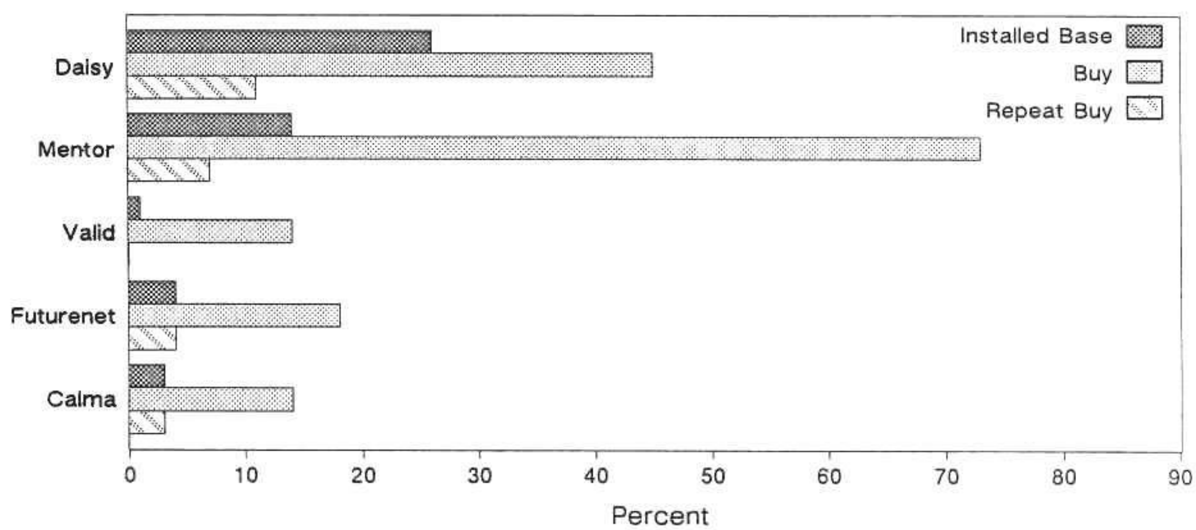
WHO DOES THE DESIGN?



Source: Dataquest
July 1986

Figure 5

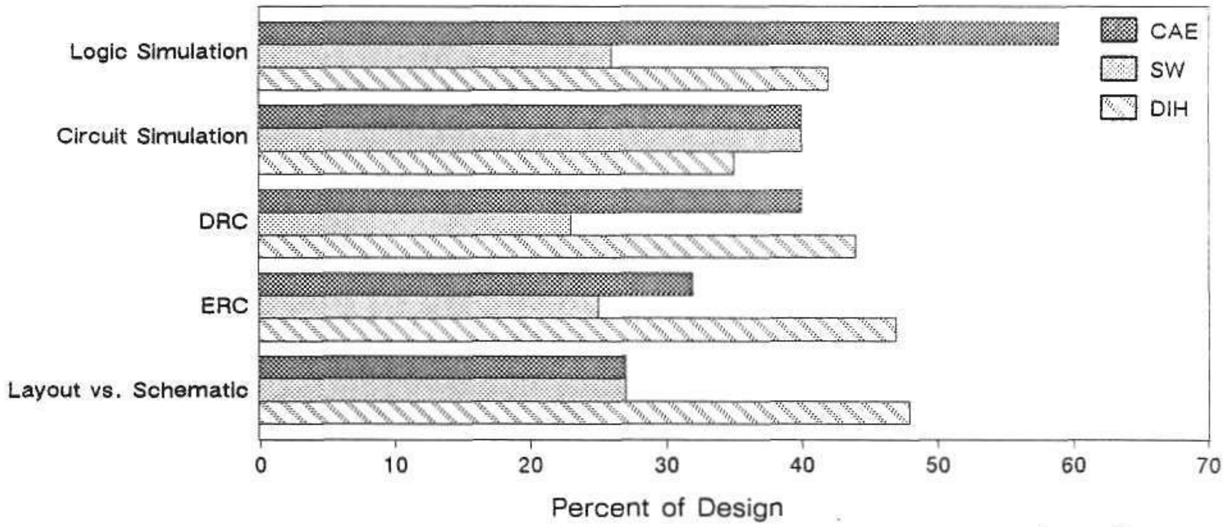
ANALYSIS TOOLS: INSTALLED BASES AND BUYING PLANS



Source: Dataquest
July 1986

Figure 6

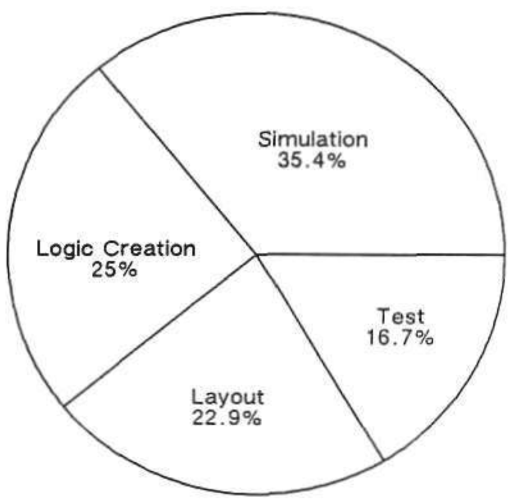
ANALYSIS TOOLS: USAGE AND SOURCES



Source: Dataquest
July 1986

Figure 7

AVERAGE DISTRIBUTION OF TIME PER DESIGN PHASE



Source: Dataquest
July 1986

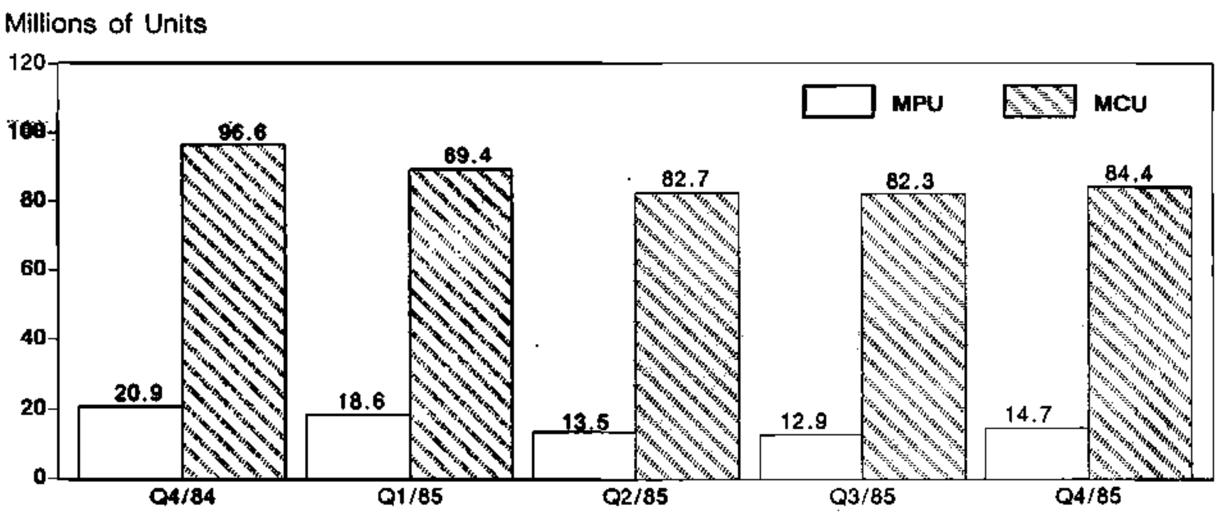
SUIS Code: Newsletters
1986-26

FOURTH QUARTER 1985 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the fourth quarter of 1985, worldwide microprocessor and microcontroller unit shipments increased by approximately 4 million units or 4.2 percent from third quarter 1985. Estimated shipments of all microcontroller devices totaled approximately 84.4 million units. Shipments of both 4-bit MCUs and 8-bit MCUs increased slightly. Estimated shipments of all microprocessor devices totaled approximately 14.7 million units. Shipments of 8-bit MPUs and 16-bit MPUs increased in the fourth quarter by 13 percent and 22 percent, respectively, over the prior quarter's shipments. Figure 1 shows MCU and MPU unit shipments from the fourth quarter of 1984 through the fourth quarter of 1985.

Figure 1

**MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS
FOURTH QUARTER 1984 THROUGH FOURTH QUARTER 1985
(Millions of Units)**



Source: Dataquest
August 1986

Table 1 shows the quarterly revenue for microcontrollers and microprocessors from the fourth quarter 1984 through the fourth quarter 1985.

Table 1

TOTAL MICROCONTROLLER AND MICROPROCESSOR REVENUE
FOURTH QUARTER 1984 THROUGH FOURTH QUARTER 1985
(Millions of Dollars)

	Q4/84	Q1/85	Q2/85	Q3/85	Q4/85
MCU	$372.2	$293.9	$255.6	$260.0	$300.4
MPU	169.9	131.0	102.0	96.0	104.8
Total	$542.1	$424.9	$357.6	$356.0	$405.2

Source: Dataquest
August 1986

Table 2 shows the change in total microcontroller unit shipments from the third quarter of 1985 through the fourth quarter of 1985.

Table 2

TOTAL MICROCONTROLLER UNIT SHIPMENTS
THIRD QUARTER 1985 THROUGH FOURTH QUARTER 1985
(Thousands of Units)

	Q3/1985		Q4/1985		Percent Growth
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
4-Bit	44,187	53.7%	45,635	54.0%	3.3%
8-Bit	38,060	46.2	38,726	45.9	1.7%
16-Bit	56	0.1	71	0.1	26.8%
Total	82,303	100.0%	84,432	100.0%	2.6%

Source: Dataquest
August 1986

Table 3 shows the change in total microprocessor unit shipments from the third quarter of 1985 through the fourth quarter of 1985.

Table 3

TOTAL MICROPROCESSOR UNIT SHIPMENTS
THIRD QUARTER 1985 THROUGH FOURTH QUARTER 1985
(Thousands of Units)

	Q3/1985		Q4/1985		Percent
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
8-Bit	11,018	85.7%	12,434	84.6%	12.9%
16-Bit	1,804	14.0	2,199	15.0	21.9%
Others	37	0.3	52	0.4	40.5%
Total	12,859	100.0%	14,685	100.0%	14.2%

Source: Dataquest
August 1986

Table 4 shows the change in the shipments of the leading 8-bit MPUs from the third quarter of 1985 through the fourth quarter of 1985.

Table 4

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1985 THROUGH FOURTH QUARTER 1985
(Thousands of Units)

	Q3/1985		Q4/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
Z80	4,085	37.1%	4,988	40.1%	22.1%
8085	2,616	23.7	3,200	25.7	22.3%
6802	903	8.2	979	7.9	8.4%
8088	817	7.4	865	7.0	5.9%
6809	638	5.8	680	5.5	6.6%
Others	1,959	17.8	1,722	13.8	(12.1%)
Total	11,018	100.0%	12,434	100.0%	12.9%

Source: Dataquest
August 1986

Table 5 shows the changes in estimated shipments of 16-bit microprocessors from the third quarter of 1985 through the fourth quarter of 1985.

Table 5

16-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1985 THROUGH FOURTH QUARTER 1985
(Thousands of Units)

	Q3/1985		Q4/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
68000	438	24.3%	618	28.1%	41.1%
8086	431	23.9	599	27.2	39.0%
80286	405	22.5	410	18.6	1.2%
80186	210	11.6	228	10.4	8.6%
V30	120	6.7	130	5.9	8.3%
Z8000	89	4.9	85	3.9	(5.0%)
32016	71	3.9	75	3.4	5.6%
Others	40	2.2	54	2.5	35.0%
Total	1,804	100.0%	2,199	100.0%	21.9%

Source: Dataquest
August 1986

Table 6 shows the changes in estimated shipments of 8-bit microcontrollers from the third quarter of 1985 through the fourth quarter of 1985.

Table 6

8-BIT MICROCONTROLLER SHIPMENTS
THIRD QUARTER 1985 THROUGH FOURTH QUARTER 1985
(Thousands of Units)

	Q3/1985		Q4/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
6805	5,505	14.5%	6,776	17.5%	23.1%
8049	6,520	17.1	5,902	15.2	(9.5%)
8051	3,931	10.3	3,930	10.2	-
8048	4,241	11.1	3,280	8.5	(22.7%)
Others	17,863	47.0	18,838	48.6	5.5%
Total	38,060	100.0%	38,726	100.0%	1.7%

Source: Dataquest
August 1986

Table 7 shows market share by technology for 8-bit microcontroller and microprocessor devices from the fourth quarter of 1984 through the fourth quarter of 1985, and indicates increased shipments of 8-bit CMOS microcontrollers and microprocessors.

During fourth quarter 1985, approximately 78 percent of all 8-bit CMOS MCU shipments and approximately 64 percent of all 8-bit CMOS MPU shipments were Japanese manufactured and shipped.

Table 7

MARKET SHARE BY TECHNOLOGY FOR MICROCONTROLLERS AND MICROPROCESSORS FOURTH QUARTER 1984 THROUGH FOURTH QUARTER 1985

Device	Tech.	Q4/84	Q1/85	Q2/85	Q3/85	Q4/85
8-Bit MCU	CMOS	15.3%	16.9%	20.4%	20.4%	21.7%
8-Bit MCU	NMOS	84.7	83.1	79.6	79.6	78.3
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	11.6%	12.0%	15.2%	17.2%	19.3%
8-Bit MPU	NMOS	88.4	88.0	84.8	82.8	80.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: Dataquest
August 1986

DATAQUEST ANALYSIS

Dataquest estimates that revenue from microprocessor and microcontroller shipments for fourth quarter 1985 was $405.2 million, an increase of approximately 13.8 percent from the previous quarter. MPU/MCU shipments revenue totaled $1,543.7 million for 1985, which represents a decrease of 23 percent from 1984 MPU/MCU shipments revenue.

Brand Parks
Patricia Galligan

SUIS Code: Newsletters
1986-25

PRELIMINARY SECOND QUARTER 1986 MICROCOMPONENTS WORLDWIDE UPDATE

After some signs of recovery during second quarter 1986, worldwide microcomponent business began weakening. Orders had improved since second quarter 1985, when orders were at the lowest point of the downturn. Second quarter 1986 experienced the highest microcomponent booking since third quarter 1984, seven quarters earlier. During second quarter 1986, the turns business was high, indicating quick turnaround of microcomponent device inventory. And, the microcomponent book-to-bill ratio had been approximately 1:1 for the last few quarters. Recovery appeared to be in sight, but, orders at the end of June became soft. Furthermore, the third quarter appears to be weak due to typical slow summer months. Dataquest has updated its quarterly microcomponent forecast, as shown in Table 1. We estimate that most of the year's growth occurred in the first half of 1986, with a slow third quarter and slight growth expected in the fourth quarter. Real recovery is expected during the first half of 1987.

Table 1

WORLDWIDE QUARTERLY MICROCOMPONENTS FORECAST
(Millions of Dollars)

	1986				
	Q1*	Q2*	Q3	Q4	Year
MCU	$322	$359	$359	$389	$1,429
MPU	99	135	153	171	558
MPR	378	397	380	405	1,560
Total	$799	$891	$892	$965	$3,547

*Actuals

Source: Dataquest
July 1986

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North America microprocessor demand is very weak because of the computer industry slump. As a result, prices of most microprocessor products are expected to decrease during the rest of 1986 and 1987. Exceptions to this are prices for products like the Z80 and 8085 that decreased below reasonable levels in 1985 and are expected to increase during the next year.

Demand in Europe and Japan is flat or growing slowly. Japanese microcomponent manufacturers continue to increase their shares of the microcontroller and low-end microprocessors used widely in consumer and personal computer peripherals.

The ROW region, dominated by the Pacific Rim countries other than Japan, is the only high-growth region. We believe that this is being driven by increased purchases offshore by U.S. manufacturers to take advantage of lower prices, growing production of PC clones in the Far East, and movement of production of low-cost Japanese consumer products to countries outside of Japan to counter the increasing value of the yen versus the dollar. We expect these trends to continue during the balance of 1986 and into 1987.

Stan Bruederle
Janet Oncel

SUIS Code: Newsletters
1986-24

SILICON COMPILATION: MYTH OR OPPORTUNITY?

INTRODUCTION

Silicon compilation has become a new buzzword in the area of Application Specific Integrated Circuits (ASICs). Dataquest's CAD/CAM Industry follows the development of this important engineering design tool. This newsletter describes the current status of silicon compilation and puts it in perspective relative to other design methods. People involved in the selection of engineering design tools should find this newsletter very useful.

In 1985, the electronic CAD/CAM marketplace learned what silicon compilation is all about, from trade shows, published articles, technical sessions, and workshops. Despite this marketing blitz, many observers still consider silicon compilation too immature to be a serious contender in the IC CAD arena. One critic put it bluntly: Nobody wants it yet.

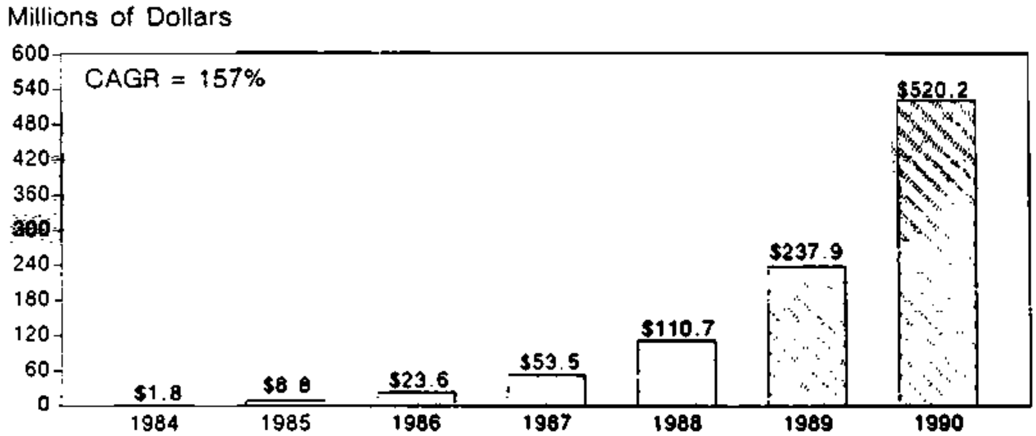
Well, somebody must. At Dataquest's recent CAD/CAM Industry Conference, four early adopters of silicon compilation testified to the design successes they have achieved. Furthermore, Dataquest estimates that silicon compilers accounted for $8.8 million of 1985 IC CAD revenue, growing impressively from $1.8 million in 1984. As silicon compilation technology becomes increasingly incorporated onto IC CAD workstations alongside competing design tools, we expect the demand for compilation functionality to soar (see Figure 1).

This newsletter:

- Defines silicon compilation methodology and product types
- Analyzes the case for and against silicon compilation
- Examines user attitudes expressed during our silicon compiler end-user panel
- Offers Dataquest's conclusions

Figure 1

ESTIMATED IC CAD SYSTEMS WITH SILICON COMPILATION
(System Revenue*)



* Includes CAD-only vendors

Source: DATAQUEST
April 1986

DEFINITIONS

Distinctions

Some important distinctions have to be made immediately because silicon purists will object to our referring to this automatic IC design technology as "silicon compilation" rather than "cell compilation."

Dataquest believes that silicon compilation is the ultimately intended product and that the current generation of cell-based tools represents evolutionary steps on the way to true or fully automated IC design. We can see no competitive advantage in confusing end users with such academic distinctions at this time.

"True" silicon compilation, in the sense of artificial intelligence-based, design synthesis, may not be here yet, but the form of it that does exist is usable, and is being used, right now. A more significant way to distinguish the various products calling themselves silicon compilers is by the level of IC design expertise required to use them.

Silicon compilation currently exists as two types of design tools, one aimed at the non-IC designer and the other at the IC designer. Dataquest classifies these design tools, respectively, as silicon compilers and compiler generators. For example, Concorde from Seattle Silicon Technology (SST) and Genesil from Silicon Compilers Incorporated (SCI) are silicon compilers. GDT from Silicon Design Labs (SDL) is an example of a compiler generator. (A subsequent newsletter will examine in depth both silicon compiler market participants and specific products.) Silicon compiler companies offer design services in addition to these products.

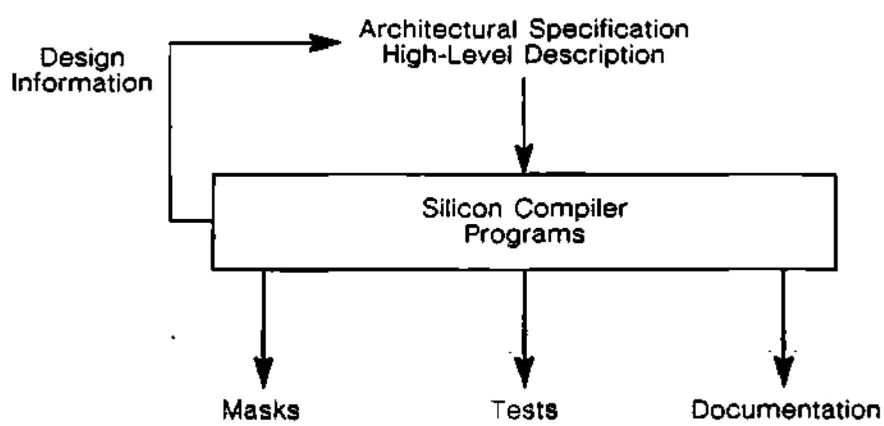
Silicon compilation as a design service is also being offered to customers by a growing number of ASIC houses, such as Cirrus Logic, Gould-AMI, LSI Logic, and VLSI Technology Incorporated (VTI). We expect the ranks of ASIC suppliers offering compilation to grow dramatically over the next year. Additionally, VTI offers compilation products based on its own cell libraries.

Silicon Compiler

Dataquest defines a silicon compiler as a set of programs to automatically generate the physical layout of an ASIC. Silicon compilers generally employ a top-down, hierarchical design methodology that begins with a high-level specification (see Figure 2).

Figure 2

TRUE SILICON COMPILATION



Source: DATAQUEST
April 1986

The user enters this specification using either a menu or a form, choosing from a pre-designed functional library and specifying the particular process, electrical characteristics of the functional modules, and foundry design rules. The functional library could consist of such less complex cells as ALUs, ROMs, RAMs, register arrays, and steering logic, or of more complex cells such as CRT controllers.

The silicon compiler translates this specification, creates the necessary cells, and generates a layout. The compiler coordinates routing and placement decisions. The user manipulates this layout and the specification until a satisfactory design is produced. Within the compiler are simulation, design and timing verification, design rules checking routines, and design data base management facilities--a fully integrated design solution.

Compiler Generator

Dataquest defines a compiler generator as a system for creating the functional modules used by the compiler. Simply, it is a compiler development system. Compiler generators differ from silicon compilers in the way designs are entered, in design methodology, and in the level of IC design expertise required (see Table 1). In reality, compiler generators have more in common with handcrafted IC design systems, to which they represent an alternative, plus a migration path to automatic layout.

Table 1

COMPARISON OF EXPERTISE REQUIRED FOR IC DESIGN

	Design Entry			
Methodology	Schematic	Language	Form	Physical Layout
Compiler	N/A	N/A	Logic	Novice
GA, SC	Logic	N/A	N/A	Novice
Compiler Generator	Silicon	Silicon	N/A	Silicon
Handcrafted	Silicon	N/A	N/A	Silicon

N/A = Not Applicable

Source: Dataquest
June 1986

Functional modules are described in algorithms by means of high-level programming languages such as C or LISP, or the logic itself. Compiler generation description includes a set of customizable characteristics in the modules or design primitives. These parameterized designs eventually become the functional model libraries of a silicon compiler and are the means that allow compiler end users to specify characteristics of the particular module, such as aspect ratios, register size, memory size, timing information, and other functional properties.

COMPILATION

Benefits

From our end-user research, we have identified the following as the benefits of silicon compilation:

- Reduced design turnaround, compared with other methodologies
- Integrated design solution
- Greater design exploration/creativity
- Enforced standard design practice
- Automated layout

ASICs are, at present, most often designed by customers entering the design using schematic capture and running logic simulation. In the case of gate array or standard cell workstations, physical design is accomplished via automatic place and semiautomatic route programs. The resulting design is then passed over to the foundry either for physical design or for redesign, and for test. By and large, the tools used during the design process are coming from a variety of vendors and are often highly nonintegrated. This fragmentation within the design process can result in high nonrecurring engineering (NRE) costs, as the design moves from concept to manufacturable product.

Silicon compilation bypasses the time-intensive and error-prone schematic entry phase, and thus reduces costs both in-house and at the foundry. We think that users will find it strategically important to know their designs are manufacturable months before they get to the foundry.

Increased design creativity also results from freeing system engineers or non-IC designers from the time constraints of schematic entry and allowing them to work at a higher level of abstraction. Compilers allow users to explore a variety of architectures or floor plans, and their resulting layouts, before committing their designs. This expanded product development phase results in better designs because there are more opportunities to try out design alternatives.

Compilers assure design manufacturability by enforcing the standard design practices of the specified foundry. The design and test rules the compiler uses to accomplish this can be either a generalized set of design and process rules of supported foundries, or the highly specific manufacturing rules of a single manufacturer. In either case, the ultimate design benefits from having to conform to manufacturing design rules early in the design process. Turnaround time, both during design and at the foundry, also benefits from such enforcement of standard design practice, which translates into lower costs. That's the bottom line.

The advantage of compiler generators is that they provide the means for ASIC houses and semiconductor manufacturers to capture their design experiences in libraries that are more descriptively and efficiently developed, as well as more easily maintained. This type of tool permits designs to be generalized and silicon expertise to be encapsulated. Redesign is expedited. For the IC designer, the compiler generator represents the freedom and creativity of designing at all levels of abstraction. For the users of silicon compilers, IC designers using compiler generators translates into having more cells to choose from or, in marketing terms, increased design flexibility.

In our opinion, the overriding advantage of both silicon compilers and compiler generators is to provide a shared method of satisfying the design demands of both system engineers and IC designers. These tools provide the means of communicating IC design methodology in terms understood by each class of user.

NEEDS

From our end-user research, we have also identified the following shortcomings of current compilation products:

- Lack of automated test generation
- Limited number of functional design modules
- Limited number of supported IC manufacturers
- Inefficient silicon usage
- Low user comfort level or lack of user-friendly interface
- Few design successes

On the negative side, current silicon compilers do not include automatic test vector generation. Dataquest believes that to be ultimately successful, silicon compilation is going to have to solve the enormous problem of automatic test generation.

At present, the designer's choices, in terms of numbers of functional design modules to choose from, are limited. This is an area that will require close cooperation between CAD vendors and IC manufacturers in order to develop a richer functional module set.

Compilers necessarily employ block placement and routing of cells, often resulting in inefficient utilization of the silicon. This means expense. Better design compaction routines would result in a use of silicon real estate that is comparable to the efficiency of handcrafted chips. In any event, the trade-off between time-to-design and silicon efficiency must be reduced.

The critics' most convincing argument concerns user reluctance to change their current design methods. Rhetorically, the case can be made either way. System engineers are being asked to think in terms of IC designers, and IC designers are being asked, not only to think in terms of logic designers, but also to become software engineers. Compiler vendors are going to have to provide migration paths to the new methodology. For example, they must either provide easier user interfaces that include on-line help and training facilities, or offer some synthetic mechanism for translating a schematic into the higher-level description required by a compiler.

There is only one way out of this to-change-or-not-to-change juggernaut, and that is when the cost of NOT using compilation tools begins to hurt competitively. Specifically, it's when the design successes and resulting productivity gains of compilation clearly outdistance the price of designing with older methodologies. Dataquest believes that the use of compilers increasingly will represent a significant competitive advantage, and that publicized endorsements of compiler design successes will fuel the demand for these products.

SILICON COMPILER ISSUES AND END-USER PANEL

The following user comments are from the silicon compiler end-user presentations and panel discussion conducted during Dataquest's CCIS conference held in May. Included are brief Dataquest analyses of various silicon compilation issues. The panel itself consisted of three system engineers who are using silicon compilers and, amazingly enough, only one "tall thin IC designer," who uses a compiler generator product.

Reasons for Choosing Silicon Compilation

"We needed a full custom design and we couldn't get the density in conjunction with the speed we needed from either standard cells or gate arrays. We know how to apply more logic, but more logic was prohibitively expensive."

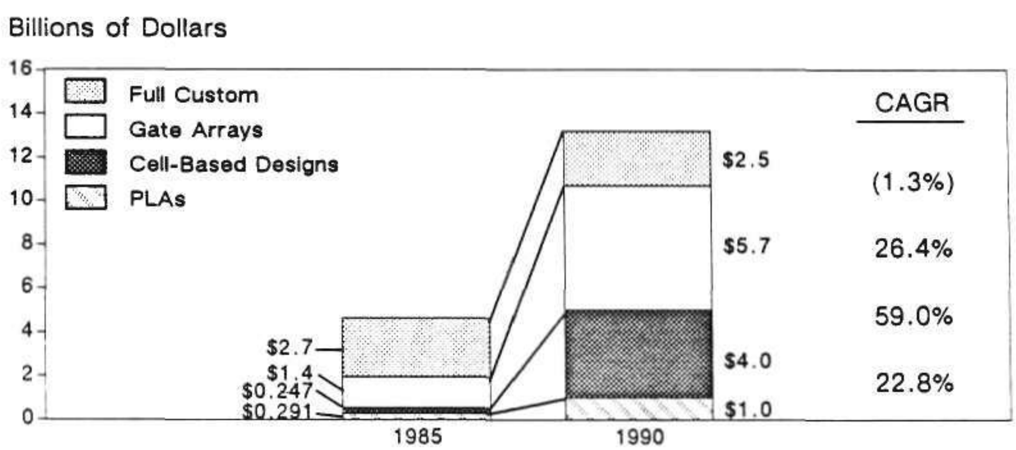
"Obviously, anything that a silicon compiler can do could be put into a standard cell library . . . but we couldn't find a standard cell manufacturer with all the cells we needed. It's simply a question of the size of the library versus the capabilities of the compiler. When you compare silicon compilers and standard cells, I expect you'll see silicon compilers eat up the definition of standard cells as silicon compilation becomes more tried and true. So we had to look at some form of silicon compiler."

Dataquest classifies chips designed by the current generation of silicon compilers as cell-based ICs. These cell-based designs satisfy a demand for something between standard cells and fully handcrafted ASICs. Full custom will ultimately yield to cell-based technology.

Dataquest's Semiconductor Industry Service forecasts that merchant sales of cell-based ASICs will grow at 59 percent CAGR between 1985 and 1990, faster than the 26 percent CAGR of gate arrays and, more significantly, faster than the negative 1.3 percent CAGR for full custom ASICs (see Figure 3). In our opinion, the demand for cell-based designs and cell-based design tools (i.e., silicon compilers) go hand-in-hand. (For more information on this subject, refer to our CCIS Research Newsletter, No. 91, entitled "Sharing the Expertise: The Semiconductor and Electronic CAD Markets Team Up for Automated Design.")

Figure 3

ESTIMATED MERCHANT ASIC MARKET
(Billions of Dollars)



Source: DATAQUEST
February 1986

Process Independence

"During design itself, there's no visibility of the target foundry or process. You essentially compile out to all supporting foundries and decide, based on power, speed, and die-size--essentially yield--which foundry you'll go to."

"Process and foundry independence was key in our choice of compilers . . . . We had a choice of four foundries and eight different processes."

Process-dependent tools and products, in our opinion, do not offer users the design portability that Dataquest research indicates is a major user demand. The rule-of-thumb is the larger the customer, the more critical the need for second-sourcing. The VTI end user on our panel, however, disagreed; the assurance of manufacturability provided needed security in adopting a new design methodology. Another system end user predicted that the growth of ASIC design will eventually result in longer foundry queues, thus making the case for second-sourcing via process-independent design tools.

Slow User Acceptance

"The problem is expectations . . . because we're not there yet. There's no totally automatic silicon compiler to automate the IC design process yet. It's still pretty much an interactive tool."

"System engineers don't really care to be bothered with layout. . . . There's a built-in reluctance to changing a design methodology."

"We're still going through the first generation of design successes using silicon compiler technology."

"We are not silicon designers. We couldn't spell silicon when we started this process using compilation and, more importantly, after finishing it, we still can't spell silicon . . . . If it's not a one or a zero, we don't want to know about it."

"Just because we use handcrafted IC CAD workstations, don't assume we like 'em."

From these comments, it is clear that in order for silicon compilers to win widespread acceptance among non-IC designers, the human interface is going to have to be related to the logic level and no lower. From our primary research, IC designers themselves are actively pursuing both compiler generator evaluation and purchase decisions.

Time to Design

"Our first two designs took ten months from CAD system delivery to working silicon. Our estimate of how long it's going to take to do parts in the future is around seven-and-a-half to eight-and-a-half months total."

"So, even with the one error we found . . . it took us about 15 months to get to production silicon from the idea of doing a silicon compiled chip, which is extremely good comparing it to another music chip from another company. They were at first silicon with a handcrafted chip the day that we started working on ours . . . . They have still to get working silicon back from this handcrafted chip. The silicon compiler is a tremendous leverage tool."

DATAQUEST CONCLUSION

What Are We Saying?

We are saying that not every IC design will require a compilation solution. Silicon-compiled chips are not yet quicker to design than gate arrays, nor do we expect that they will displace this popular implementation. Nor, for that matter, are compiler generators completely satisfactory for microprocessor development and other highly yield-sensitive designs. But we are saying that for a range of full-custom applications, compilers do represent a significant design alternative. For a long time to come, there will be an appropriate role for all three IC design methodologies: handcrafted, autoplace and route, and compilation.

Furthermore, we are saying that users will want the option of choosing the appropriate methodology on a per design, rather than on a per workstation, product basis. And this means offering the choice of methodologies on a single IC CAD workstation. The market for silicon compilation cannot be separated from the market for all IC CAD tools, because each one is a piece of the puzzle.

Silicon compilation is not a myth. It is a functioning IC design methodology in beta site, and the first reports, such as those presented by the panelists at our annual conference, are impressive. We believe that both early adopters and vendors recognize silicon compilation as the IC design tool the market has been demanding for quite awhile now: an integrative design solution.

We said earlier that 1985 was the year for market education. Well, 1986 is the year for endorsements and design successes. We believe that word-of-mouth endorsements from early adopters will snowball. From this point on, we expect silicon compilation to combine with, and eventually displace, competing IC design methodologies.

(This newsletter is reprinted with the permission of Dataquest's CAD/CAM Industry Service.)

Stan Bruederle
Tony Spadarella

SPECIALTY MEMORIES: FOUR EXAMPLES

This newsletter was produced by the Semiconductry Industry Service and primarily addresses supplier marketing issues. We think that users considering decisions regarding the selection and use of the following types of memory products should find this newsletter informative as well.

SUMMARY

Specialty memories have recently attracted a great deal of attention. Many semiconductor manufacturers are looking at this marketplace as a way to escape from the roller coaster of commodity memory pricing and, through their designs, to offer high-value-added products aimed at simplifying system design problems.

An overview of market factors is discussed in a companion SIS newsletter, "Perspectives on Specialty Memories," dated July 1986.

This newsletter discusses four specialty memory products, along with their suppliers, product availabilities, applications, and current and projected market sizes. The products discussed are dual-port RAMs (DPRs), First-In First-Out memories (FIFOs), video RAMs (VRAMs), and content-addressable memories (CAMs).

DUAL-PORT RAMs (DPRs)

A dual-port RAM is a RAM (static or dynamic) that has two independent access ports consisting of a pair of address, data, and control signals. Hence, a DPR has a relatively large number of pins associated with it (almost double that of traditional single-ported SRAMs). The two ports act independently of each other, and each side has full access to the memory array. (A certain amount of "arbitration" may be included to handle almost-simultaneous accesses from both sides.)

The major technical advantage that a dual-port RAM device has over its single-port rival is that it is significantly easier for the systems designer to "share" memory between two processors. On-chip arbitration and the incorporation of all the access pins onto the same device saves tremendously in external buffers, multiplexers, and latches for such an application. Hence, cost savings is a major factor--as evidenced by reduction in the number of packages used, as well as reduction in board area.

DPR design-ins generally are found in systems where there are two (or more) processors on the same board, such as a main microprocessor with an intelligent peripheral controller. Systems that warrant use of large buffer memory between two processors are typically complicated (or just large) computer/communications interfaces; these applications require more than the small number of bytes of buffering generally found in peripheral controllers. Another major application area is in the distributed processor field, where separate computational units must communicate their data at nearly real-time speeds. The number of such designs, however, is quite small. Very few users have been able to apply such features to their own systems due to the overall complexity of that particular implementation technique.

DPR Replacement Potential

A 1Kx8 DPR chip in one package replaces the following equivalent TTL parts:

- An address multiplexer (8-bit buffers/latches)--four packages
- Two data in/out latches and buffers--two packages
- An arbiter/controller--one package
- A 1Kx8 SRAM--one package

The single-chip DPR can replace a minimum of eight packages. Unlike the FIFO, however, a DPR is a high-pin-count device because all the address pins (two sets for both ports) are input to the chip. That point has led a number of suppliers to consider multiplexing address inputs for higher-density DPRs.

Product Availability

Actual DPR devices have been available only recently in a steady enough supply for design-ins to take place. The first commercially and application-viable DPR was a Synertek 1Kx8 part, the 2130. When the product was initially introduced, it generated much customer interest; however, due to Synertek's inability to remain a supplier, the design-ins did not pick up. Only recently, after being reintroduced through Signetics and then VTI, is the device getting some consideration. IDT is the largest supplier of DPRs, with its 8K and 16K CMOS parts; IDT has contributed significantly to the establishment of the dual-port RAM market. The following suppliers either have just recently started to supply DPRs or are about to enter this market:

- Vitelic recently entered the DPR market with 8K- and 16K-density devices. Incorporation of special features for two-processor organizations makes Vitelic's parts very useful in multi-processor communications.

- AT&T Technology's entrance in this market is with a 68-pin PLCC 2Kx9 part. AT&T's strategy is to introduce high-density monolithic DPRs at moderate speeds. AT&T also has 512x8 and 512x9 devices.

- AMD has recently introduced a 1Kx8 DPR. AMD's marketing expertise and experience has helped the company in generating much customer interest.

- IDT offers monolithic 1Kx8 and 2Kx8 DPRs, as well as 64K- and 128K-density hybrid modules. Access speeds that are sub-80ns are one of IDT's strengths, as well as a commitment to offer a variety of DPR products. It is estimated that IDT owns more than 50 percent of the DPR market today.

- VLSI Technology has inherited the Synertek 1Kx8 and has the largest market share after IDT. VTI's experience with semicustom design techniques is being used to provide a wide product offering based on a common DPR memory core.

Table 1 lists the dual-port RAMs currently available. (The dual-port RAM market described here does not include video RAMs; they will be discussed later in this newsletter.)

There are many important issues in the DPR market: customer inputs, density, pin count, "features," speed, power, and packaging. There is no single criterion that Dataquest believes is the most important in supplying or selecting a "good" DPR device, but rather there is a combination of features that are appropriate for each particular application. For example, interrupt features would be useful in communications but might not necessarily be an advantage in a multiprocessing environment. Multiplexed inputs might be appropriate for mass memory applications, but not for peripheral function controls.

Discussion with some suppliers and users indicates a common misconception that any dual-port RAM will do for most applications. However, even within the dual-port RAM market there is room for product differentiation, and there will be a need for many different types of DPRs in the marketplace.

Table 1

DUAL-PORT RAM AVAILABILITY

Company	Part No.	Technology	Device Organization	Access Time	Package
AMD	29705	TTL	16x4	25ns	DIP
	2130	CMOS	1Kx8	70ns	DIP
AT&T	78004	NMOS	512x8	200ns	40 P-DIP
	79004	NMOS	512x9	200ns	40 P-DIP
	79018	CMOS	2Kx9	150ns	68 PLCC
	79072	CMOS	8Kx9	N/A	68 PLCC
Cypress	7C130	CMOS	1Kx8	N/A	48 DIP or 48 PLCC
ERSO	2433	CMOS	2Kx8	N/A	48 DIP
IDT	7130 Master	CMOS	1Kx8	55ns	48 DIP or LCC
	7132 Master	CMOS	2Kx8	55ns	48 DIP or LCC
	7140 Slave	CMOS	1Kx8	55ns	48 DIP or LCC
	7142 Slave	CMOS	2Kx8	55ns	48 DIP or LCC
	7M134	CMOS	8Kx8	100ns	Module 600 mil
	7M135	CMOS	16Kx8	100ns	58 CERDIP
MOSel	6130	CMOS	1Kx8	55ns	48 sidebraze DIP
	6132	CMOS	2Kx8	55ns	48 P-DIP
TCMC	4511	CMOS	512x9	120ns	28 P-DIP or 32 P-DIP
UMC	2130	NMOS	1Kx8	N/A	DIP
Vitelic	61C30	CMOS	1Kx8	70ns	48 DIP
	61C32	CMOS	2Kx8	70ns	48 DIP
VTI	2130	NMOS	1Kx8	100ns	48 DIP
	2131	NMOS	1Kx8	100ns	48 DIP

Source: Dataquest
July 1986

Market Size and Growth Prospects

Dataquest estimates that sales of DPR devices for the 1985 calendar year were approximately $5 million. Most 1985 sales were from initial prototyping. It is expected that 1986 sales for dual-port RAMs (not including video RAMs) will be on the order of $18 million to $20 million. A necessary cross-check when establishing market size and growth prospects for DPRs at this time is to look at the number of customer target designs and the diversity of these applications. Suppliers' data indicate that more than 250 companies in the United States are currently designing-in DPRs from a number of vendors (including IDT, VTI, AMD). These particular systems vary from one-of-a-kind aircraft simulators to minicomputers to magnetic disk buffers. The levels of volume production are expected to vary just as widely.

Factors that will contribute to the growth of this market include the breadth of applications and the increasing popularity of these chips with board-level designers.

FIRST-IN FIRST-OUT MEMORIES (FIFOs)

A FIFO is similar to a dual-port RAM in that it has two access ports. However, the addition of the internal indexing and the restriction of the ports to being write-only and read-only, respectively, shape the device for some very useful applications. This memory has no address inputs, as the control clocks increment and decrement internal address counters. One can think of a FIFO as a "rubber-band memory," dynamically stretching in capacity when more storage is required and shrinking when there is less data to buffer.

FIFOs are most widely used in communications-buffering applications. It is no surprise that AT&T is the largest single consumer of FIFO memories. When an asynchronous data stream must be interfaced with a tightly controlled processor, a FIFO is ideal. The depth of the FIFO (number of memory locations) required is proportional to the degree of lack of coupling of the two systems and, to a certain extent, to their speeds and speed disparities.

An application where very shallow FIFOs have been used is in the bit-slice architecture market. There FIFOs are used for register-like temporary storage. FIFOs are also being used today in digital signal processing (DSP) systems where they can implement a variable and adaptable digital delay unit.

Because of the major target application of communications buffering, FIFOs typically have been used for high-bandwidth operation. Speed is generally a more critical factor with FIFOs than it is with DPRs. Another important issue with FIFOs used as buffers is that of flags. Many FIFOs have a number of output signals representing the fullness of the buffer. Some FIFOs have a half-full flag, while others have a full-minus-two flag, and so on. The exact function of the flag in commercial FIFOs is a point of disagreement among suppliers and users alike. FIFO output flags are truly an application-specific issue and should be treated as such.

FIFO Replacement Potential

A FIFO chip in one package can replace a number of external "glue logic" packages by internally integrating the functions very efficiently. In order to implement a 1Kx8 FIFO function using a generic static RAM, the systems designer must use the following (for a minimal implementation using standard TTL parts):

- Two sets of address counters (one for each port, each consisting of three 4-bit counters)--six packages
- An address multiplexer (four buffer or multiplexer chips)--four packages
- A data in and data out buffer/latch--two packages
- An address comparator for (simple) flag generation--two packages
- Control logic to perform access arbitration and counter and buffer control--three packages
- The 1Kx8 SRAM--one package

Clearly, the monolithic FIFO single chip is an efficient solution to the implementation of such a memory, compared to 18 other packages. Another important point to remember regarding the FIFO is that there are no address inputs needed on the chip; hence, the number of pins on a FIFO is not large.

Product Availability

Traditionally, small shallow register-based FIFOs (32- to 128-bit density) have been implemented in bipolar technology. Major suppliers for such bipolar parts are AMD, TRW, and MMI. More recently, a number of vendors have begun offering CMOS versions of these small FIFOs, where the speeds have been comparable (20- to 40-MHz clock rates) at significantly lower power.

Larger RAM-based FIFOs have also emerged in the past few years, where the depth has been significantly increased. FIFOs of increasing depth can be packaged using the same pinout, as there are no address inputs. Thomson Components Mostek Corporation's (TCMC's) introduction of a 512x9 FIFO began a wave of design-ins, and the part has emerged as a pinout standard, much like Synertek's DPR. A number of suppliers have plans to introduce deeper FIFOs with the same pinout.

Table 2 lists FIFO suppliers and their product offerings, including the following:

- TCMC's 512x9 FIFO has set a pinout standard in the marketplace as a result of its early market entry. The company's strategy is to increase depth and speed, as these are two critical FIFO areas.
- IDT is the other strong contender in FIFOs, as in DPRs. IDT's FIFOs are offered in both monolithic and hybrid forms, with TCMC-type pinouts. IDT's main strength is the speed of operation of its FIFOs.
- TRW's FIFOs consist of low-density, high-speed bipolar FIFOs aimed mostly at the military market. TRW's market experience in the military area allows it to emphasize the low-density, rad-tolerant/hard FIFO devices.
- Monolithic Memories is also a military supplier of FIFOs, although its strategy is to use CMOS for small, lower-power devices. MMI is also attempting to break into the large communications FIFO market by developing a deeper device.
- Cypress has used its advanced CMOS process to attack the niche military and bit-slice architecture FIFO markets. Cypress' strength is in providing a full product line for the implementation of bit-slice systems.

Table 2

FIFO AVAILABILITY

Company	Part No.	Technology	Device Organization	Package
AMD	2812	PMOS	32x8	CERDIP
	2813	PMOS	32x9	CERDIP
	3341	PMOS	64x4	CERDIP
Cypress	7C409	CMOS	64x4	CERDIP & P-DIP
	7C402	CMOS	64x5	CERDIP & P-DIP
Fairchild	74F403	TTL	16x4	24 CERDIP, P-DIP
	74F413	TTL	64x4	16 CERDIP, P-DIP
IDT	7201	CMOS	512x9	28-pin P-DIP, PLCC,
	7201	CMOS	1Kx9	28-pin CERDIP, 32-pin ceramic LCC

(Continued)

Table 2 (Continued)

FIFO AVAILABILITY

Company	Part No.	Technology	Device Organization	Package
MMI	67401	TTL	64x4	16-pin & 18-pin
	67402	TTL	64x5	CERDIP, flatpack
Thomson-Mostek	4501	CMOS	512x9	28-pin side brazed, CERDIP, 32-pin
TI	232	TTL	16x4	16-pin DIP, 150 mil SO
	233	TTL	16x5	20-pin DIP, 300 mil SO
Vitelic	61C01	CMOS	512x9	DIP
	61C02	CMOS	1Kx9	DIP

Source: Dataquest
July 1986

Market Size and Growth Prospects

The market for FIFOs today is as dispersed and undefined as the DPR market. While low-density FIFOs have been commercially available in the market for more years than the large ones, small FIFOs have tended to go into specialty military applications where the ASPs are high and vary tremendously and where quantities are small. Dataquest estimates that in 1985, the total FIFO market was $53 million. We also estimate that in 1986, sales will reach $70 million to $80 million. The wealth of possible design applications coupled with explosion of the telecommunications market and expanding activity in digital signal processing are fueling the FIFO market niche's growth.

MMI is the leading supplier of FIFOs, with its low-density devices. IDT and TCMC have approximately equal shares of the high-density FIFO market, and these two suppliers combined represent about one-half to two-thirds of the high-density FIFO market.

VIDEO RAMs

Video RAMs (VRAMs, sometimes referenced as multiport DRAMs) are true application-specific memories, designed in response to the increasing fraction of dynamic RAMs that are used in graphics applications. Video RAMs have one random access port and one serial access port. Initially derived from a basic x4 DRAM core, video RAMs attach a virtual 256x4 serial shift register to the DRAM array. Dual porting allows simultaneous memory access while being able to sustain an uninterrupted serial data stream during screen scan, increasing CPU efficiency to nearly 100 percent, compared with 50 to 60 percent typical with conventional DRAMs used in video applications.

Product Availability

Video RAMs were first introduced by Texas Instruments in late 1984, with its TMS4161, a 64K device. As this was rather late in the 64K DRAM product life cycle, it was not long before 256K devices were available. NEC's uPD41264 was available early in 1985 and became the first 256K VRAM available. It also incorporated what was to become the standard 256K feature set: Subsequent 256K feature sets either matched or exceeded those of NEC's part. Present announced suppliers of 64K and 256K VRAMs are shown in Table 3. Others include Motorola, Toshiba, and existing or potential licensees of the announced participants.

Video RAMs at the 1Mb density are not expected before the end of 1986. Most are expected to be CMOS, built around a 256Kx4 DRAM core, but there may also be some diversion to x8, x1, and x2 configurations, as well.

Table 3

VIDEO RAM AVAILABILITY

Company	Part No.	Device Organization	Technology	Package**	Speed
TI	TMS4161	64Kx1	NMOS	20 PLCC, DIP*	-15, -20
ATT Tech.	M51064	64Kx1	NMOS	20 P-DIP	-15, -20
AMD	Am90C644	64Kx4	CMOS	24 P-DIP	-10, -12
Fujitsu	MB81461	64Kx4	NMOS	24 P-DIP	-12, -15
Hitachi	HM53461/2	64Kx4	CMOS	24 P-DIP	-10, -12
Mitsubishi	M5M4C264P	64Kx4	CMOS	24 P-ZIP	-12, -15
				24 P-DIP	-12, -15
NEC	uPD41264	64Kx4	NMOS	24 P-DIP	-12, -15
Texas Inst.	TMS4461	64Kx4	NMOS	24 P-DIP	-12, -15
Vitelic	V51C264-	64Kx4	CMOS	24 P-DIP	-12, -15

*Also available in 4-5 chip SIP modules
**400 mil DIP package for 256Ks

Source: Dataquest
July 1986

Market Size and Growth Prospects

The total market for video RAMs was estimated to be $10 million to $12 million in 1985, split about 60 to 70 percent for 64Ks and 30 to 40 percent for 256Ks. The 1986 market is expected to be about $25 million, with at least six producers in volume production by the end of the year.

From an applications perspective, there is little doubt that graphics (and related serial-output) applications will constitute an increasingly large part of the DRAM market in years to come. Digital TV alone could eventually be a market equal to the total dynamic RAM bit consumption in 1985 (30 million TV units annually, at 4Mb each). Higher-resolution and color graphics displays also add considerable incremental demand for graphics RAMs.

Most estimates point to as much as 15 to 20 percent of the bit demand in the early 1990s coming from graphics applications. This demand may be met by video RAMs per se, or by other memories that are not quite so specialized but may not be hindered by the difficulties in building a specialty memory market. Those difficulties include:

- Uncertain initial feature set and available second sources
- Unacceptable price premiums
- System designer education time
- Lack of availability in the market until 18 to 24 months after standard parts of equal density

Most DRAM suppliers offer fast page mode, nibble mode static-column devices, and x4 organization devices long before the more tailored video RAMs of the same density.

On the other hand, suppliers, through standardization committees such as the EIA JEDEC organization, are making every effort to define and adhere to a standard feature set, with upscale options for those users needing more functionality. SIP modules, incorporating four or five PLCC (or SOJ) monolithic chips, can provide improved packing densities prior to availability of monolithic chips. After initial early market pricing, VRAMs are often quite cost competitive with their standard DRAM counterparts: $3.00 for 64K VRAMs; $5.50 for 256K VRAMs. Volume multisourced competitive pricing should eventually put VRAM prices within 20 to 30 percent of standard dynamic RAMs. So, in spite of some drawbacks, VRAMs can offer a substantial improvement in price/performance ratio and reduced chip count.

CONTENT-ADDRESSABLE MEMORIES (CAMs)

The content-addressable memory (CAM) is an old memory concept that has only recently gained some research interest. It is included in this newsletter in order to demonstrate to the user the breadth of possibilities for special application memories that are nonstandard, and hence, application-specific.

A CAM is a memory that stores both a tag and associated data. The data are accessed via the tag, which may or may not be present inside the device. The memory architecture of a CAM is significantly different from traditional memories, although the basic function of storage is an integral part of the chip's operation.

Applications for CAMs are diverse: Cache modules can be constructed using a CAM as a building block, hardware data base systems can be implemented, or even Prolog language processors can be realized using these memories. The CAM is a nonconventional memory unit that has yet to be truly understood and appreciated by the general semiconductor sector.

Current CAM Activities

Since CAMs are highly application specific and application intensive, it is generally true that the few research projects for building these devices are found largely in systems companies rather than in semiconductor firms. The role of the user as the real driver in the definition (and sometimes even in the development) of these specialty memories is an important aspect that Dataquest believes is not particularly appreciated in the industry.

Dataquest believes that CAM devices are beginning to be incorporated into systems, although they are not being seen on the open market yet. Nevertheless, small CAM circuits do have many more conventional applications, and at least one semicustom vendor, LSI Logic, offers a small CAM as a standard cell library module.

NEW DIRECTIONS IN SPECIALTY MEMORY DESIGN

Specialty memories provide a challenge in integrating quick-turnaround semicustom design cycles with high-performance, high-density specialty memories. We believe that there is much innovation to be exploited in order to satisfy these two diverging requirements.

A number of semicustom vendors have begun to incorporate FIFO- and DPR-like features as part of their standard cell libraries. It is difficult to predict the effect that such devices can have on the component-level specialty memories, although the semicustom threat is real and appreciable. These vendors' strategies are very simply to incorporate significant amounts of memory on the chip, along with programmable access modes (i.e., multiport RAMs with two, three, or more ports) while maintaining all the peripheral logic required to implement any special features and computations. Semicustom techniques are highly applicable to the specialty memory marketplace.

DATAQUEST CONCLUSIONS

Dual-port RAMs, FIFO memories, video RAMs, and content-addressable memories are but subsets of conceivable specialty memory products. They benefit from technology developed for high-density commodity memories and from design techniques for semicustom ICs. Because of the recent introduction of a number of such devices, customer design-in activity has been booming, but manufacturing and volume shipments have been lagging behind by 12 to 18 months. There is great diversity in applications and product definitions that are available for marketing. However, a number of suppliers have already encountered pitfalls, particularly by relying on narrow product line offerings in FIFOs and/or DPRs as though they were commodity memories with which a "one part fits all applications/sockets" attitude is prevalent. One very crucial criterion for success in this exploding market niche is customer participation in the definition and development process, and, indeed, a few semicustom vendors entering the specialty memory market have already benefited from their previous experience.

Brand Parks
Patrick Antaki

SUIS Code: Newsletters
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NEC VERSUS INTEL: BEHIND THE LAWSUIT LIES THE STRUGGLE FOR MARKET SHARE

The NEC/Intel copyright lawsuit, currently being tried in San Jose before U.S. District Court Judge William Ingram, raises several legal and competitive issues of great significance to the semiconductor industry. These issues deal with:

- The battle for market share between two of the world's leading producers of microprocessor products

- The effectiveness of current legal protection for microcode

- The manner in which second-source licensing agreements are negotiated and maintained

The outcome of the current trial may significantly affect the semiconductor industry in a number of ways. To begin with, a loss for NEC could deny its V-Series products access to the U.S. microprocessor market--a market that Dataquest predicts will be worth more than $550 million in 1990. A loss for Intel, on the other hand, will add a serious market share contender in not only the current 8- and 16-bit microprocessor arena, but in the promising market for 32-bit devices as well.

Above all, any ruling on the copyright issue would give the industry its clearest reading yet on the extent to which it can protect investments in that form of intellectual property known as microcode, the hardware implementation of instruction sets that regulate the flow of data in a microprocessor.

In this newsletter, Dataquest will review the history of the NEC/Intel lawsuit, the legal arguments presented by both sides, and the market share considerations at stake on the outcome.

NEC/INTEL DISPUTE HISTORY--A CHRONOLOGICAL OUTLINE

The following outline reviews the events leading up to the present litigation:

- 1982--Intel claims that the NEC uPD 8086 contains a bit-for-bit copy of the 8086 microcode.

- April 1983--The dispute over the 8086 microcode is settled out of court.

- Mid-1984--Intel becomes aware of the NEC V-Series microprocessors (V20/V30), which are described as compatible with the 8086. Intel begins an investigation into possible copyright infringement of the 8086 microcode by NEC, a licensed second source for both the 8086 and 8088.

- December 1984--NEC files a declaratory relief action asking the court to declare that a) microcode is not copyrightable and that b) the V-Series does not infringe on the 8086 microcode copyright.

- February 1985--Intel files a counter claim alleging that the V-Series microcode infringes on the 8086 microcode copyright.

- August 1985--Judge Ingram of the Northern California Circuit Court denies a summary judgement motion by Intel that microcode is copyrightable as a matter of law, ruling instead that the issue should be part of the scheduled trial.

- October 1985--NEC files a summary judgement asking the judge to declare that Intel lost its 8086 microcode copyright because certain licensees (including NEC) were not marking their 8086 parts.

- December 1985--Intel amends its copyright infringement suit to include the NEC V40 and V50 series of microprocessors, claiming that these devices utilize the same microcode as the V20 and V30. Intel asks for an extension of the discovery period from February 20, 1986, to April 4, 1986.

- January 9, 1986--Judge Ingram denies NEC's October 1985 summary judgement motion.

- January 22, 1986--Judge Ingram grants Intel's request for extension of the discovery period and the inclusion of the NEC V40 and V50 microprocessors to the suit.

- March 1986--The court rules that damage claims filed by Intel against NEC and counterclaims of unfair competition by NEC should be tried separately and at a later date.

Intel's Legal Position

Intel argues that certain NEC V-Series microprocessors infringe on copyrighted microcode found in Intel's 8086 and 8088 microprocessors--both of which are licensed to NEC for second-source manufacture and distribution. To win its argument, the U.S. District Court must uphold the overall copyrightability of microcode, and must then be convinced that NEC is guilty of copying the Intel 8086/8088 microcode.

To support its arguments, Intel is relying on the United States Copyright Act and several precedent cases involving software copyright infringement. In 1980, Congress amended the Copyright Act to include "computer programs" to the list of copyrightable expression. The 1980 amendment defines a computer program as "a set of statements . . . instructions . . . to be used in a computer . . . to bring about a certain result." As a result of this legislation, software is treated as a literary work which, according to the Act, may be "expressed in words, numbers, or other verbal symbols . . . fixed in any tangible medium of expression now known or later developed . . . (and) can be perceived, reproduced, or otherwise communicated . . . with the aid of a machine or device."

Microcode, Intel maintains, clearly meets the criteria set forth in the Copyright Act for the following reasons:

- Microcode is expressed in numbers, or numerical or verbal symbols, and can be fixed on disks, paper, or magnetic tape. It can also be perceived by humans directly or indirectly by aid of machines.

- Microcode is a series of instructions generally created by a programmer in source code, which will direct a computer's operations when converted into object code. As a set of instructions, microcode is clearly distinguishable from the functions it directs in a microprocessor.

NEC's Legal Position

Despite the fact that NEC is the plaintiff in this case, its legal arguments more closely resemble a series of defensive perimeters. This should not be surprising, considering that NEC fired the first legal salvo (see Chronological Outline section) in an effort to head off a suit by Intel.

To begin with, NEC maintains that its V-Series microcode was developed independently of Intel's and does not constitute a copy of the microcode used in the Intel 8086/8088 microprocessors. More fundamentally, NEC challenges the assumption that the Copyright Act extends to microcode. Microcode, NEC claims, is more accurately described as a process or method of operation rather than as a literary expression, and as such is the domain of patent law.

NEC argues that the addition of computer programs to the Copyright Act has no bearing on its case since there are significant differences between instruction sets in a microprocessor and computer programs stored in read-only memory (ROM). In microprocessors such as the 8086/8088, NEC reasons, ROM is an integral part of the control mechanism and cannot be externally accessed without very specialized equipment.

Finally, it is NEC's contention that the creation of microcode is itself dictated by hardware design. While it may in theory be possible to build a "microprogrammable" general-purpose computing engine, such devices are not a commercial reality. A single-chip microprocessor is a merger of ROM sequence and logic circuits, with microcode falling into a gray area between software and hardware.

Beyond this perimeter, NEC maintains that Intel's negligence in its copyright policies invalidated the integrity of its copyright claims. The positions of both litigants on this issue will hopefully become clearer during the trial proceedings.

THE MICROPROCESSOR ARENA: A BACKGROUND

Behind the more ponderous legal issues of microcode copyright, two major chip manufacturers are fighting for market share in the arena of 8-, 16-, and 32-bit microprocessors. The microprocessor (MPU) market is a significant one. Dataquest predicts that the demand for microprocessor products will grow at a faster rate than the overall IC industry. In 1986, the MPU sector should see a 16 percent increase in revenue to approximately $503 million, with a 51 percent increase in 1987 to approximately $761 million.

We expect the lowering of the average selling price for MPUs to encourage systems designers to take advantage of the cost reductions, creating a rapid growth of demand that will strain limits of capacity and draw more capacity into the market in the 1987-1988 time frame. The long-term outlook for microprocessors through 1991 is for a 34.7 percent compound annual growth rate (CAGR) in units shipped.

If successful in this current lawsuit, Intel could not only prevent the future sales of NEC V-Series MPUs in the United States, but could, according to recent courtroom evidence, press for the same decision in Japan, which subscribes to the basic tenets of the Copyright Act through an international trade agreement.

To date, Intel has named four of NEC's six V-Series MPUs in its charges of infringement: the V20, V30, V40, and V50. Each of these devices directly competes with an Intel MPU, as Table 1 illustrates.

Table 1

COMPARISON OF INTEL AND NEC MPUs

Intel MPU	Competing NEC MPU	MPU Type
8088	V20	8-bit
8086	V30	16-bit
80188	V40	8-bit/High Integration
80186	V50	16-bit/High Integration

Source: Dataquest
July 1986

Intel, the leading U.S. supplier of microprocessors, largely withdrew from the random access memory market as a result of intense competitive pressure from the Japanese. Since then, Intel's success has depended heavily on the sales of its MOS microprocessor lines, which accounted for nearly 66 percent of its 1985 revenues. In 1981, when Intel's RAM sales represented approximately 24 percent of revenues, its MOS microprocessors accounted for 41 percent.

Intel now finds itself facing aggressive competition from Japan in the MPU market. In 1980, NEC trailed Motorola, Zilog, Intel, and Synertek with an 8.33 percent market share in 8-bit microprocessors. In 1982, NEC took the lead with a market share of 12.03 percent--nearly 2 percent more than Intel, its closest competitor. In the years following 1982, NEC's market share lead in 8-bit microprocessors has widened further, a fact that is attributable in no small part to the higher demand for these devices in Japan itself.

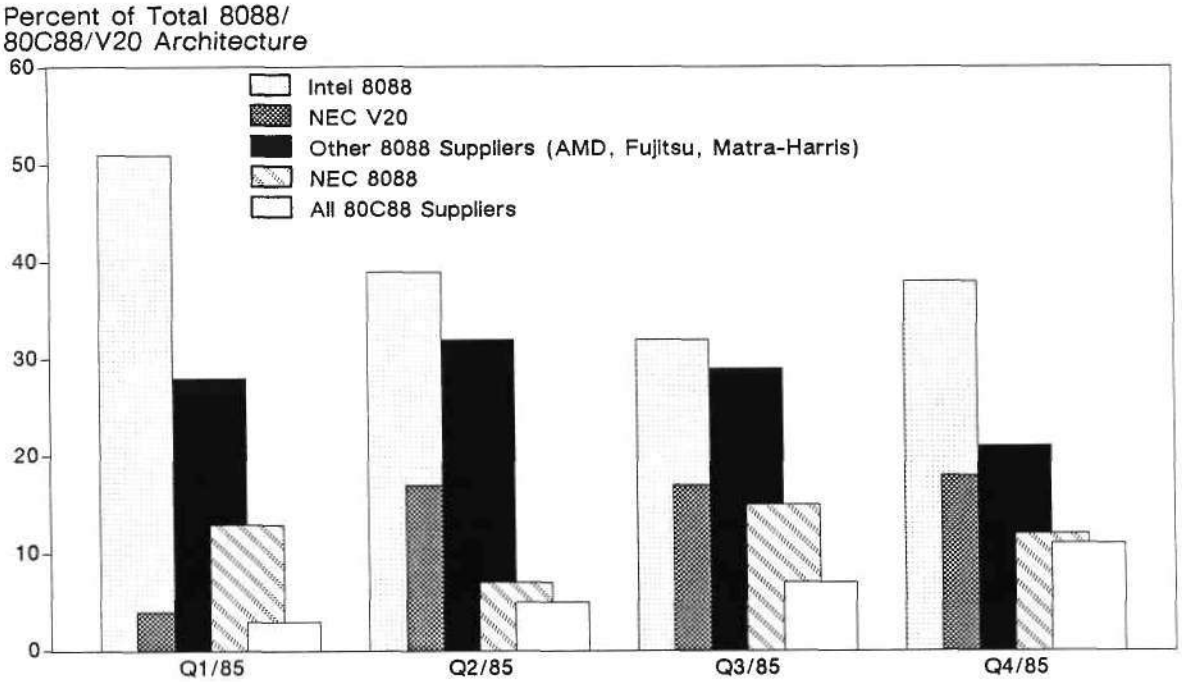
In the arena of 16-bit MPUs, NEC's impact on the market has been less dramatic. The Japanese electronics giant is currently ranked behind Intel and Motorola in market share. Intel enjoys a more than 30 percent lead in market share over NEC, which until 1985 competed in this sector as a second-source supplier of Intel 8086 microprocessors.

NEC'S CHALLENGE: THE V-SERIES MPUs

In 1985, however, NEC began volume shipments of its V20 and V30 CMOS microprocessors. The gains in sales of these devices, at the expense of Intel's 8- and 16-bit MPUs, is illustrated by Figures 1 and 2.

Figure 1

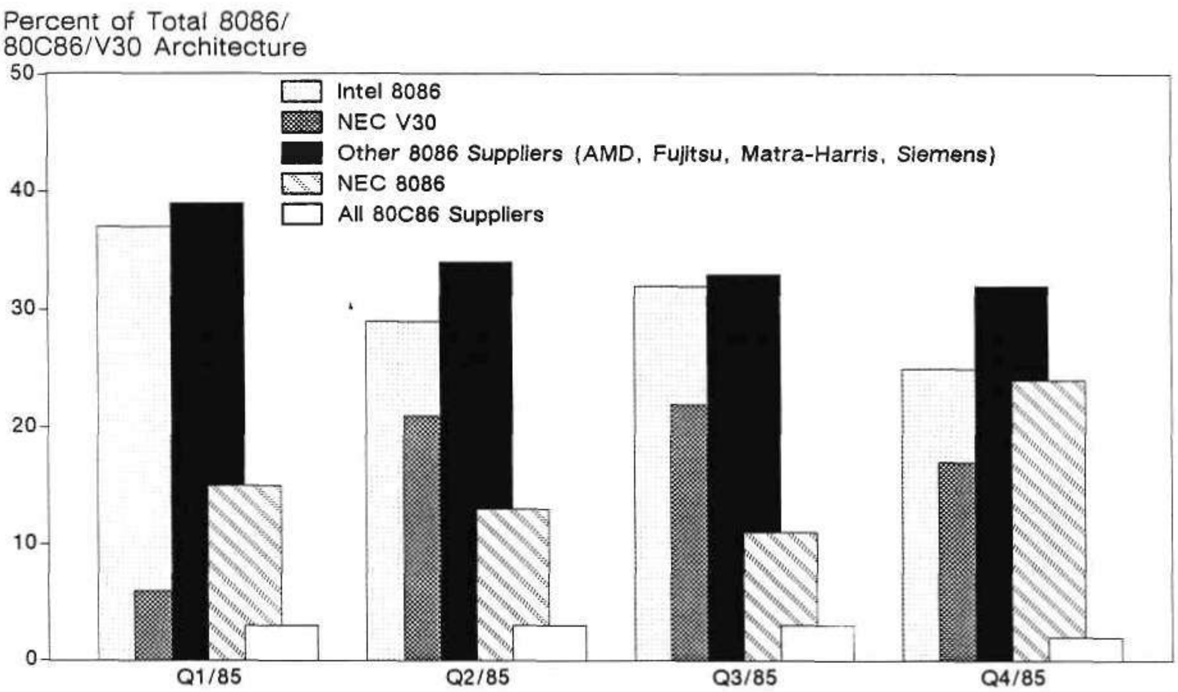
V20 VERSUS 8088/80C88--MARKET SHARE COMPARISON



Source: Dataquest
July 1986

Figure 2

V30 VERSUS 8086/80C86--MARKET SHARE COMPARISON



Source: Dataquest
July 1986

In both figures, supplier revenues are compared with total revenues for V-Series and Intel 8088/8086 MPU architectures. The figures clearly show that throughout 1985, NEC managed to grow market share for its V-Series MPUs without adversely affecting the sales of its own Intel product lines. In fact, in the case of the NEC 8086, market share was increased by fourth quarter 1985 to a level nearly equal to Intel's. The price for V20 gains in 1985 was paid both by Intel and other 8088/80C88 suppliers, while sales of V30 devices primarily affected Intel's 8086 MPU market share.

The steady growth in sales of NEC's V-Series devices has certainly been aided by the existence of a sheltered domestic market, but the V20 and V30 also boast gains in performance over comparable Intel devices, and both NEC microprocessors are fabricated using CMOS technology. Although CMOS versions of the 8088 and 8086 are currently available, shipments of these devices have been lower than the NEC MPUs, as demonstrated by the above figures.

The CMOS Advantage

The move toward CMOS MPUs has clearly established itself. CMOS technology offers systems designers some significant advantages over comparable NMOS devices. To begin with, the lower heat dissipation of CMOS allows high-density circuits to be built with manageable die sizes. In addition, many growing applications require CMOS characteristics, including industrial products that require high noise immunity, tolerance to temperature extremes, low power consumption, and tolerance to voltage variations. Dataquest believes that CMOS MPUs will be a larger market in 1989 than the total 1985 MPU market ($597 million).

The Battleground

The battle for market share between Intel's 8088/8086 and NEC's V20/V30 MPUs may seem moot in light of the technology these devices represent. In 8-bit MPUs, the five devices that have controlled 85 percent of the market (Z80, 8085, 8088, 6802, and 6809) have reached their life cycle peaks. Dataquest believes that while 8-bit MPUs will continue to grow in units and revenue for the remainder of the decade, they will represent an increasingly smaller percentage of total MPU revenue.

Total shipments of 16-bit MPUs have increased nearly tenfold since the end of 1980 and are expected to increase at a compound annual growth rate (CAGR) of 46.6 percent from 1986 through 1991. Dataquest believes that 16-bit microprocessors will maintain more than 50 percent of total MPU revenue until the middle to late 1990s. Four devices controlled 85 percent of the 16-bit MPU market during 1985: the 68000, 80286, 80186, and 8086. NEC's 16-bit entry, the V30, has largely been consumed in Japan.

The real plum that Intel and NEC will be competing for is the more lucrative market for high-integration MPUs. Dataquest believes that there will be a definite market shift to such high-volume/high-integration devices, which will raise the average selling price (ASP) for microprocessors in 1988 and 1989. The greatest market share of the high-integration MPUs has so far gone to Intel's 80186 and 80188 devices. Coming into this market are Signetics' 68070, Hitachi's 64180, NEC's V40/V50, and Zilog's expected Z800. NEC is currently shipping its V40 for sampling, with the V50 having gone into volume production in first quarter 1986.

The Fork in the Road

NEC's marketing strategy does not rely solely on direct competition with pin-compatible/software-compatible Intel MPUs. Beyond the NEC V50 lies the V60, which will compete with the Intel 80286, a high-performance MPU featuring on-chip memory management aimed at multitasking environments. NEC is currently sampling the V60, with volume shipments scheduled third quarter 1986. While similar in function to the 80286, the V60 breaks a precedent set by all previous V-Series products: it is not operationally compatible with its Intel counterpart.

The "fork in the road" that the V60 establishes is aimed at the incipient market for 32-bit MPUs. Once a designer commits to the NEC V60, the upgrade path to a 32-bit MPU can lead only to the V70, which NEC plans to ship sometime next year. Switching to Intel's 32-bit 80386, which is scheduled to be in volume production by the third quarter of 1986, will be difficult and time consuming.

There are two ways that NEC can induce customers to migrate along the V-Series path. One way is to capture design-ins at the high-integration 16-bit level through successful competition with Intel's 80286. Running at 3.5 million instructions per second (MIPS) with a 16-MHz clock, NEC boasts an overall throughput 10 times better than Intel's, with the added advantages of CMOS fabrication. While high performance is a compelling argument, the fact remains that the 80286 is not only here today, but has been shipping since 1983.

NEC's chances of successfully competing for new designs would certainly have been improved had it concentrated on an earlier introduction of the V60, rather than putting its energies into the older technologies represented by the V20 and V30.

Such criticism, however, ignores the second, albeit longer, path to the 32-bit implementation--that of upgrades from 8- and 16-bit devices. Adept at long-range tactics, the Japanese are fully aware that the older 8-bit market alone still has plenty of vitality, particularly if lap-top computers ever take off. If the V-Series can successfully raid the market dominated by the Intel 8088, 8086, 80188, and 80186, then design upgrades must eventually lead customers to the NEC side of the fork in the compatibility road.

THE 32-BIT MPU MARKET OUTLOOK

This line of reasoning assumes, of course, that the industry will see a large-scale evolution of 8- and 16-bit systems to 32-bit MPUs. Some manufacturers believe that market growth for 32-bit MPUs will come as these devices replace minicomputers, rather than as the result of upgrades of 16-bit applications. According to this scenario, future MPUs will have microcoded instruction sets that can emulate minicomputer instruction sets. These devices will have the profound effect on the industry of destroying the distinction between computer companies, thus raising the level of competition.

Dataquest predicts three stages of 32-bit MPU adoption:

- The first stage of utilization will see the replacement of 16-bit devices. This will occur initially with engineering workstations.

- The second stage will see the use of 32-bit MPUs in minicomputers and small business systems.

- The third stage will occur once 32-bit MPUs are well understood and accepted. These devices will then become the basic design elements of many microprocessor-based systems. Rapid growth in consumption of 8- and 16-bit MPUs occurred about five years after they were first introduced. Following the same trend, rapid growth in 32-bit MPUs should occur beginning in 1989.

RAMIFICATIONS OF THE COURT'S RULING

A successful outcome for Intel in the current lawsuit could deprive NEC of a U.S. market in which to exploit its upgradability strategy. In this case, the Japanese beachhead into the U.S. market for 32-bit microprocessors will have to be won through direct competition with the Intel 80286 for new systems designs. Designers may be loath to hop on the V60 bandwagon if they have had no previous experience with the V-Series product line.

While a final ruling may be weeks or months away, the current litigation has already cast a pall over the NEC V-Series. NEC claims that sales have suffered as a result of the suit, and has charged Intel with unfair competition. The controversy surrounding the V-Series will also make second-source availability highly unlikely, although a license to produce the V60 has been granted to Zilog. For now, says NEC, the V60 will probably be limited to the Japanese market, with sales rising to 30,000 units in 1987.

The outcome of the Intel/NEC battle will certainly not decide who will dominate the 32-bit market. Out of an estimated 100,000 units shipped during 1985, Motorola controlled 60 percent of the 32-bit MPU market with an estimated 55,000 units shipped. National Semiconductor shipped an estimated 30,000 units of their 32032 and 32332, and Inmos shipped 5,000 32-bit devices. In its introduction year, AT&T shipped 1,000 units of its 32100, and is selling microprocessors for the first time on the merchant market. Because of its UNIX V expertise, Dataquest believes that the 32100 will be a winner in the future. Motorola's 68020 and National's 32032 will both have initial advantages since many existing workstations have been designed with their 16-bit predecessors. Captive manufacturers such as Data General, Digital Equipment, and Hewlett-Packard could also play a role if they offer devices to the merchant market.

A number of other companies have also thrown their hats into the ring, including Fairchild, Fujitsu, Hitachi, Matsushita, Oki, Sony, Texas Instruments, Toshiba, and Zilog. Many of these will use their designs internally or will second-source other 32-bit MPUs.

The stakes for all players are eminently high. While initial forecasts for numbers of 32-bit MPUs shipped in no way compare with 8- and 16-bit devices, the ASP for 32-bit microprocessors will represent significant revenue for leading manufacturers. Dataquest predicts that market activity will continue to pick up for the 32-bit MPUs and will become significant during the second half of 1986. The expected CAGR for this segment over the next four years is 96.6 percent.

A decision against NEC in the current trial will force the Japanese colossus to try and straddle the 32-bit MPU market on one leg of its marketing strategy--a serious disadvantage. A decision against Intel, on the other hand, will strengthen the position of its most formidable Japanese opponent in the playing field; and if a decision against Intel is reached on the basis of copyright's application to microcode, the legal outcome will surely cause the industry to seriously evaluate the effectiveness of its current means of protecting investments in microcode development.

Brand Parks
Michael J. Boss

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MOS MEMORY LICENSING AGREEMENTS AND JOINT VENTURES 1982 TO 1986

SUMMARY

The MOS memory marketplace has experienced a large number of licensing agreements and joint ventures during the last few years. Several trends are emerging in these agreements. The trends include:

- Increasing numbers of agreements
- Increasing complexity of agreements
- Technology being supplied by U.S. companies
- Technology being purchased by Japanese and Korean companies
- More sharing of fab capacity

JOINT VENTURE AND LICENSING AGREEMENT TRENDS

Increasing Numbers of Agreements

Licensing agreements and joint ventures pertaining to MOS memory products are increasing. There were 7 exchanges in 1982, 14 in 1983, 17 in 1984, and 18 in 1985. There have been 9 agreements just in the first few months of 1986.

There are many reasons for this increase in licensing agreements and joint ventures. One of the most evident is the need for capital. In 1985, many semiconductor companies experienced deep financial losses. The selling of technology was a means of creating revenue in a very depressed market. Venture capital has been tight over the last few years, and many start-up companies were not able to attract the additional rounds of financing needed to sustain their growth. These companies sold their designs as a means of survival. Other companies were rich in manufacturing capabilities but in need of technology and products to fill their factories; these companies sold fab space to create revenue.

Increasing Complexity of Agreements

Licensing agreements and joint ventures have become more complex over the last few years. In the early agreements, technology was often simply purchased from one company by another. Other arrangements were made where wafers and processing were purchased in foundry deals between one company with a chip design and another with excess capacity. Agreements now include any number of combinations of purchase or trade of process, technology, or fab capacity. Stipulations are made as to what markets the participating companies can sell to.

Transfers of high-level personnel have also taken place. For example, Toshiba assigned Dr. Yoshio Nishi, manager of Toshiba's 1Mb DRAM team, to head Hewlett-Packard's VLSI Research Center for three years.

Technology Supplied by U.S. Companies

Currently, nearly all MOS memory agreements utilize technology from U.S. companies. One reason for this primarily one-directional flow is that the United States is still the largest innovator of new technology. Another, and perhaps more significant reason, is that the Japanese are very reluctant to sell their technology for short-term gains in revenue or market share.

Overall, companies in the United States have been less successful at semiconductor production than those in Japan and Korea. Japanese and Korean companies often have fab capacity that is subsidized by larger parent corporations, allowing them to run very efficient fab facilities. This has encouraged a large number of U.S. companies to trade technology for Japanese and Korean fab capacity (see Figure 1).

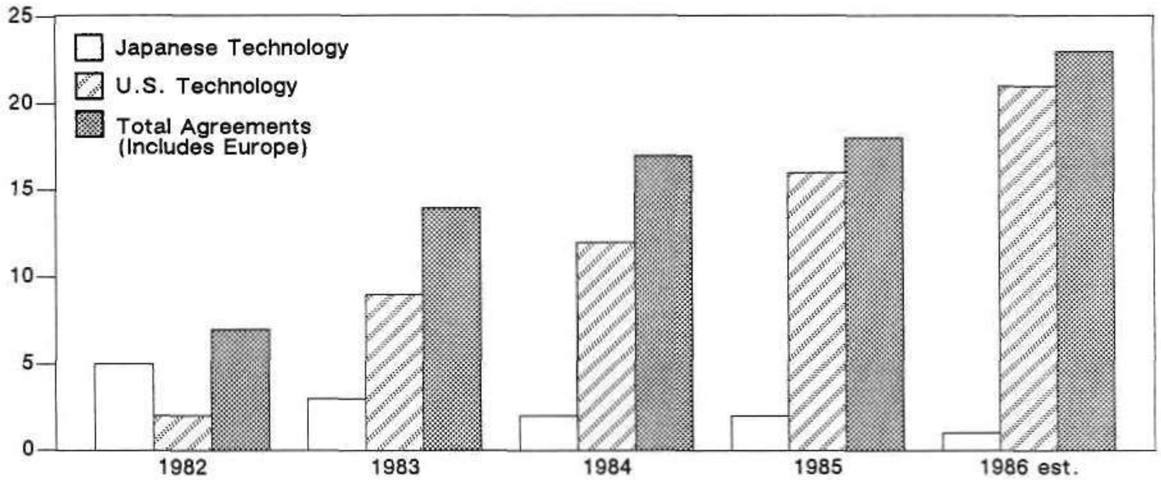
Another reason for the large number of U.S. technology transfers has to do with the semiconductor industry slump of 1985. While the world MOS memory market was down 39 percent in dollars from 1984 to 1985, U.S. companies suffered the most with a drop of 46 percent. This drop in revenue encouraged the U.S. sale of technology.

Technology Purchased by Japanese and Korean Companies

The technology that is being supplied for the most part by U.S. companies is being purchased by Japanese and Korean companies. Since 1982, Japanese companies have been the recipients of technology in 24 percent of licensing agreements. Korean companies, while commanding only 1 percent of the MOS memory market in dollars, received technology in 25 percent of the agreements. Japanese and Korean companies are gaining the technological advances necessary to obtain a much higher proportion of the MOS memory market share in the near future.

Figure 1

JOINT VENTURE AND LICENSING AGREEMENTS
BY SOURCE OF TECHNOLOGY



Source: Dataquest
July 1986

More Sharing of Fab Capacity

There has been a worldwide excess in semiconductor wafer fab capacity since 1984. Because of this, venture capital agreements have typically not included funds for companies to build their own fabs. This has caused an increase in the number of agreements associated with the sharing of fab capacity. Currently, more than half of all licensing agreements and joint ventures include fab arrangements.

CLASSIFICATION OF AGREEMENTS

Dataquest has classified these exchanges into five main categories:

I. Company A designs a product. Company B manufactures the product and both Company A and B sell the product.

   A. Company B can compete with Company A in all markets.

   B. Company B is forbidden to compete with Company A (in-house use only) or must sell the product only in restricted markets.

II. Company A designs product and pays Company B to manufacture it, but Company B doesn't have marketing rights. This is also known as a foundry agreement.

  A. Company A's process is installed at Company B.

  B. Company A's process is not installed at Company B.

III. Two companies agree to develop methods for achieving consistent specifications, ensuring a second source.

IV. Company A designs and manufactures a product; Company B buys the product and markets it under the Company B label.

V. Company A and Company B exchange technology; this may or may not include a transfer of money.

Table 1 lists, in reverse chronological order, specifics of some of these agreements.

Table 1

MOS MEMORY LICENSING AGREEMENTS AND JOINT VENTURES
1982-1986

Number	Company A	Company B	Type	Products	Date
1	MOSel	Sharp	II	256K fast SRAM	86/05
2	Inova	UMC	IIA	Monolithic Macro Circuits	86/05
3	Vitelic	Philips	V	CMOS SRAM	86/04
4	GI/Amtel	Hyundai	II	64K CMOS EEPROM; OTP EPROM	86/03
5	Lattice	Seiko-Epson	IB	16Kx4 Fast SRAM	86/02
6	AMD	Sony	V	Joint Development	86/02
7	Vitelic	Hyundai	IIA	64K, 256K, 1Mb CMOS DRAM; 16K CMOS SRAM	86/02
8	MOSel	Hyundai	II	8Kx8 Fast SRAM	86/01
9	Dallas	Thomson-Mostek	IA	Multiport Memory; FIFO	86/01
10	Mostek	Samsung	I	256K DRAM	85/11
11	Vitelic	NMB	IIA	1Mb CMOS DRAM	85/11
12	Cypress	Matra-Harris	IA	4K, 16K fast SRAM	85/10
13	MOSel	Fuji Electric	II	64K SRAM	85/10
14	National	VLSI Technology	II, IV	CMOS EPROM	85/10
15	WSI	Sharp	IB	64K, 256K CMOS EPROM	85/10
16	Toshiba	Hewlett-Packard	V	1Mb DRAM	85/09
17	Intel	Signetics	IA	256K EPROM	85/09
18	SEEQ	Silicon Compilers	IA	All EEPROM Designs	85/07
19	Synertek	UMC	IA	4K, 16K SRAM; 8K, 16K, 32K, ROM	85/07

(Continued)

Table 1 (Continued)

MOS MEMORY LICENSING AGREEMENTS AND JOINT VENTURES
1982-1986

Number	Company A	Company B	Type	Products	Date
20	Toshiba	Siemens	IA, V	1Mb CMOS DRAM	85/07
21	Vitelic	Sony	IIA	256K, 1Mb, 4Mb CMOS DRAM	85/07
22	Xicor	Intel	III	EEPROM	85/07
23	Fairchild	GoldStar	IB	64Kx1 CMOS Fast SRAM	85/06
24	Exel	Oki	IA	2Kx8 NMOS EEPROM	85/03
25	AMD	GoldStar	IB	64K, 256K DRAM	85/01
26	Atmel	General Instrument	IA	OTP EPROM; UV EPROM; EEPROM	85/01
27	Synertek	Signetics	IA	Dual Port RAM	85/01
28	Inmos	Hyundai	I	64K, 256K DRAM	84/12
29	RCA	Sharp	V	256K CMOS DRAM	
30	WSI	Sharp	II	64K, 256K CMOS EPROM	84/12
31	Micron	National	IA	64K DRAM	84/11
32	Visic	Monolithic Memories	V	CMOS Memory	
33	Oki	Thomson	IA	64K, 256K DRAM	84/10
34	Modular Semi.	Ricoh	IB	16K SRAM; 256K DRAM	84/09
35	Intel	Altera	V	CHMOS EPROM Technology	84/08
36	Lattice	VLSI Technology	IA	CMOS EEPROM; 64K SRAM	
37	Lattice	Synertek	II	64K Fast SRAM	84/07
38	National	Synertek	III	2K EEPROM	84/07
39	MOSel	UMC	IIA	EEPROM; 2Kx8 SRAM	84/06
40	Inmos	NMB	IB, V	64K, 256K, 1Mb CMOS DRAM	84/06
41	Philips	Siemens	V	4Mb DRAM	84/06
42	Vitelic	ERSO	V	EPROM; 64K, 256K CMOS DRAM	84/05
43	Motorola	Thomson	I	64K DRAM	84/03
44	Visic	VLSI Technology	V	64Kx1, 16Kx4 CMOS DRAM	84/02
45	Intel	Inmos	III	64K, 256K CHMOS DRAM	83/12
46	ICT	Hyundai	V	1K CMOS EEPROM; 64K EPROM	83/10
47	Inmos	General Instrument	III	8Kx8 EEPROM	83/10
48	AT&T	GoldStar	I	64K, 256K DRAM	83/09
49	Micron	Standard Telecom	I	64K DRAM	83/09
50	VLSI Technology	Ricoh	V	64K, 128K, 256K ROM	83/09
51	Micron	Commodore	I	64K DRAM	83/08
52	Micron	Samsung	IA, V	64K, 256K DRAM	83/08
53	Philips	General Instrument	III	1K EEPROM	83/06
54	Exel	Samsung	V	16K EEPROM	83/04
55	Mitsubishi	TI	IV	64K EPROM	83/03
56	National	Eurotechnique	I	16K, 32K CMOS EPROM	83/03
57	Sharp	Hyundai	I	2Kx8 CMOS SRAM	83/03
58	Seiko	RCA	IV	2Kx8 CMOS SRAM	83/01
59	Oki	National	IA	64K DRAM	82/12
60	Ricoh	Rockwell	V	32K, 64K CMOS EPROM	82/12
61	Intel	IBM	IB	64K DRAM	82/09
62	Mitsubishi	Sperry	V	64K NMOS DRAM	82/08
63	SEEQ	Rockwell	IA	16K EEPROM; 64K UV EPROM	82/07
64	Toshiba	Zilog	V	16K CMOS SRAM	82/04
65	Hitachi	Hewlett-Packard	IB	64K DRAM	82/03

Source: Dataquest
July 1986

LICENSING AGREEMENTS AND JOINT VENTURES

1. MOSel and Sharp

MOSel exchanged a license for its 256K fast SRAM with Sharp Electronics in May of 1986. MOSel obtained foundry capacity from Sharp.

2. Inova and UMC

An agreement was reached in May of 1986 between Inova Microeletronics and United Microelectronics Corp. (UMC). Inova will receive base wafers with their IC designs from UMC and will use its proprietary interconnect technology on these 1.5 CMOS wafers to form multichip devices. The agreement also provides Inova with access to any process advances developed by UMC.

3. Vitelic and Philips

A joint-venture agreement between Vitelic and Philips was signed in April of 1986. In exchange for access to Philip's proprietary process technology, Vitelic was to design a family of high-performance CMOS SRAMs for manufacture, use, license, and sale by both companies.

4. General Instrument/Atmel and Hyundai

An agreement was reached between General Instrument (GI), Atmel, and Hyundai in March of 1986. In this agreement, Hyundai obtained license to manufacture GI's 64K CMOS EPROMs and EEPROMs.

5. Lattice and Seiko-Epson

Lattice Semiconductor announced a manufacturing and second-source agreement with Seiko-Epson and SMOS Systems on February 4, 1986. Seiko-Epson acquired the license to Lattice's 16Kx4 SRAM design and process technology, and SMOS acquired the rights to market the part in North America.

6. AMD and Sony

A joint technology-development agreement between Advanced Micro Devices (AMD) and Sony was signed in February of 1986. Sony gained access to part of AMD's current product line. The two companies planned joint development of the next generation of ICs.

7. Vitelic and Hyundai

In February 1986, Hyundai obtained license to Vitelic memory products in exchange for manufacturing capability at Hyundai. Products covered in this agreement included 16K CMOS SRAMs, as well as 64K, 256K, and 1Mb CMOS DRAMs.

8. MOSel and Hyundai

MOSel traded fast 8Kx8 SRAM technology for foundry capacity at Hyundai in January of 1986.

9. Dallas Semiconductor and Thomson-Mostek

In January of 1986, Thomson-Mostek agreed to second source a multiport memory device under development by Dallas Semiconductor. Thomson gained royalty-free rights to the part; Dallas Semiconductor will be able to buy a percentage of the output. Dallas will also obtain laser production equipment from Thomson and technical information on Thomson-Mostek's MK4501, a FIFO memory device.

10. Mostek and Samsung

Early in 1986, Mostek and Samsung signed an agreement covering Mostek's 256K DRAM technology.

11. Vitelic and NMB Semiconductor

An agreement between Vitelic and NMB was signed in November of 1985. Vitelic granted license to its 1Mb DRAM in exchange for one-third of NMB's plant capacity.

12. Cypress and Matra-Harris

In October of 1985, Cypress transferred masks for its 4K and 16K fast SRAMs and its 1.2 CMOS technology to Matra-Harris. In addition to an undisclosed amount of cash, Cypress will get 2 percent of Matra-Harris' stock. A similar deal for Cypress' 0.8 process and 64K SRAM is also planned.

13. MOSel and Fuji Electric

In October of 1985, Fuji Electric agreed to produce CMOS 64K SRAMs for MOSel using MOSel's 1.5- to 2.0-micron CMOS process.

14. National Semiconductor and VTI

In October of 1985, National Semiconductor supplied CMOS EPROM technology to VTI. VTI produced the part and gave finished wafers back to National.

15. WSI and Sharp

In October of 1985, Wafer Scale Integration (WSI) and Sharp expanded their 1984 agreement to include WSI's 1.6-micron CMOS technology in exchange for royalties and plant capacity.

16. Toshiba and Hewlett-Packard

In September of 1985, Toshiba assigned Dr. Yoshio Nishi, manager of its 1Mb DRAM team, to head Hewlett-Packard's VLSI Research Center for three years.

17. Intel and Signetics

Intel provided its 256K EPROM technology to Signetics in September of 1985. Signetics already had a 64K EPROM on the market but did not choose to upgrade its own 64K part to a 256K version.

18. SEEQ and Silicon Compilers

In July of 1985, SEEQ provided all of its EEPROM designs for Silicon Compilers to use in ASIC designs.

19. Synertek and UMC

In July of 1985, United Microelectronics Corp. (UMC) gained nonexclusive product licenses for 18 types of ICs formerly produced by Synertek. UMC also purchased some production equipment and inventory from Synertek. In exchange, Synertek received $3 million plus royalties of 3 to 5 percent over the next three years. MOS memory products covered by this arrangement include 4K and 16K SRAMs, 8K, 16K, and 32K ROMs.

20. Toshiba and Siemens

In July of 1985, Siemens agreed to pay Toshiba for design, testing, and production data on Toshiba's 1Mb DRAM. Both companies agreed to cross-license their entire field of semiconductor components with mutual worldwide rights.

21. Vitelic and Sony

A joint-venture agreement between Vitelic Corporation and Sony was signed in July of 1985. Sony gained access to Vitelic's 256K, 1Mb, and 4Mb CMOS DRAM technology in exchange for providing fab capacity to Vitelic.

22. Xicor and Intel

In July of 1985, Intel and Xicor signed a letter of intent covering joint development of advanced EEPROMs. This also covered a second-sourcing agreement on other undisclosed products. Intel provided the bulk of the $10 million needed to cover the costs of the joint R&D program.

23. Fairchild and GoldStar

A 10-year agreement between Fairchild and GoldStar was signed in June of 1985. Fairchild provided its 64Kx1 fast SRAM technology to GoldStar. GoldStar obtained exclusive rights to market the part in Korea and nonexclusive rights to market it in other Asian countries.

24. Exel and Oki

Exel Microelectronics and Oki Electric reached an agreement in March of 1985, whereby Oki will be a second source for Exel's 2Kx8 NMOS EEPROM. Oki also planned to start producing 64K EEPROMs in mid-1985. Exel has been shipping its 2Kx8 EEPROM in volume since November of 1984.

25. AMD and GoldStar

GoldStar entered an agreement with Advanced Micro Devices (AMD) early in 1985. GoldStar will manufacture and obtain limited marketing rights to AMD's 64K and 256K DRAM.

26. Atmel and General Instrument

Atmel provided technology for its OTP EPROM, UV EPROM, and EEPROM to General Instrument (GI) in exchange for fab capacity at GI's plant in Chandler, Arizona.

27. Synertek and Signetics

Synertek's dual-port RAM technology was sold to Signetics after Synertek shut down.

28. Inmos and Hyundai

In December 1984, Hyundai signed a contract with Inmos Corporation for technology from Inmos to begin mass production of the 256K DRAM. Hyundai has paid a portion of $6 million for the technology, and production was scheduled for the latter half of 1986. In April 1986, Hyundai charged Inmos with delaying the transfer of the technology and asked the U.S. District Court to order Inmos to enter into arbitration over this transfer.

29. RCA and Sharp

RCA and Sharp entered into a broad joint venture in December of 1984. This venture included the establishment of a jointly owned company, taking technology from the parent companies. Ownership was to be 51:49 in RCA's favor. The transfer included the design of a 256K CMOS dynamic RAM by Sharp for production by RCA.

30. WSI and Sharp

On December 20, 1984, Sharp announced that it had signed a technical cooperation contract with Wafer Scale Integration (WSI). By using WSI's technology, Sharp planned to produce the 64K CMOS EPROM. WSI received manufacturing capacity and royalties from Sharp. Development and production of 256K CMOS EPROMs were also planned.

31. Micron Technology and National Semiconductor

On November 30, 1984, National Semiconductor purchased a license to manufacture and sell Micron Technology's 64K dynamic RAM. It was estimated that this license cost National close to $5 million. This deal also involved an option on a 512K DRAM array that National could manufacture as a second source when Micron started up its own line. As of January 1985, National had still not decided whether or not to build the part in production volume.

32. Visic and Monolithic Memories

On November 8, 1984, Monolithic Memories signed a technology exchange and cross-licensing agreement with Visic. The agreement included joint development of a high-performance, 1.5-micron double-level metal CMOS process and an exchange of advanced proprietary products. Visic stated that its product line would be "high-performance CMOS memories," but would not specify the type of memory to be built. The relationship also ensured alternate sourcing for these products at initial market introduction.

33. Oki and Thomson

Thomson used its own technology for 64K RAMs but got substantial production assistance from a five-year industrial know-how exchange with Oki Electric in October of 1984.

34. Modular Semiconductor and Ricoh

In September 1984, Ricoh signed a five-year contract with Modular Semiconductor. Modular supplied the design and process technology for the CMOS 256K DRAM and the 16K SRAM. Ricoh planned to market those devices in Japan and also to supply them to Modular and Panatech Research and Development.

35. Intel and Altera

Intel and Altera signed a technology exchange agreement on August 13, 1984. Under the terms of the agreement, Intel was to provide Altera with its CHMOS EPROM design technology. In exchange for this, Altera would allow Intel to produce the Altera electrically programmable logic devices.

36. Lattice and VLSI Technology

In July of 1984, Lattice Semiconductor Corporation provided technology for CMOS EEPROMs and SRAMs to VLSI Technology in exchange for foundry services at VLSI Technology.

37. Lattice and Synertek

Lattice Semiconductor and Synertek signed a cross-licensing, second-source agreement on July 1, 1984. Under the terms of the agreement, Synertek was licensed to use Lattice's proprietary process in the manufacture of a 35ns, 64K static RAM in exchange for a portion of Synertek's production capacity at its wafer fab facility in Santa Cruz, California.

Synertek was also licensed to manufacture any other static RAM that Lattice makes using its proprietary "ultra MOS" process, which is a CMOS process. In exchange, Lattice was licensed to manufacture any products Synertek would design using this process.

38. National Semiconductor and Synertek

National Semiconductor and Synertek signed an agreement in July of 1984, under which National would serve as a licensed alternate source for Synertek's 2K EEPROM.

39. MOSel and UMC

MOSel, a small design group out of Fairchild, designed an advanced EEPROM and a high-speed 2Kx8 static RAM. In exchange for a fraction of the wafer start capacity, MOSel transferred rights to production of these products to UMC in Taiwan. In addition, the advanced process used to manufacture them would be used to bring up the 2-micron CMOS process at UMC in Taiwan.

40. Inmos and NMB

NMB obtained a five-year license to produce Inmos 256K CMOS DRAMs in June of 1984. Under the terms of the agreement, NMB was to pay Inmos a large initial sum and continuing royalties. The two companies also agreed to cooperate on the technology for Inmos' 64K DRAM and a 1Mb DRAM. Inmos would have the right to purchase up to 50 percent of NMB's 256K DRAM output, and NMB would sell Inmos products exclusively to Inmos' Japanese customer base.

41. Philips and Siemens

In June 1984, Philips and Siemens agreed to a joint venture to set up a semiconductor fabrication plant in Holland to produce 4Mb RAMs. This venture involved an investment of approximately $10 million.

42. Vitelic and ERSO

In May of 1984, Taiwan's government-sponsored Electronics Research and Service Organization (ERSO) signed a cooperative agreement with Vitelic Corporation of the United States with the aim of jointly developing VLSIs. Under the terms of the agreement, development of EPROMs and 64K and 256K CMOS DRAMs would be completed within a year.

43. Motorola and Thomson

Motorola transferred its 64K DRAM technology to Thomson in March of 1984.

44. Visic and VLSI Technology

Visic and VLSI Technology announced a joint development venture on February 22, 1984, to develop CMOS RAM technology and products. Included in this agreement were 64Kx1 and 16Kx4 CMOS DRAMs.

45. Intel and Inmos

Intel and Inmos entered into an agreement in December of 1983 to develop methods for achieving consistent specifications on 64K and 256K CHMOS DRAMs. Each company planned to develop, introduce, and market its own products independently, while adherence to the same CHMOS specifications would ensure a second source for users.

46. International CMOS Technology and Hyundai

Hyundai licensed International CMOS Technology (ICT) to do product development in 1983. This joint enterprise required ICT to develop three advanced CMOS products, while Hyundai would develop three other products. Hyundai funded ICT's initial product development and allocated a certain fraction of the wafer fab capacity at its Korean plant to produce ICT's part. Out of this venture, both manufacturers planned to produce a total of about seven or eight different parts, including 1K CMOS EEPROMs, fast SRAMs, and 64K EPROMs.

47. Inmos and General Instrument

In October 1983, Inmos licensed General Instrument to be a second source for an 8Kx8 EEPROM. The pact involved complete technology transfer including masks and processing information.

48. AT&T Technology and GoldStar

GoldStar Semiconductor was licensed by AT&T sometime before September of 1983 to produce 64K and 256K DRAMs.

49. Micron Technology and Standard Telecom

Sometime before September 1983, Standard Telecom, formerly IT&T, acquired the rights to produce the Micron Technology 64K dynamic RAM.

50. VLSI Technology and Ricoh

In September of 1983, Ricoh and VLSI Technology signed a contract to exchange production technology of large-capacity mask ROMs. VLSI Technology supplied 64K, 128K, and 256K mask NMOS ROM technology to Ricoh, and Ricoh supplied the same capacity of mask CMOS ROM to VTI.

51. Micron Technology and Commodore

In August 1983, Micron Technology licensed Commodore to produce Micron's 64K DRAM. This was the only semiconductor part used by Commodore in its personal computer and other microsystems that it did not make itself.

52. Micron and Samsung

Samsung obtained a license to manufacture and market the 64K DRAM design of Micron Technology in August of 1983. This pact provided Micron with cash and is believed to have involved a swap of technical information. This agreement was later extended to include Micron's 256K DRAM.

53. Philips and General Instrument

General Instrument (GI) and Philips reached an agreement in June of 1983 under which GI planned to develop a new line of nonvolatile memory devices that supported the Philips 1^2C bus standard. The first product was planned to be a 1K EEPROM.

54. Exel and Samsung

In 1983, Samsung entered into a joint development project to act as a second source for Exel's forthcoming 16K EEPROMs.

55. Mitsubishi and Texas Instruments

Sometime before March of 1983, Mitsubishi supplied both loose dice and packaged 64K EPROMs to Texas Instruments (TI) to be sold through TI's distribution channel and with TI's markings on them. TI would continue to produce its own part at full capacity.

56. National Semiconductor and Eurotechnique

National Semiconductor transferred technology for its 16K and 32K CMOS EPROMs to Eurotechnique in 1983.

57. Seiko and RCA

In 1983, Seiko was supplying loose dice and/or packaged parts of its 2Kx8 CMOS Static RAM to RCA to be sold through RCA's marketing chain.

58. Oki and National Semiconductor

In late 1982, Oki Electric supplied its 64K dynamic RAM technology to National Semiconductor. National allocated about half of its 64K DRAM output to Oki. National planned to market the Oki DRAM, using a National label and part number.

59. Ricoh and Rockwell

In December 1982, Ricoh and Rockwell International signed a cross-licensing agreement for memories, microprocessors, and other semiconductor devices. As part of that agreement, Ricoh and Rockwell would exchange production technology. Ricoh would provide Rockwell with its technology for producing 32K and 64K CMOS EPROMs. In return, Rockwell would provide its technology to Ricoh for producing 8-bit CMOS microprocessors.

60. Intel and IBM

In September of 1982, IBM purchased the tapes and process know-how for Intel's 64K dynamic RAM. This agreement also provided IBM with on-site technical assistance in setting up the production process. Intel agreed to supply IBM with finished 64K DRAMs until IBM's line was running. IBM would produce the part for in-house use only.

61. Mitsubishi and Sperry

In 1982, Mitsubishi agreed to supply 64K NMOS DRAM technology to Sperry. In exchange, Sperry agreed to train Mitsubishi engineers in large mainframe computer technology. Mitsubishi also obtained rights to sell Sperry products in Japan.

62. SEEQ and Rockwell

Rockwell signed an exclusive licensing agreement with SEEQ Technology on July 6, 1982. SEEQ provided Rockwell with its 16K EEPROM and 16K UV EPROM technology. In exchange, Rockwell paid SEEQ $5 million and leased $5.5 million of SEEQ's equipment. Rockwell also agreed to pay SEEQ a 3 percent royalty on sales of these products (up to $4 million). However, by October of 1984, Rockwell had not made any sales of products subject to this royalty.

63. Toshiba and Zilog

Toshiba provided Zilog with the design and process information for its 16K CMOS SRAM in April of 1982. The agreement allowed Zilog to market Toshiba's product worldwide. In return, Zilog provided Toshiba with masks for its microprocessors.

64. Hitachi and Hewlett-Packard

In March of 1982, Hitachi sold Hewlett-Packard (HP) its 64K DRAM technology. HP was planning to use the 64Ks in its minicomputers but not to market them to outside users.

(Portions of this newsletter were originally published by Dataquest's Semiconductor Industry Service.)

Brand Parks
Sue Kelly

SUIS Code: Newsletters
1986-20

1986 CAPITAL SPENDING:
CAPITAL SPENDING TRENDS FORETELL CHANGING INDUSTRY STRUCTURE

SUMMARY

Worldwide capital spending is expected to bottom out in 1986 at $6.3 billion, 5.4 percent less than 1985 expenditures of $6.7 billion. Expenditures of Japanese semiconductor companies continue to surpass those of U.S. companies, indicating that worldwide market share of Japanese companies will continue to increase for the next two to three years. However, 1986 spending by Japanese companies is expected to be 11 percent less than 1985, a greater decrease than that of any other region (see Table 1). We believe that this is the beginning of a new trend by Japanese companies to lower capital investment per dollar of revenue for the rest of the decade, slowing their rate of increase in market share. This reverses the trend during the late 1970s and early 1980s, as shown in Figure 1. The slowdown in Japanese capital spending coupled with continued fast growth in Japanese semiconductor consumption foretells a balancing of supply of product between the United States and Japan in the next five years.

JAPAN: A TOUGH TRANSITION YEAR

Impact of a Weaker Dollar

The decline of, the dollar relative to the yen masks the actual magnitude of the decline of the Japanese equipment market. Table 2 illustrates this point, which is explained below. It is also possible that any further appreciation of the yen could cause a decline in Japanese semiconductor revenues. Such a decline would, of course, further weaken the demand for capital goods.

In 1985, when the yen/dollar rate was 237, Japanese capital spending was ¥793 billion, down 6.3 percent fromm 1984. (It should be emphasized that this 6.3 percent decline is for calendar 1985.) For the fiscal year ending March 31, the decline in capital spending was more severe, 15.9 percent. In 1986, Japanese capital spending is expected to decline 23.7 percent to ¥605 billion. However, because the yen will buy more dollars in 1986, the decline expressed in dollars is only an estimated 10.9 percent, going from $3,346 million in 1985 to $2,980 million in 1986. The yen/dollar rate in 1986 is assumed to be 203 yen to the dollar.

Whether expressed in dollars or yen, there is no escaping the fact that the market for semiconductor equipment in Japan will likely be down by a large amount in 1986. The reason for this steep decline is that the industry is in a state of overcapacity, and the industry is now in a position to do something about it. Japanese semiconductor manufacturers are in this position because they now, in effect, own the markets in which they participate. They therefore no longer have to scramble to build market share.

DATAQUEST believes that this steep decline represents the beginning of a fundamental readjustment in the Japanese semiconductor industry. If the Japanese semiconductor industry had continued to spend at its historic capital spending-to-revenue ratio of 30 percent, its revenue-per-dollar value of property, plant, and equipment (PPE) would have fallen to below unity. To avoid this, we believe that the capital spending-to-revenue ratio will fall from a 30 percent level to slightly below 22 percent (see Table 3).

Japanese Company Spending

Several of the larger Japanese semiconductor manufacturers have cut back their capital spending plans for calendar 1986 by amounts greater than 30 percent. Among those that we believe have done so are Hitachi, Matsushita, Mitsubishi, and Toshiba. (See Table 4 for a list of changes in the Japanese semiconductor companies' capital spending in yen.)

Because of the appreciation of the yen relative to the dollar, some companies' capital spending expressed in dollars will increase (Rohm or Sony, for example), while expressed in yen they will decrease. (See Table 5 for the same companies' capital speding changes in dollars.)

This could be an opportunity for North American equipment manufacturers. The yen will now buy more dollars than it did a year ago. Therefore, the cost of purchasing North American equipment expressed in yen is now less for Japanese semiconductor manufacturers.

Long-Term Forecast

The long-term growth for capital spending in Japan is basically sound since it is basically a function of the growth of the Japanese semiconductor industry. DATAQUEST believes that Japanese capital spending will bottom out in the third quarter of calendar 1986, and will thereafter begin to rise at a compound annual growth rate (CAGR) of 17 percent between 1986 and 1990.

NORTH AMERICA: POSSIBILITIES FOR OPTIMISM

Ambiguous Trends

There are differing signs in the wind about which way the North American industry will go in 1986. DATAQUEST has unofficially surveyed the major semiconductor companies, and the results are a disheartening decline of 18 percent from $2,227 million in 1985 to $1,827 million in 1986. In spite of these results, we are forecasting merchant capital spending to be substantially higher in 1986 than our survey indicates--at a level of $2,193 million.

The reason for our optimism is because at $1,827 million, the capital spending-to-revenue ratio is less than 13 percent. The industry has not been at this level since 1978. It is DATAQUEST's opinion, confirmed by industry sources that we contacted, that as the market for semiconductors increases, plans that were generated in the depths of 1985 will be revised upward. We are therefore adding an adjustment factor of $365 million onto our survey for our 1986 forecast, resulting in only a 0.8 percent decline (see Table 6).

North American Equipment Spending Up

A decline of 0.8 percent is still a decline. However, when one subtracts the spending for bricks and mortar, we believe that merchant capital spending for equipment will increase from $1,632 million in 1985 to $1,821 million in 1986. This is because equipment as a percent of total PPE is expected to increase from 74 percent in 1985 to 83 percent in 1986 (see Table 7).

This shift from bricks and mortar toward equipment is a continuation of a trend that DATAQUEST noted previously. (See the SEMS Research Newsletter dated October 4, 1985, entitled "Capital Spending: Japan to Continue to Outspend the United States"). The industry is continuing its shift away from areas of overcapacity and toward those technologies where future demand is expected to exceed capacity, such as devices with submicron geometry. Because of the industry's continuing need to achieve better line balance, increase utilization, and lower both contamination and breakage from handling, spending for automation should be robust. We also expect the demand for sub-2-micron equipment to be vigorous.

AFTER THE RECESSION: 1987 THROUGH 1990

DATAQUEST believes that semiconductor capital spending in Japan will begin to rebound in the third quarter of 1986 and will increase a robust 31 percent in 1987. We expect it to have healthy growth in 1987 even though capital spending as a percent of revenue will continue to decline. We expect this ratio to approach stability in the 21 to 22 percent range (see Table 8). Because of this fundamental readjustment of the Japanese industry, we have lowered our earlier forecast from 22 percent to 17 percent--which is still a healthy growth.

We expect North American semiconductor merchant capital spending to experience a CAGR of 25 percent from 1986 to 1990. As we have noted previously, the North American merchant semiconductor industry has been more tied to the ups and downs of business expansions and contractions than the Japanese industry has. Specifically, North American industry has matched its capacity to the business cycle. We therefore expect North American capital spending to be more in line with historical patterns than the Japanese industry.

We forecast European semiconductor capital spending to increase from $381 million in 1985 to $430 million in 1986. This reflects the continuing commitment of both European companies and their governments to reemerge into the forefront of the industry. We expect capital spending to grow at a CAGR of 27 percent through 1990 and to break the $1 billion mark in 1990.

Rest of World capital spending was the only area that did not experience a downturn in 1985. It grew from $201 million in 1984 to $244 million in 1985. We expect ROW capital spending to reach $263 million in 1986, up 8 percent from 1985. Overall, ROW capital spending will grow at an estimated CAGR of 30 percent, the highest of any region, and reach an estimated $751 million by 1990.

Stan Bruederle
George Burns

Table 1

ESTIMATED WORLDWIDE CAPITAL SPENDING
(Millions of Dollars)

	1985	1986	1987	1988	1989	1990	CAGR 1986-1990
North America	$2,211	$2,193	$3,569	$ 4,579	$ 4,528	$ 5,410	25%
Japan	3,346	2,980	3,905	4,495	4,679	5,509	17%
Europe	381	430	589	817	950	1,119	27%
ROW	242	263	394	533	593	751	30%
Captive	486	482	785	1,007	996	1,190	25%
Total	$6,667	$6,349	$9,242	$11,432	$11,746	$13,980	22%

*Columns may not total due to rounding

Source: DATAQUEST
March 1986

Figure 1

CAPITAL SPENDING RATIOS AND CHANGING MARKET SHARE--U.S. AND JAPAN

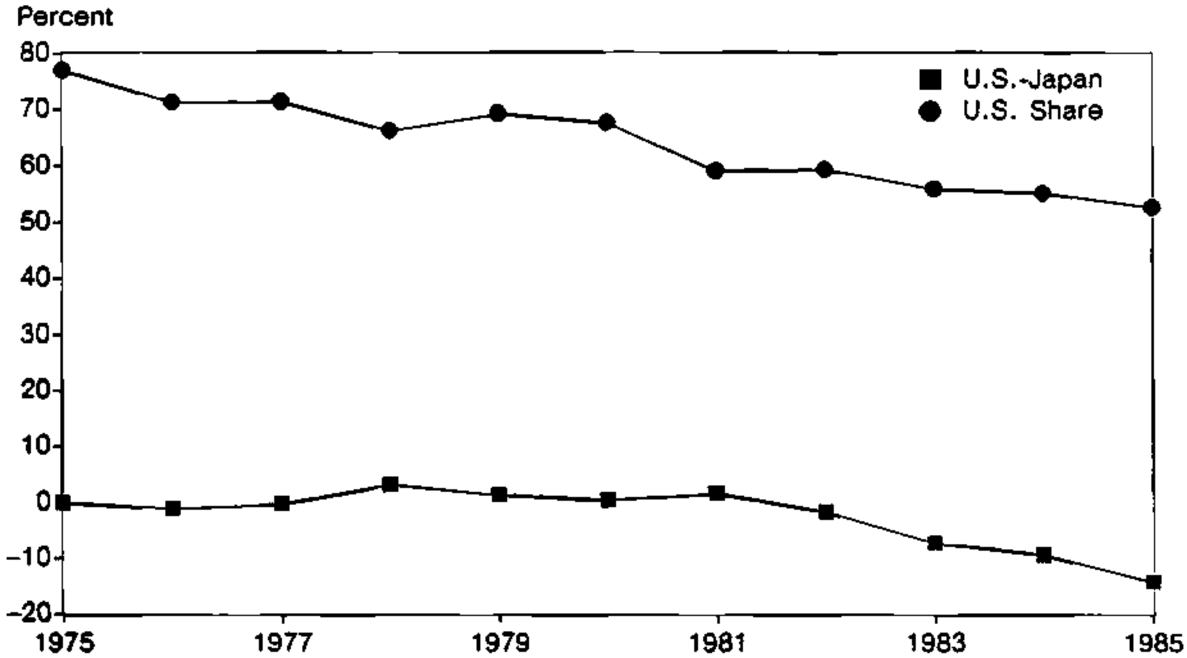


Table 2

ESTIMATED 1986 DECLINE IN YEN AND IN DOLLARS
(Billions of Yen, Millions of Dollars)

	Japanese Capital Spending in Yen	Percent Change in Yen	Japanese Capital Spending in Dollars	Percent Change in Dollars
1985	¥793	(6.3%)	$3,346	(7.1%)
1986	¥605	(23.7%)	$2,980	(10.9%)

Source: DATAQUEST
March 1986

Table 3

ESTIMATED JAPANESE CAPITAL SPENDING/REVENUE RATIOS
1984-1990
(Billions of Yen)

	1984	1985	1986	1987	1988	1989	1990
Revenue	¥2,733	¥2,325	¥2,355	¥3,445	¥4,119	¥4,458	¥5,177
Capital Spending	¥ 846	¥ 793	¥ 605	¥ 793	¥ 913	¥ 950	¥1,118
Spending/ Revenue	31.0%	34.1%	25.7%	25.2%	22.5%	21.3%	21.6%

Table 4

ESTIMATED CHANGES IN JAPANESE COMPANIES' CALENDAR CAPITAL SPENDING
1985-1986
(Billions of Yen)

Company	1985	1986	Percent Change
Fujitsu	¥ 72	¥ 58	(19%)
Hitachi	92	65	(30%)
Matsushita	87	58	(33%)
Mitsubishi	62	40	(35%)
NEC	123	102	(18%)
Oki	26	22	(13%)
Sanyo	47	42	(10%)
Sharp	36	32	(12%)
Fuji Electric	12	8	(33%)
Shindengen	1	1	-
Seiko Epso	8	4	(50%)
NJRC	5	6	20%
Japan Semiconductor	-	11	-
Toshiba	123	85	(31%)
Sony	36	32	(12%)
Rohm	9	8	(8%)
Sanken	6	3	(50%)
NMB	14	3	(78%)
Others	32	24	(25%)
Total	¥793	¥605	(24%)

Note: Columns may not add to totals shown due to rounding.

Source: DATAQUEST
March 1986

Table 5

ESTIMATED CHANGES IN JAPANESE COMPANIES' CALENDAR CAPITAL SPENDING
1985-1986
(Millions of Dollars)

Company	1985	1986	Percent Change
Fujitsu	$ 303	$ 287	(6%)
Hitachi	390	318	(18%)
Matsushita	368	287	(22%)
Mitsubishi	260	198	(24%)
NEC	520	500	(4%)
Oki	108	109	1%
Sanyo	199	208	5%
Sharp	152	156	3%
Fuji Electric	52	42	(20%)
Shindengen	4	5	20%
Seiko Epso	35	21	(40%)
NJRC	22	31	44%
Japan Semiconductor	-	52	-
Toshiba	520	417	(20%)
Sony	152	156	3%
Rohm	39	42	7%
Sanken	27	16	(42%)
NMB	61	16	(74%)
Others	134	119	(11%)
Total	$3,346	$2,980	(11%)

Note: Columns may not add to totals shown due to rounding.

Source: DATAQUEST
March 1986

Table 6

ESTIMATED CHANGES IN NORTH AMERICAN CAPITAL SPENDING
1985-1986
(Millions of Dollars)

Company	Capital Spending	Percent Change From 1985
AMD	$ 143	(21%)
Gould-AMI	20	(33%)
Fairchild	150	11%
Intel	180	(16%)
MMI	35	(28%)
Motorola	250	(24%)
National	145	(40%)
Others	574	(19%)
Signetics*	70	40%
Texas Instruments	260	(7%)
Subtotal	$1,827	(17%)
Adjustment Factor	$ 365	
Total	$2,193	(0.8%)

*Signetics is a subsidiary of Phillips of the Netherlands.

Source: DATAQUEST
March 1986

Table 7

ESTIMATES OF SELECTED NORTH AMERICAN COMPANIES'
EQUIPMENT SPENDING
1986
(Millions of Dollars)

Company	Equipment Spending	Equipment PPE	Weighted Average
Gould-AMI	$ 18	92%	2%
Fairchild	100	87%	7%
Intel	130	72%	10%
MMI	30	85%	3%
Motorola	225	90%	22%
National	116	80%	10%
Signetics*	58	83%	5%
Texas Instruments	234	95%	23%
Subtotal	911		83%
Others	910		
Total	$1,821		

*Signetics is a subsidiary of Phillips of the Netherlands.

Source: DATAQUEST
March 1986

Table 8

ESTIMATED CAPITAL VS. REVENUE: NORTH AMERICA, JAPAN, AND EUROPE
1985-1990
(Million of Dollars)

	1985	1986	1987	1988	1989	1990
North American Revenue	$11,272	$14,209	$18,329	$22,518	$22,622	$26,584
Capital Spending	$ 2,227	$ 2,193	$ 3,569	$ 4,579	$ 5,639	$ 5,410
Capital/Revenue	20%	15%	19%	20%	25%	20%
Japanese Revenue	$10,185	$11,600	$15,494	$20,291	$21,962	$26,584
Capital Spending	$ 3,346	$ 2,980	$ 3,905	$ 4,495	$ 4,679	$ 5,509
Capital/Revenue	33%	26%	25%	22%	21%	21%
European Revenue	$ 2,301	$ 2,732	$ 3,780	$ 5,031	$ 5,398	$ 6,573
Capital Spending	$ 381	$ 430	$ 589	$ 817	$ 950	$ 1,119
Capital/Revenue	17%	16%	16%	16%	18%	17%

Source: DATAQUEST
March 1986

SUIS Code: Newsletters
1986-19

EIA FIRST-QUARTER REPORT: ELECTRONIC EQUIPMENT FACTORY SHIPMENTS DOWN 2 PERCENT

A recent report published by the Electronic Industries Association (EIA) shows that U.S. factory shipments of electronic equipment were lower in the first quarter of this year than they were for the same period in 1985.

While the EIA's and DATAQUEST's segmentations for electronic equipment differ slightly, we believe that the EIA data (see Table 1) are good indicators of electronic equipment demand. DATAQUEST's figures for U.S. semiconductor consumption are also included in Table 1.

Table 1

U.S. FACTORY SHIPMENTS OF ELECTRONIC EQUIPMENT AND SEMICONDUCTORS
(Billions of Dollars)

Segment	Q1'85	Q4'85	Q1'86	Percent Change Q1'86/Q1'85	Percent Change Q1'86/Q4'85
Computers and Industrial	$17.93	$18.17	$15.74	(12.2%)	(13.4%)
Communications	12.60	13.80	13.09	3.9%	(5.1%)
Consumer	4.32	5.84	4.13	(4.4%)	(29.3%)
Other*	7.83	8.75	8.96	14.4%	2.4%
Total Equipment	$42.68	$46.56	$41.92	(1.8%)	(10.0%)
Semiconductor	$ 2.70	$ 2.22	$ 2.30	(14.8%)	3.6%

*Other includes automotive, aircraft, and other electronic products

Source: EIA
DATAQUEST
June 1986

DATAQUEST ANALYSIS

Although the severity of the computer slump is greater than most people had anticipated, the trends indicated in the EIA data are in line with our recent forecast for electronic equipment growth in the near future. DATAQUEST foresees strong growth this year for automotive electronics, with moderate improvement for the industrial, communications, and consumer segments.

However, for any significant recovery to occur in either the electronic equipment markets or the semiconductor industry, an upturn is needed in the computer segment. The question is when.

Recent Department of Commerce (DOC) data are not encouraging. While communications equipment shipments are in line with inventory, and bookings are on the rise, new orders for computer equipment continue their downward trend. Shipments of computers are still declining, leading to possible increases in equipment inventory in the next few months.

While the short term is not encouraging, we believe that the computer industry will improve by the end of this year, surpassing 1985's revenue by 8 percent. Although far below historical growth rates, we believe that the year-end upswing in computer sales, coupled with a strong 1987, will pull this industry out of its slump.

For semiconductor manufacturers, this translates into relatively little increase in demand from the data processing community for the short term. Nevertheless, an improvement is expected by the end of this year, leading to robust growth in 1987.

Mark Giudici
John M. Brew

LONG-TERM PROCUREMENT IMPLICATIONS OF SEMICONDUCTOR PRICE DUMPING

SUMMARY

The current situation involving the dissemination of information about the dumping rulings and the administration of those rulings is at best confusing and at worst very costly. This newsletter will:

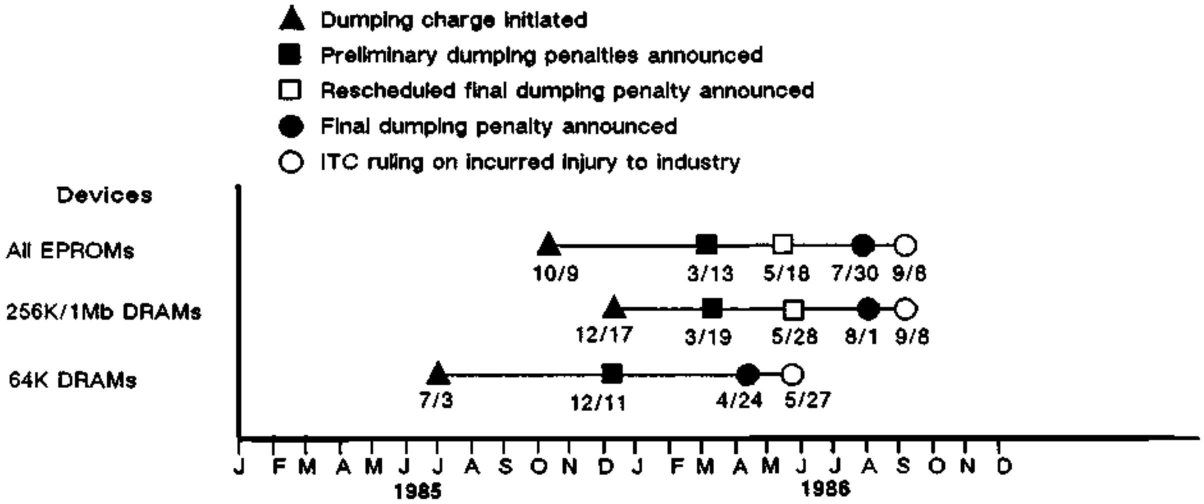
- Review the current situation
- Evaluate the Japanese Ministry of International Trade and Industry (MITI) proposal
- Examine the reasons the Federal Trade Commission (FTC) concurs with the Japanese manufacturers that claim that no dumping has occurred
- Analyze the effects of both the short- and long-range price trends and recommend strategies for success

INDUSTRY STATUS

Figure 1 illustrates the current situation. The ITC ruled on May 27 that the U.S. IC industry had been "injured" by price dumping of Japanese 64K DRAMs. The 256K DRAM and EPROM rulings have not gotten that far in the proceedings and are awaiting the U.S. Department of Commerce's announcement of the final dumping penalty percentages by company. The final penalty percentage decision for the 256K DRAMs and EPROMs was delayed so that the Japanese manufacturers involved could gather more accurate cost data.

Figure 1

SEMICONDUCTOR PRICE DUMPING PROCEEDING SCHEDULE



Source: DATAQUEST
June 1986

As stated in our SUIS Research Newsletter 1986-8, "Semiconductor Dumping and Prices: Who Pays the Bill," the effects of the dumping charges have accelerated the then ongoing price stabilization caused by inventory replenishment and increased demand. The question at that time was whether the imposed penalties were applied before or after prices had risen above continually declining costs. It appears that the crossover point has been reached and that 64K DRAM, and to some extent 256K DRAM and EPROM, prices will peak by the third quarter of this year. Price declines will then follow gradual cost reductions. The pricing of 1Mb DRAMs has not been appreciably affected by the dumping penalties due to limited shipments. Furthermore, because of the soft systems market, we do not expect new designs implementing the 1Mb DRAM to be pushed into the market any sooner than necessary. As a result, shipments of these parts will not force cost-related price cuts faster than the normal experience curve. Using a 4:1 trade-off point, we estimate that by the fourth quarter of 1987, 1Mb parts will reach bit price parity with the 256K device.

Table 1 shows the 1985 prices for the major semiconductor devices and the expected price trends for the rest of 1986.

Table 1

MAJOR SEMICONDUCTOR PRICES AFFECTED BY DUMPING RULINGS

	1985				1986			
Device	Q1	Q2	Q3	Q4	Q1	Q2	Q3*	Q4*
64K DRAM	$ 1.75	$ 1.10	$ 0.80	$ 0.85	$ 1.10	$ 1.15	$ 1.20	$ 1.15
256K DRAM	$ 9.75	$ 4.75	$ 2.75	$ 2.10	$ 2.25	$ 2.50	$ 2.60	$ 2.45
1Mb DRAM	N/A	N/A	$160.00	$125.00	$50.00	$34.00	$24.00	$18.50
128K EPROM	$ 6.57	$ 4.14	$ 3.11	$ 2.61	$ 2.90	$ 2.90	$ 2.90	$ 2.85
256K EPROM	$21.55	$12.14	$ 5.67	$ 4.70	$ 4.35	$ 4.75	$ 4.20	$ 3.85

*Estimated prices
N/A = Not Available

Source: DATAQUEST
June 1986

MITI Proposal

If implemented, the MITI proposal to monitor semiconductor production and prices has many long-range implications for the electronics industry (see the SUIS Research Bulletin 1986-15, "MITI Offers Proposal to Avoid Dumping Penalties"). Though the proposal will eliminate dumping penalties and all the headaches that go along with them, the resulting MITI-imposed market controls will transfer marketing decisions from individual industry competitors to the state and will moderate the Japanese memory industry.

Both sides of the bargaining table are exerting enormous political pressure to force acceptance of this proposal or a variant thereof. The Japanese desire improved U.S.-Japanese business relations, and the United States wants greater access to the Japanese electronics market. An agreement like this would, with one stroke, eliminate the administrative burden of dumping penalty enforcement and possibly allow price reduction to resume in the near term. In return, U.S. companies would receive a guarantee of greater access to Japanese markets over the long term.

The wild card in this arrangement is whether competing U.S. and Korean memory manufacturers will follow MITI's pricing structure or if they will undercut the set floor prices to regain market share. Near-term pricing will likely stabilize if the proposal is made official policy. Longer-term pricing under the proposal will remain market-driven, with the MITI-orchestrated price structure acting as a single megavendor that can influence memory price trends although not necessarily all contract prices. The exclusion of ASICs in the proposal implies that this may be the next major target for the Japanese manufacturers.

FTC Determination

The FTC has stated that after looking at the cost data criteria, it found that dumping had not occurred for the 64K DRAM device. The key to this statement is the criteria used in determining what constitutes price dumping. The FTC claimed that using "constructed costs" in determining dumping violations would "not assure benefits of fair price competition for U.S. consumers." Although the constructed-cost method of determining price dumping is required by law, the FTC remarked that the U.S. Department of Commerce should determine dumping by comparing the retail selling price of 64K DRAMs in the home Japanese market versus the U.S. prices for the same device over the entire life of the device.

Micron Technology's financial reports provide a good example of how dumping based on costs can be misleading (see Table 2). Although product-related revenue and shipments dropped, fully loaded product expenses rose, resulting in higher costs per unit as more overhead had to be spread over fewer shipments. To compound the problem, the average selling price dropped by a factor of three. In effect, semiconductor companies sometimes have to sell below cost in order to ride out the cyclical swings of the market.

Table 2

TYPICAL OVERHEAD VERSUS VOLUME DILEMMA
(Micron Technology, 1984-1985)

	1984		1985	
	FY	Q4	FY	Q4
Revenue ($M)	$84.00	$31.20	$69.80	$ 5.00
Cost of Sales ($M)	$48.10	$15.50	$77.00	$12.70
Profit/(Loss) ($M)	$35.90	$15.70	($ 7.20)	($ 7.70)
Units Sold (M)				
64K DRAM	33.50	19.20	59.70	2.80
256K DRAM	-	-	0.40	1.50
ASP	$ 2.50	$ 1.62	$ 1.16	$ 1.16
Cost Per Unit	$ 1.43	$ 1.00	$ 1.28	$ 3.39
Profit/(Loss) Per Unit	$ 1.07	$ 0.62	($ 0.12)	($ 2.23)

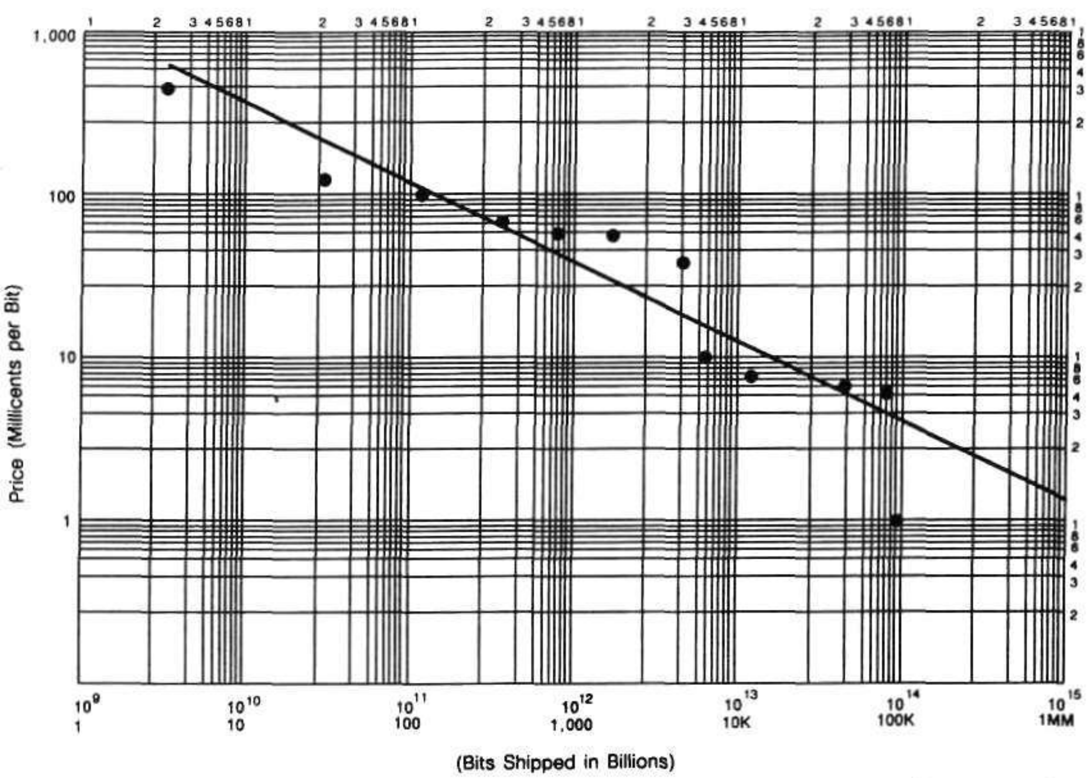
Source: Micron Technology
DATAQUEST
June 1986

The FTC issue echoed the arguments of the Japanese companies involved and was dismissed as inadmissible under current antidumping law. The implication for foreign semiconductor manufacturers is that the current laws provide little recourse to disprove dumping using the traditional comparative price argument. As it now stands, semiconductor users can expect near-term price increases for the affected devices until the dumping penalty time frame expires. Any price reductions in the interim will have to be well documented with cost-reduction justifications.

Near-term price stability or selective hikes will result regardless of whether dumping penalties remain or an agreement is reached through diplomatic channels. Long-term prices and their impact on manufacturing costs are expected to follow the normal bit price experience curve for semiconductors once the price dumping furor subsides (see Figure 2). Market share opportunities at the expense of Japanese manufacturers and overall cost reductions will force the continued trend toward long-term price decreases. The current strength of the yen against the dollar makes the United States an attractive site for investment in the very industries that are seeking dumping protection. Joint ventures between Japanese and U.S. companies are increasing both in response to the strength of the yen and as a means of improving business relations between the two countries.

Figure 2

DRAM EXPERIENCE CURVE



Source: DATAQUEST
June 1986

As worldwide quality standards improve due to acquired and created productivity gains, the short-term cost advantages of offshore manufacturing may prove to be long-term liabilities as automation and increased emphasis on high quality become the standard. The proliferation of technology transfers and joint ventures between Japan and the United States is advantageous for both parties. The U.S. companies gain manufacturing efficiencies and process enhancements while the Japanese companies attain licenses to state-of-the-art designs for future products. Since material and equipment costs are relatively equivalent, the cost differential of the variables involved with offshore manufacture versus U.S. manufacture center around labor, logistics, and facility costs. Long-term automation gains and the resulting lower labor costs coupled with quality improvements may overshadow the short-term savings resulting from overseas labor and facilities.

DATAQUEST ANALYSIS

The current semiconductor pricing situation raises questions that will affect many companies' long-term plans. One of the major questions many companies are dealing with is whether to move manufacturing facilities offshore. Some of the key factors influencing these decisions are cheap labor, lower capital costs, lower material costs, and proximity to suppliers. Balanced against offshore plant construction are domestic productivity gains made with automation, potential political volatility of the offshore country, required logistical support, and proximity to customers. Long-term overall semiconductor bit price reductions will continue to keep the semiconductor price per function down, thus negating the need for offshore plants due to semiconductor price trends.

Regardless of final dumping penalty percentages or agreements reached diplomatically, all Japanese products (including semiconductors) will continue to cost more due to the yen exchange rate. Prices for non-Japanese parts (U.S., Korean, European, etc.) will be less, unless a company attempts to skim some extra profit in relation to Japanese pricing. The semiconductor market will prevent any extended skimming as opportunities to gain market share overcome temporary price supports. As their quality comes up to par with the U.S. and Japanese manufacturers, the Korean semiconductor manufacturers are more than willing to gain market share at the expense of their competitors.

As the international financial markets settle upon consistent exchange rates, the near-term speculative exchange differentials will become less of a factor in determining whether to move facilities offshore. Interesting questions arise in light of the current phenomenon of Japanese companies coming to manufacture in the United States and U.S. companies going offshore. If Japanese companies can manufacture in the United States and make a profit, why cannot U.S. companies do the same? And, assuming many U.S. companies do go offshore to save costs, to whom will the U.S.-based Japanese companies sell?

Recommendations

In order to maximize profits, near-term strategies for using offshore turnkey assemblers and subcontractors while automating onshore facilities will provide a strong foundation for long-term growth. This approach minimizes exposure to fixed offshore plant expenses yet offers the advantages of labor savings. Logistical support for offshore manufacturing is critical and must be thoroughly understood before embarking into the international traffic channels.

Price dumping should be viewed as a temporary blip in an otherwise consistent reduction of semiconductor costs per function. As market forces regain control, competition will force prices downward in line with reduced costs. Procurement specialists should consider the following when negotiating prices:

- If dealing with a Japanese vendor, compare the exchange rate used for the last contract with the current exchange rate to determine the net price differential for the current contract.

- Prices in general will trend downward by the third quarter of this year as available capacity is filled and dumping adjustments become absorbed into pricing schedules.

- Before deciding to move facilities offshore, a thorough check of a company's traffic department is necessary (i.e., if there are logistical problems in dealing with domestic suppliers, the Pacific Ocean will only compound the problem).

- Continue to encourage close vendor-buyer relations that include price and delivery guarantees in order to ensure consistent pricing.

By understanding the current pricing phenomenon as a temporary anomaly and not a long-term trend, the decision to move manufacturing offshore also appears as a short-term fix. Long-term growth and industrial strength require the determination to invest where the markets are, not necessarily where the short-term costs are lowest.

Mark Giudici

SUIS Code: Newsletters
1986-17

GRAPHICS-SPECIFIC ICs--REVOLUTION IN THE GRAPHICS INDUSTRY

EXECUTIVE SUMMARY

Graphics-specific integrated circuits (GSICs) are finding their way into a substantial number of graphics terminals, controllers, and add-on boards. This has caused a faster price/performance increase than ever before in the graphics industry. The result has been a large increase in the number of new, first-time users for personal computer-based graphics systems. DATAQUEST forecasts that by the end of 1985 the number of PC-based graphics systems installed will equal almost two times the installed base of bit-mapped graphics terminals and standalone workstations. This is remarkable when one considers that in 1983 the installed base of conventional graphics terminals was 1.3 times the installed base of PC-based graphics. We believe that the role of GSICs in sustaining this expansion will continue and increase both in the low-end or PC-based arena and in the higher-performance graphics terminal segments.

This is the first in a series of newsletters that address the impact and nature of merchant ICs for graphics. In this newsletter we will present a background of GSICs and review the application of such graphics-specific ICs to various graphics functions that make up a complete graphics system. Future newsletters will address captive or proprietary GSIC products available or in development, and will look at the performance levels of both merchant and captive GSIC products.

DEFINITIONS

DATAQUEST defines an ASIC as a semiconductor product that is designed for a single customer. ASICs include both custom and semicustom products; custom products are either standard cell or full-custom designs, while semicustom products are either gate arrays or field-programmable devices. GIS defines a graphics-specific IC as a close cousin of an ASIC, but one that is usable only as a component in a graphics device or system. We consider a GSIC to be a merchant device if it is available to more than one customer, and we call it a captive or proprietary device if it is designed by and for one customer. Compared to the ASIC definition, only the captive GSIC is truly an ASIC, and since these captive devices are a minority in the market, we believe that it is necessary to create the GSIC designation. Our definiton of a GSIC excludes from consideration general-purpose devices such as digital signal processors (DSPs), digital to analog converters (DACs), floating point or array processors, and bit-slice microprocessors (e.g., an AMD 29116). These excluded devices frequently are present in graphics systems, but are general purpose in nature and can also be used in a variety of other, non-graphics systems. In addition, they follow the more general semiconductor market in terms of price, performance, and technology and so do not necessarily respond to the narrower demands of the graphics market.

BACKGROUND

One of the first merchant GSIC products for graphics was the NEC7220 Graphic Display Controller. Although it was not a high-performance device, it replaced a PCB in function and at a much lower cost ($175 versus $500). In addition, it made the use of small form-factor boards for an entire graphics system a reality. This in turn made add-on boards for personal computers a new graphics market segment that is growing at 100 percent per year. The first proprietary GSICs appeared in graphics products in late 1983. Most of these are semicustom gate array and are used in such products as the Ramtek 2020 and the Raster Technologies One/60. Silicon Graphics' Geometry Engine, however, which is used in all of its products, is full-custom VLSI. Other, newer merchant and captive GSIC products are now on the market and are expected to have a similar impact in various graphics segments. They are also expected to obsolete current GSIC designs used by graphics companies in those segments.

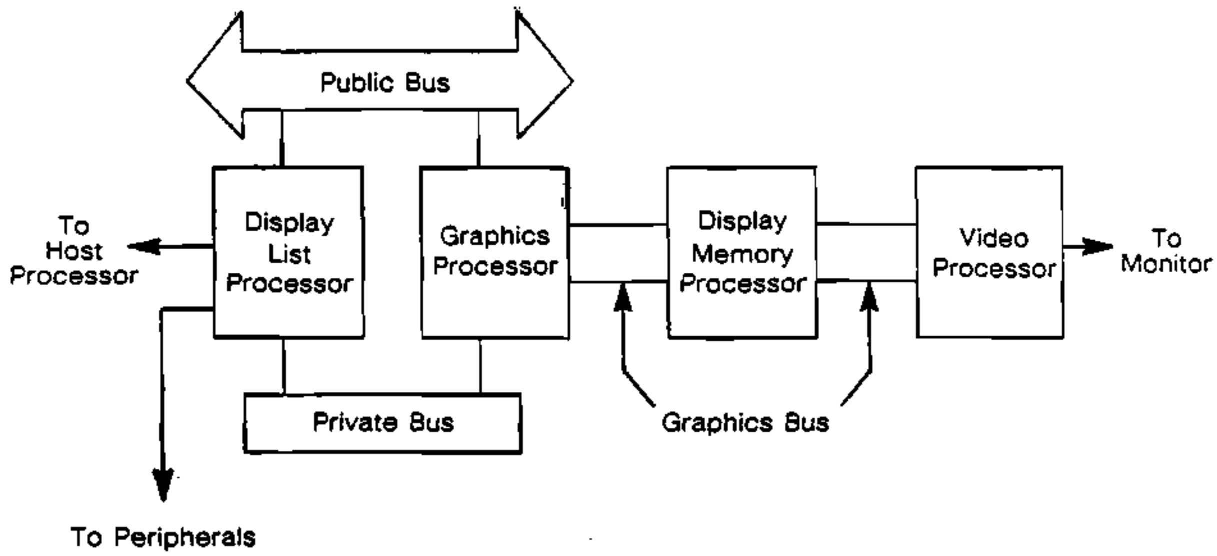
TECHNOLOGY OVERVIEW

Graphics Architecture

Figure 1 presents a generic graphics architecture in block diagram format. This figure serves as a basis for the following discussion about uses of an ASIC or a GSIC in a graphics terminal or controller. A graphics controller can be thought of as four logical processors, which in the past corresponded to one or more physical printed circuit boards. The advent of GSICs has reduced this one-to-one correspondence to some extent today, and we expect fewer boards per logical process in the future. The functions carried out in each of these processors are summarized below.

Figure 1

GENERIC GRAPHICS ARCHITECTURE



Source: DATAQUEST
June 1986

<u>Display List Processor</u>

This is the first step in the graphics pipeline. The functions normally carried out here are:

- System memory and control
- Graphics display list memory and control
- Control of the interface between the host processor and the graphics system
- Management of the input and output peripherals attached directly to the graphics system
- Other device emulation
- Running system start-up and diagnostic procedures

The display list processor can be thought of as the front end to the basic function of a graphics system; its purpose is to create and display graphics or geometric entities. This front end off-loads some host computer activities while it speeds up user response times. It can also be used to make the system emulate other graphics devices at a small fraction of the performance penalty associated with carrying out such emulation in the host central processor. It should be noted that not all graphics controllers or terminals use display lists, and on many products they are optional. In the concept design and imaging application areas, display list processors have become quite popular, but in the data conversion and personal computing application areas, they have yet to gain a foothold. When offered, these functions generally require the use of a 16- or 32-bit microprocessor as a monitor for the display list function, especially very large display lists on the order of 2Mb to 4Mb, which have become popular. In addition, the host interface communications may entail one or more combinations of DMA, serial, or Local Area Network (Ethernet, MAP, X.25) protocol, further increasing the computational load on the display list processor. Control of a keyboard, mouse, light pen, data tablet, or even a local hard copy and disk storage device, is also carried out by this processor. In fact, many display list processors already utilize VLSI components for serial I/O, LAN, and peripheral controllers, as well as incorporating the latest high-density DRAMs. In the future, GSICs that incorporate graphics standards such as the computer graphics interface (CGI) portion of GKS will probably find a home in the display list processor part of a graphics system.

Graphics Processor

The second step is the graphics processor. A wide variety of functions can take place here, some of which are very dependent on the application and thus may not be used at all in certain graphics systems. The typical functions are:

- Transformation of display list data from world or application program coordinates to the two-dimensional display coordinate system, in preparation for transfer to the graphics image, or pixel, memory
- Generation of characters and/or vectors (including lines, circles, and arcs) and/or polygons based on display list data
- Bit block transfers (BITBLT) and raster operations (raster ops) such as rapid moves of groups of pixels
- Support for picking of graphics entities by the user
- Execution of simple two-dimensional clipping, rotation, and translation calculations on displayed graphical data
- Execution of more complex three-dimensional transformations on graphics entities based on interactive user input
- Control of hardware pan, zoom, scroll, and roam
- Control of local windowing of independent processes
- Calculation of algorithms for rendering of solid objects

This step is the first in the actual display process since it takes in application-generated data and transforms it into a displayable format corresponding to the layout of the display or pixel memory. This is also the location for rendering operations that are used to depict graphics entities as hidden line/hidden surface objects that enhance the realism of the viewed objects in terms of their surface texture and three-dimensional nature. The combination of rendering with three-dimensional transformations is also addressed in this logical process and is used in such areas as vehicle simulation, video effects, solid modeling, and mechanisms/kinematics. The complexity of this process is much greater than in any of the other functions, since it involves the generation of shaded images made up of large numbers of polygons, as well as the calculation of light sources and reflectivity values for all the objects displayed. Three-dimensional transformations of these objects further add to the computational complexity of the task.

In imaging application areas, this step in the block diagram would be called the image processor, and image enhancement and modification calculations would replace some of the vector and geometry-related operations carried out in a graphics environment. Actually this step could be skipped altogether in imaging applications since another input to the display and pixel memory step can come from direct video inputs that bypass both the display list and graphics/imaging processors and go directly into the raster image memory.

Display Memory Processor

The third step is the display memory processor. The functions carried out here are:

- Control and synchronization of the high-speed display, or pixel, memory with the graphics processor and the video processor
- Management of display memory buffering, when offered
- Management of the Z-buffer memory, when offered
- Read back of memory locations to the graphics processor
- Control of memory mapping for some imaging applications

In traditional graphics terminals this processor is usually called a frame buffer. It is the core of the graphics process and is memory intensive, especially in the imaging areas where the number of memory bits assigned to each displayed pixel on the graphics monitor can run between 24 and 48 bits. Another area of complexity is that of memory buffering; the typical display memory for all but the imaging applications is either single or double buffered, meaning that the equivalent of one or two planes of display memory are stored for every plane of viewable memory on the monitor. In imaging applications, two, four, or more buffers may be used. Z-buffer management refers to separate memory used in the display of hidden line or hidden surface objects.

Video Processor

The fourth step is the video processor. The functions carried out here are:

- Management of the color palette or look-up table that maps color assignments from the display memory to viewable pixel locations on the monitor

- Control and synchronization of the video circuitry that drives the monitor

- Control of the memory interface from the memory processor or frame buffer

- Management of hardware cursors and light pens

Not all systems offer look-up tables, but when offered these may be programmable or fixed. Look-up tables vary in complexity depending on the number of simultaneously displayable colors desired, the number of colors available to choose from for display, and the bandwidth of the monitor on the system. Video circuitry control and the memory interface control are necessary elements in all graphics systems. There is little difference among the various graphics applications regarding the video processor functions, although imaging applications generally have more complex look-up tables.

VLSI Application Areas

Table 1 presents a list of representative suppliers that offer GSIC products. The table also indicates what functional step of Figure 1 is addressed by each product.

As this table indicates, most of the merchant GSICs are aimed at the graphics processor step. Not all of the products are complete graphics processors, but many of them address specific functions such as rendering (Weitek's Tiling Engine), bit block transfers, raster ops (Pacific Mountain Research's BLT Chip), or two-dimensional polygon and vector generation (XTAR's GMP). In general, these products reduce the cost of a given level of performance, but do not increase the performance. For example, the Weitek product offers rendering speeds that are attained or exceeded in most current three-dimensional terminal offerings but at a fraction of the cost. In addition, soon to be announced terminal products will exceed the tiling engine performance by a factor of 10 or more but at a price at least ten times that of the board-level version of the tiling engine (the WTE7100). These newer terminal products will utilize captive GSIC products to accomplish the complex graphic/imaging display functions, which will advance the performance at a constant price in the high end of the graphics marketplace. So, despite the performance difference, merchant GSICs are available at a competitive level of price/performance.

Table 1

REPRESENTATIVE SUPPLIERS AND GRAPHICS SPECIFIC ICs

Company	Product	Functional Area*	Unit Price
Chips and Technologies	Enhanced Graphics CHIPSet	G.P.	$85.40 (Quantity 100)
Hitachi	HD63484	G.P.	$46.80 (Quantity 1,000)
Intel	82716VSDD	V.P.	$20.00 (Quantity 1,000)
Motorola	6845	G.P.	$5.00 (Quantity 1,000)
	68490	G.P.	N/A
National Semiconductor	DP8500	G.P.	N/A
	DP8512/15/16	V.P.	N/A
NEC	uPD7220A	G.P.	$130.00 (Quantity 100)
	uPD4126C	D.M VRAM	N/A
Pacific Mountain Research	PMR96016	G.P.-Raster Operations	$39.80 (Quantity 100)
Texas Instruments	TMS34061	V.P.	$35.50 (Quantity 100)
	TMS34070	V.P. Look-up Table	$24.00 (Quantity 100)
	TMS4161EV4	D.M.P.VRAM	$24.00 (Quantity 100)
Weitek	Tiling Engine	G.P. Solid Rendering	N/M*
XTAR	X1001/1002-GMP	G.P.	$325 (Quantity 100)

N/A = Not Available
N/M = Not Meaningful
G.P. = Graphics Processor
D.M.P. = Display Memory Processor
V.P. = Video Processor

*The Weitek chip set is only available in a board-level product incorporating other Weitek components.

Source: DATAQUEST
June 1986

The video processor and display memory areas are the others to be addressed by the merchant suppliers. The memory area is, of course, a natural one for the large merchant houses, but the video control area is a new one for them. Consistent with the products for the graphics processor step, these products offer lower-priced solutions at a level of performance equivalent to previous or current terminal offerings. One difference is that these products are appealing to both high- and low-end graphics systems vendors and are not likely to be addressed by captive design efforts.

ANALYSIS

Many functions in a graphics system lend themselves to VLSI implementations. The functional areas discussed in the previous section usually are separate circuit boards in traditional graphics systems and, in many cases, such as in the display memory area, are multiple boards. The attractiveness of VLSI is twofold to a graphics vendor: on the one hand, VLSI can significantly reduce both board count and complexity with the benefit of lower cost, lower power consumption, simpler board design, and better manufacturability and servicability; on the other hand, a vendor could maintain a given board count and increase performance per board.

A simple example of this would be the use of 256K DRAMs in place of 64K DRAMs on a memory board to either cut real estate requirements by a factor of four or increase the number of bits/board by a factor of four. A vendor's choice here is dictated by the market segment for the particular graphics product in question. The business graphics and process control segments, which are less performance sensitive than others, will rapidly move to merchant GSICs for all the functional areas of Figure 1, while performance-sensitive segments such as CAD/CAM, simulation, and imaging will move to merchant solutions only in the video processor and memory areas and rely on their own captive GSIC designs in the other areas. Of course, the high-performance vendors will continue to utilize other non-graphics VLSI products such as bit-slice, array processor, and signal processor devices and remain customers of the merchant suppliers.

The move to more and more GSIC devices in the graphics industry not only affects the user base because of better price/performance, but also has a dramatic effect on the vendors of graphics systems. These vendors will no longer be able to add significant value to graphics systems in areas where commodity GSICs exist; they will have to look to other, non-GSIC parts of the overall system to add value or accept steadily decreasing prices for their products. We have already seen the effect of these advances. In the personal computer graphics board market segment, virtually all of the products utilize either the NEC, Motorola, or Hitachi chip and produce screen resolution and performance equivalent to the traditional business graphics and process control terminals. More important in DATAQUEST's view is that the price of a PC XT plus graphics board and monitor is equal to the traditional terminal price exclusive of any CPU resources, and the PC solution can include both Digital Equipment's VT-100 and Tektronix's graphics emulation. This will result, we believe, in loss of business for the traditional, low-end terminal suppliers unless they can compete on a price basis with the PC board suppliers.

Moreover, as the graphics market matures, price/performance is becoming the crucial measure of a graphics system, and such price/performance is being measured in the context of an application solution. And, with the growing number of merchant and captive GSICs available, it is possible to produce low-cost products that are oriented to very specific application areas. Users will no longer pay a higher price for higher performance unless it can be used in their particular graphics application. For example, in a two-dimensional drafting application, the crucial performance metric is the two-dimensional vector drawing performance features of a given system. Offering advanced solid modeling features in such a system will not fetch a higher price than a simpler and less costly two-dimensional system that uses merchant GSICs to attain acceptable vector drawing rates. In addition, vendors that choose not to use GSICs when all or some of their competition do, will be at a significant cost disadvatage. This disadvantage could be as much as a factor of ten if one considers the cost of one GSIC chip versus a circuit board implementation using only discrete components.

For low-performance application areas, these off-the-shelf GSICs are providing acceptable performance for the users at lower prices than ever before and putting pressure on the traditional low-end terminal vendors to use the most current VLSI products or perish. In high-performance applications, graphics systems vendors with the most advanced captive GSIC design capability will be at a significant advantage not only from a technical but also from a business point of view.

(This newsletter is reprinted with the permission of DATAQUEST's Graphics Industry Service.)

Brand Parks
Lew Brentano

SUIS Code: Newsletters
1986-16

A LOOK AT THE TI CHIP SET FOR LOCAL AREA NETWORKS

BACKGROUND

In 1982, IBM contracted with Texas Instruments (TI) to develop a chip set to implement IBM's Token-Ring protocol for a local area network. These chips were intended to implement protocols supporting the majority of IBM's product line and to operate with twisted-pair wiring at speeds from 2 to 16 Megabits per second. The chip set was to conform to the IEEE 802.5 Token-Ring specification.

The IBM Token-Ring was designed as an open system architecture. The TI chip set will support IBM products but will also provide a standard interface for attaching computers, terminals, telecommunications equipment, and other information-processing equipment from other manufacturers. This compatibility is possible since the IBM Token-Ring network specifications are public and allow anyone who has the initiative to create the combination of circuit boards, software, and wiring that constitutes this LAN.

It was widely reported that TI had experienced dificulties in the development process. It was not until May 1984 that IBM announced its Token-Ring Network statement of direction, saying products would be in development for two to three years. The first products were unveiled in IBM's October 15, 1985 announcement. DATAQUEST understands that the long development cycle of the Token-Ring was due in part, but not in whole, to the delays experienced by Texas Instruments in the chip set development.

THE TMS380

The TMS380 chip set has significant implications for the LAN industry from the perspectives of semiconductor design and marketing impact. The issue of price per connection and cost improvements associated with increasing volume have been fundamental in the growth of the LAN market.

Design Characteristics

The TMS380 comprises five chips, which collectively include about 350,000 transistors. Of the five-chip set, three are metal oxide semiconductor (MOS) large scale integration (LSI) chips and two are bipolar medium scale integration (MSI) chips. The three MOS devices are 2.4-micron NMOS (N-channel MOS) using the single-level polysilicon manufacturing process, and the two bipolar chips are low-power Schottky transistor transistor logic (LSTTL). A total of 2.8 watts of power is consumed by the five-chip set. Two of the three MOS devices use 48 dual in-line pin (DIP) packaging, and the two bipolar chips use 20 and 22 DIP packaging. The remaining MOS chip has a 100-pin grid array (PGA) and connects directly to the system bus.

Marketing Impact

The IBM Token-Ring Network was one of the most anticipated announcements of strategic direction of this decade. Although the affected industries were aware of many of the characteristics of the product prior to the announcement, the act of unveiling the specifics of a general-purpose local area network from the world's most successful computer manufacturer has had wide-ranging consequences. Competitive LAN vendors with advance knowledge of the IBM Token-Ring announced similar and/or compatible products simultaneously with the IBM announcement. These companies purchased early Token-Ring chip sets and development kits from Texas Instruments, after signing a non-disclosure agreement with IBM.

Potential LAN customers are expected to stop postponing their buying decisions in anticipation of IBM's direction, and they may or may not opt for the competition. Telecommunications companies are concerned about the Token-Ring's compatibility with voice and data PBXs, as well as its competitive effects on their own proprietary networking schemes. Semiconductor companies will benefit from contracts for manufacturing interfaces from other popular networks to the Token-Ring, as well as second-sourcing the Texas Instruments TMS380.

IBM allowed TI to provide the Token-Ring chip set to companies such as 3Com and Bridge for development purposes before the Token-Ring was announced. This would allow the necessary development of compatible interfaces to take place by the time of IBM's announcement and would increase the Token-Ring's chances of becoming an industry standard, general-purpose network. DATAQUEST believes that IBM will develop interfaces only for IBM products, while supporting these other companies in their development of interfaces to connect equipment from other vendors. At the time of the October 15, 1986, announcement, Texas Instruments indicated it was working with more than 25 vendors using the chip set to develop products for the Token-Ring.

An unexpected revelation was that IBM uses its own chips in manufacturing the PC adapter card, even though IBM had jointly developed the TMS380 with TI. Although the two separate chip sets are functionally compatible, a variety of technologies is used (such as gate arrays in the IBM chip set), disallowing any interposing of the two chip sets. DATAQUEST understands that IBM is developing a second source for the chip set, and is not buying chips from Texas Instruments.

Network Management Capabilities

IBM and TI have incorporated a number of embedded chip features within the TMS380 design, which may prove difficult for other chip manufacturers to duplicate. These features relate to network management services and what both companies are calling reliability, availability, and serviceability (RAS).

The key features included within the TMS380 for network management services are:

- Transferral of fast data bursts by the dual-bus system interface chip
- Capabilities for alleviating throughput problems
- Network management superset of the IEEE's network-messaging protocols
- Addressing of network performance information to designated Token-Ring management stations
- Self-test diagnostics
- Expansion capabilities for off-loading the processing of higher-level network protocols from the host

Due to implementing these on-chip features that minimize delay time on the network, IBM may decide to add further network control capabilities through medium-access-control (MAC) frames. MAC frames are network-management messages circulating on the Token-Ring between the attached computer systems. The basic TMS380 chip set will handle the MAC frames at the data link layer (Layer 2 of the Open Systems Interconnect model). The Token-Ring adds 21 new MAC frames to the 6 already included in the IEEE 802.5 specifications for medium-access-control. These additions are expected to be included in the IEEE 802.5 standard for Token-Rings.

The RAS implementation came about as a result of software code integration in read-only memory (ROM) and features in the hardware. This capability is not confined to any one chip, but resident throughout the five-chip set.

Availability/Pricing

TI offers a Design-In Accelerator set for customers designing their own interface boards. The set includes three chip sets, software EPROMs (erasable, programmable ROMs), an adapter bring-up guide, a user's guide, and admission to a three-day regional workshop hosted by TI. The current price for the set is $1,985. Potential customers are also being offered development boards for their evaluations of the chips and the embedded networking services.

Pricing for OEM orders of the TMS380, in quantities of 50,000 or greater, will be $125 during the second half of 1986. TI anticipates a 20 percent to 30 percent per-year price decline through 1989, resulting in a price of less than $50 by the end of the decade. This price decrease is attributed to conversion of component design from ceramic to plastic in late 1986 and early 1987; combining of certain chips within the chip set; design process change from MOS to CMOS; eventual, wide-spread availability of 1MB DRAMs; and manufacturing cost reductions associated with the classical learning curve of semiconductor manufacture.

THE LAN CHIP MARKETPLACE

The LAN chip market is divided into two areas--custom device designs and standard device designs. These two design approaches have helped lower the price of interfacing or connecting devices to local area networks, while improving the overall performance of network operations. Growth of local area networks has not matched the expectations of the industry for two reasons:

- Their high price
- The delayed IBM Token-Ring Network

The expense of early standard and custom chip designs, which were produced in quantities commensurate with market demand, did not allow the cost/price economies that could be realized through large-volume production. A "chicken and egg" quandry was apparent. The acceptance of LANs hinges on the lowering of the costs for network interface, and yet lower interface costs are dependent on the growth of the total network users.

The second limiting factor was the delayed announcement of IBM's Token-Ring Network. Both vendors and potential users were hesitant to move ahead in the LAN marketplace until IBM revealed the nature and characteristics of its Token-Ring.

Standard Chip Manufacturers

Semiconductor manufacturers have been supplying standard devices to LAN interface board builders for a number of years. These manufacturers and their devices are shown in Table 1.

Table 1

STANDARD CHIP DESIGNS

Manufacturer	Standard Chip Devices
Intel	82588 Starlan, 82586 LAN controller
Motorola	68590 Ethernet LAN controller
Mostek	MK68590
Advanced Micro Devices (AMD)	Lance 7990
National Semiconductor	DP8392, 8391, 8390
Rockwell International	R68802 LAN controller

Source: DATAQUEST
April 1986

Custom Chip Manufacturers

A variety of semiconductor manufacturers and equipment/network manufacturers have jointly developed custom LAN interface devices. These manufacturers and their devices are shown in Table 2.

Table 2

CUSTOM CHIP DESIGNS

Manufacturer	Custom Devices
IBM/Sytek	Custom design for Local Net
Texas Instruments (TI)	TMS380 developed for IBM Token-Ring
Standard Microsystems	Arcnet LAN controller chip for Datapoint Corporation
SEEQ Technology Inc.	DQ8001 Controller, DQ8023 Manchester encoder/decoder designed for 3Com Corporation
Fujitsu Microelectronics	Chips custom designed for use in Ungermann-Bass LAN Interface units
NEC	Omninet LAN controller chip for Corvus Systems Inc.

Source: DATAQUEST
April 1986

DATAQUEST ANALYSIS

DATAQUEST believes that IBM's announcement of the Token-Ring legitimizes the LAN as the technology of choice for intraoffice communications. The Token-Ring will still have to compete with Ethernet LANs for the overall share of the LAN business, but we can expect a heated contest. The Token-Ring's ability to operate over standard (unshielded) twisted-pair telephone wiring provides a market advantage for this type of network, although the applications for the unshielded wire are very limited and most sites will use the shielded wire more extensively.

We also believe that the TMS380 affects the PC network market due to IBM's dominance in the computer industry, which positions the Token-Ring as a de facto standard, the option of NETBIOS or APPC operating systems, and the on-chip superset of network management services. In addition to PC networks, these chips will be incorporated within minicomputers, CAE and CAD workstations, and peripheral products. In short, the Token-Ring chip set may prove to be the catalyst the world of computer networking has needed to realize its full potential.

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Brand A. Parks
Kent L. Nutt

SUIS Code: Newsletters
1986-15

MITI OFFERS PROPOSAL TO AVOID DUMPING PENALTIES

SUMMARY

Japan's Ministry of International Trade and Industry (MITI) has proposed a semiconductor monitoring system in an effort to avoid the implementation of dumping penalties on Japanese DRAMs and EPROMs. The MITI proposal was published in a prominent Japanese industrial journal, Nihon Keizai, as a "trial balloon" to elicit an official U.S. response. MITI has used this procedure in the past to test public and industry reaction to policies that were later made official. The new proposal includes the following:

- A demand-supply guidepost system to curb overproduction and stabilize prices
- A lowest-export-price system (price floor) to prevent below-cost sales (dumping)
- A uniform minimum price system to prevent circuitous exports to the United States or elsewhere through third countries (Europe and Asia)

Under the new system, similar to MITI's control of Japanese iron and steel production, a select committee will announce a quarterly semiconductor demand-supply outlook. If production plans exceed consumption forecasts, MITI will request Japanese vendors to reduce their production plans. Both the Japanese and U.S. governments will negotiate fully loaded production costs to determine price curves.

DATAQUEST ANALYSIS

The main reason for MITI's proposal can be seen in Table 1. In addition to the dumping penalties, the current dollar/yen exchange rate compounds export difficulties and will continue to be a problem regardless of any decision about dumping penalties. For this reason, MITI believes that dumping penalties are adding insult to injury.

Table 1

COMPOUND EFFECT OF DUMPING PENALTIES AND EXCHANGE RATE

Japanese Device	Penalty Status	Average Penalty %	Current $/Yen Difference	Total Penalty
64K DRAM	Final	20.75%	30.80%	51.55%
256K DRAM	Preliminary	40.00%	30.80%	70.80%
All EPROMs	Preliminary	63.10%	30.80%	93.90%

Note: See the SUIS newsletter number 1986-8 for individual company percentages.

Source: DATAQUEST
May 1986

MITI's new proposal is a reaction to strong pressure from Japanese semiconductor manufacturers that want to eliminate dumping penalties and improve U.S.-Japanese trade relations. It is also an effort by MITI to reassert its influence over the Japanese semiconductor industry. The key points of this proposal are:

- The end of a free market in commodity semiconductors
- A short-term rise in prices for Japanese commodity semiconductors and a more stable long-term price-reduction schedule
- The elimination of dumping charges and penalties
- Governmental negotiation of fully loaded production costs

It is important to note that South Korean semiconductors and Japanese ASICs are not included in this proposal. The ASIC marketplace is expected to become the next price battlefield soon. In response to that expectation, many ASIC companies are now absorbing their nonrecurring expenses to remain competitive.

The proposal would allow both governments to walk away from the issue without giving up any concessions or losing face. Any effects on prices will be attributed to a nonpolitical area--the dollar/yen exchange rate. Although the proposal is not policy yet, it will be interesting to see whether U.S. or Korean manufacturers will choose to follow the MITI pricing guidelines or to gain market share by setting prices below the agreed-upon rate.

It is the semiconductor user who will likely pay the bill for the market tampering done by the U.S. and Japanese governments. In return for relatively higher prices, they promise stability in the historically volatile commodity semiconductor market.

Mark Giudici

SUIS Code: Newsletters
1986-14

THE QUICK ASIC: TOMORROW'S PROTOTYPING TOOL

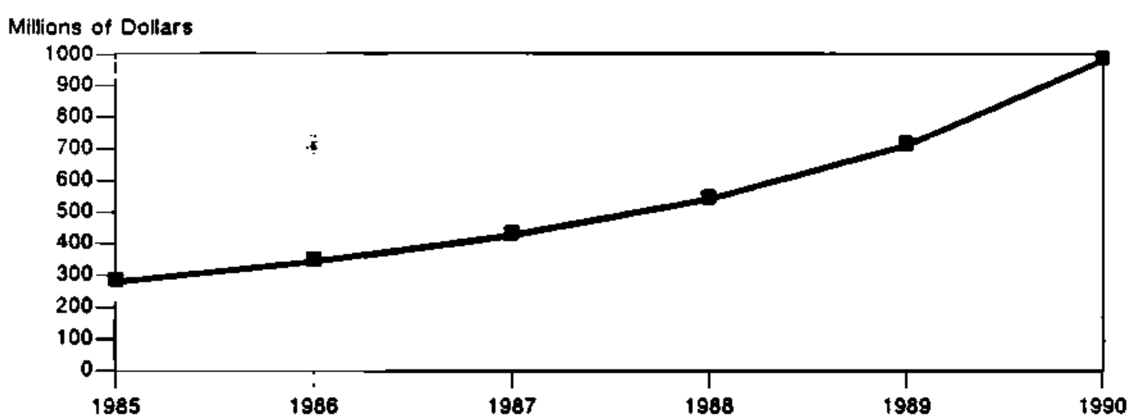
STRESS REDUCTION MEDICINE

If a thousand design engineers were asked about the cause of their anxiety and sleepless nights, they would unanimously respond, "Waiting for the prototype parts to arrive from the application-specific integrated circuit (ASIC) supplier." After months of work on a design, they wait anxiously for the first parts and hope that there are no errors. While today's electronic design automation (EDA) tools have eliminated a major portion of the errors in the design process, they cannot give advance warning of a missing logic element, or a change in the system requirements, or, even worse, the fact that the manufacturer is missing a market window.

Fortunately, this problem has not gone unnoticed. DATAQUEST believes that as the ASIC design methodologies expand into wider applications, there will be a very strong emphasis on reducing the ASIC design time and the prototype turnaround time; furthermore, there will be a group of suppliers that will bring their resources to bear on this problem. Figure 1 shows our estimate of this market and its robust growth from 1985 through 1990.

Figure 1

ESTIMATED WORLDWIDE CONSUMPTION OF QUICK ASIC



Source: DATAQUEST
May 1986

This newsletter reviews a number of very different and creative technologies that could play a critical role in quick turnaround ASIC or, as we call it, Quick ASIC. Our definition of Quick ASIC is that the cycle time is less than two weeks from the time a verified logic schematic is submitted to the ASIC supplier to the time the prototype parts are returned. We will briefly examine three very different methods:

- Programmable logic devices (PLDs)
- Direct-write E-Beam systems
- Late-mask laser processing systems

Each method has its followers and each offers a very different way to get Quick ASIC. But, regardless of which approach wins, we believe that it will significantly alter both the entire ASIC market and the printed circuit market, and that it will ultimately precipitate a decline in the consumption of standard SSI and MSI logic for breadboarding.

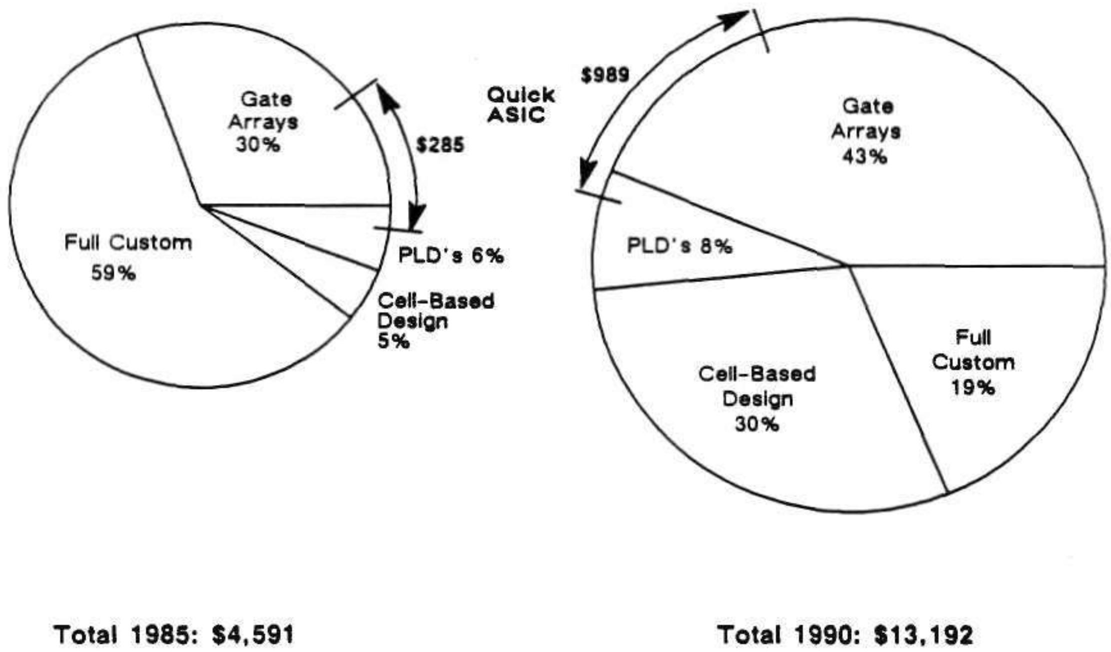
QUICK ASIC--A NEW WAY TO LOOK AT THE MARKET

The total ASIC market can be segmented into two major groups. The first group is composed of PLDs and gate arrays, and the second group is composed of cell-based and full custom designs. Both groups continually strive to reduce turnaround time for a design, but the first group offers the quickest prototype parts, largely because it tailors the fabrication process to the quickest turnaround. In the case of PLDs, the customer customizes the chip, while for gate arrays, the wafers are preprocessed up to the last two layers of metal and held in an unfinished inventory. When a supplier receives an order, the last two layers of metal are applied and the array is shipped. Therefore, both PLD and gate arrays can satisfy our definition of Quick ASIC. For the second group, the preprocessing of the wafer is not possible; thus, they are not considered candidates for our new definition of Quick ASIC.

A closer examination of PLDs and gate arrays (as shown in Figure 2) suggests that there is a growing potential subsegment to support quick-turnaround demand. This can be seen by looking at these markets in a new way, which shows that 6 percent of all ASICs in 1985 were Quick ASIC. Research through our data bases shows that as much as 5 percent of the 1985 PLD revenue and 27 percent of the gate array revenue was devoted to prototypes. In the case of gate arrays, the vast majority of the non-recurring engineering (NRE) charges can really be called Quick ASIC. We also believe that, as the overall ASIC market continues to grow, the Quick ASIC segment will grow to 7.5 percent of the total ASIC market by 1990. While market share appears to only gain a few percentage points, it is important to note that in 1985 this subsegment was $285 million, and that by 1990 it is expected to become a $989 million market.

Figure 2

ESTIMATED SUBSEGMENTATION OF QUICK ASIC
(Millions of Dollars)



Source: DATAQUEST
May 1986

PLDs--The Original Quick ASIC

While most PLDs are not used for prototyping, they have in the past six years frequently appeared on the designer's breadboard as a way to make those vital last minute changes. We estimate that in 1985 about $15 million of the total PLD consumption was used in prototype applications. But the future possibilities for the quick turn arena are even more interesting. Recently, a proliferation of new processes have been applied in this market. For example, some young, aggressive companies such as Altera, Cypress, and Lattice have introduced CMOS products using UV or EE technology, and some larger companies, such as Monolithic Memories, Intel, AMD, and Signetics are expected to announce a host of parts in 1986. These new products have a much wider appeal than just prototypes. In fact, the vast majority of the current PLD consumption goes into production applications rather than prototypes; but as the total PLD market grows, so will the Quick ASIC share.

While critics say PLDs have a relatively rigid architecture compared to gate arrays, we have found a remarkable diversity in types of configurations offered and we expect this to continue. A growing cadre of designers have recognized this diversity. For example, Altera offers a family of products that have a degree of freedom far beyond that of the parts available in the early 1980s. Xilinix, a Silicon Valley start-up, offers the ultimate in swift-configured logic. In the logic cell array, as it is called, the interconnect of the logic can be reconfigured by loading interconnect patterns from a static RAM in less than 12 milliseconds; thus, the logic can be changed under program control even after the part is installed.

Part of the PLD growth is due to two important factors. First, PLDs can be manufactured like any other standard product, thus reaping all the benefits of economies of scale in semiconductor manufacturing. The second factor can be traced to the emergence of low-cost EDA tools. But perhaps the real advantage of PDL is that the user can customize a product rather than having the supplier do it; it is this freedom that continues to attract users.

Quick Gate Arrays

There is a small group of gate array suppliers that see a window of opportunity in expediting prototype parts for their customers. In Japan, for example, many of the large, vertically integrated consumer electronic companies such as Casio, Citizen, Pioneer, Ricoh, Seiko, and Yamaha process prototypes in less than two weeks. While these arrays are relatively low in gate count--less than 500 gates--it does show that there is a strong demand for rapid prototypes in certain applications. In North America, several companies are rushing to streamline their process flows to less than four weeks. Orbit Semiconductor (formerly Comdial) and California Devices deliver both 2- and 3-micron CMOS engineering prototypes in 15 working days. While most users are willing to wait longer for the more complex arrays (i.e., greater than 8,000 gates), we believe that there is latent demand for even faster prototypes, which will ultimately affect the high gate count arrays, too.

DATAQUEST believes that this growing demand will stimulate the creative use of two emerging technologies:

- Direct-write E-Beam lithography
- Late-mask laser processing

We think this may ultimately cause a segmentation of the gate array market into a Quick ASIC and a production ASIC market.

Direct-Write E-Beam Systems

To understand the role of direct-write E-Beam technology in ASIC, we must look at its origins at IBM. Direct-write E-Beam has been used in producing low-volume, fast-turn ASIC devices for more than ten years. More recently, the merchant ASIC companies, which also must manufacture low volumes of ICs with fast turnarounds, are beginning to purchase direct-write tools. Direct-write provides a faster turnaround than optical lithography because the mask fabrication is not necessary, which also eliminates the cost of the mask set. Thus, DATAQUEST believes that E-Beam lithography will find major use in low-volume ASIC production and fast-turn prototyping.

Table 1 shows the total worldwide installed base of direct-write systems by manufacturers through 1985. It is important to understand that as many as 50 of these systems are used in ASIC applications and that most of those systems are used in captive semiconductor operations. Nevertheless, we expect the merchant segment to grow significantly. DATAQUEST has identified three companies in this merchant segment that have made an early start in using direct-write E-Beam technology to do Quick ASIC.

Table 1

TOTAL WORLDWIDE INSTALLED BASE BY MANUFACTURER OF DIRECT-WRITE E-BEAM SYSTEMS THROUGH 1985

Manufacturer	Units
AT&T	1
Cambridge Instruments	43
Electron Beam Microfabrication*	6
Hewlett-Packard	3
Hitachi	9
IBM	35
Jeol	73
Philips	7
Texas Instruments	6
Carl Zeiss (Jena)	5
Others	10
Total Systems	198

*Includes units built by Radiant Energy Systems

Source: DATAQUEST
May 1986

Fairchild Camera and Instrument

The gate array division, located in Milpitas, California, has installed a Cambridge Instrument Model EBMF 10.5 with a pattern-writing speed greater than one million shapes per hour. The system will be used to customize Fairchild's 2-micron 500 to 6,000 gate CMOS gate array family. The company expects to deliver prototype parts in less than two weeks and special orders within a matter of days.

Qudos Ltd.

This U.K.-based firm, located in Cambridge Science Park, plans to offer low-cost design software to drive an E-Beam system. The company will first offer single-layer metalization, followed later by multilayer technology.

European Silicon Structures (ESS)

ESS is believed to be the best-financed ASIC start-up in Europe, with approximately $65 million in venture capital. ESS plans to offer a two-week turnaround, using a 2-micron double-metal CMOS process, followed in early 1987 with a 1.25-micron CMOS technology. ESS also plans to use silicon compilation tools developed by Lattice Logic, along with Perkin-Elmer's new AEBLE E-Beam system.

Late-Mask Laser Processing Systems

One of the most interesting technologies that could impact Quick ASIC is the laser. Here we have identified three major efforts to use laser processing for gate arrays: two are start-up companies and the third is a research laboratory based in Livermore, California.

Lasarray Corporation

Lasarray Corporation manufactures turnkey design and manufacturing systems, optimized for Quick ASIC. The heart of its system is a direct-write laser beam pattern generator using two lasers--one helium-cadmium and the other helium-neon--which customize the wafer using positive resist exposure. The laser control has been designed to accommodate wafer-sharing of up to four different designs.

All this is done in a compact module made up of three clean rooms with all the processing equipment required to apply photoresist, etch away metal, and then deposit and etch nitride passivation using plasma technology. The initial arrays will be double-layer metal, using a 2-micron CMOS process with gate counts ranging from 600 to 3,200 gates.

The module also includes complete assembly capability as well as test equipment for engineering analysis. All EDA tools are based on a silicon compiler developed by Lattice Logic, which includes an interface to a test system capable of performing both functional and parametric testing.

The total cost of the system is less than the investment required for one E-Beam system. The Lasarray concept is believed to have a throughput rate of 48 designs per 36-hour period by using wafer sharing.

It is interesting to note that Lasarray was jointly funded for $10 million by its parent company, Fela, and by a private Swiss equity venture that has evolved from the parent company. Fela is a well-known European supplier of low-volume, multilayer, printed circuit boards (PCBs), and chip-on-board technology. Fela believes that this technology will ultimately impact the low-volume PCB market, and it is positioning Lasarray in order to strengthen Fela's position in the marketplace. Thus, both parent and subsidiary see this venture as an opportunity to vertically integrate into a new market. To address the Quick ASIC market, Lasarray has formed two companies--Lasarray SA, which is financed in Europe to service that market, and Lasarray Corporation, which will be based in California and is presently going through its financial formation.

Laserpath--The One-Day Gate Array Company

Laserpath sees its role as a very-quick-turnaround gate array supplier that specializes in prototype quantities. Laserpath just announced a production partnership with GE Semiconductor and expects to announce similar arrangements with other major semiconductor suppliers before the end of the year. GE will pay Laserpath more than $2 million for non-exclusive production rights to the Laserpath gate array family and will offer the family in the merchant market as well as in its various system divisions.

Initially, Laserpath is offering both single-layer and double-layer metal gate arrays ranging from 880 to 3,200 gates. Larger arrays will be released near the end of 1986. The company uses pre-processed 2- and 3-micron CMOS wafers and customization is done by a yttrium-aluminum-garnet infrared laser that is used to etch away metal traces on each die. The laser programming is done on packaged parts; this eliminates overbuilding of inventory, a chronic problem found in most small lot orders.

Laserpath has been developing the technology for nearly three years and has received $8.25 million in funding. The company is ahead of plan and still has $2 million in its coffer. While the concept at the outset appears to be a challenging technological feat, we believe that Laserpath has perfected the concept and is now ready to take orders.

Lawrence Livermore National Laboratory

Under a contract funded by the U.S. Navy and the U.S. Department of Energy, the Livermore Laboratory is developing laser-pantography technology that uses a laser-stimulated chemical vapor deposition process to write lines of metal or polysilicon interconnection on gate array wafers.

Laser pantography is typically done in a small chamber only slightly larger than the wafer itself. The laser passes through a fixed-quartz window on the top of the chamber with orifices on the sides introducing gas.

While this technology will not be commercially available until the next decade, it does suggest that desk-top wafer processing for small very-fast-turnaround ASIC chips could become a reality in the early 1990s.

WHAT DOES ALL THIS MEAN?

When one stands back and contemplates the significance of all this activity, some interesting trends emerge:

- A strong interest in Quick ASIC
- Unbundling of NRE

- A wide variety of technologies
- Less demand for PCBs

Each of these trends is significant, but together they mean that tomorrow's prototyping will look very different from today's.

Strong Interest in Quick ASIC

First and foremost, Quick ASIC is not a passing fad. Users of custom products will continue to demand quick turnaround and are willing to devote a significant share of their research and development budgets to getting a system design done quickly. At the outset, these users are willing to pay a premium for Quick ASIC but, as the market matures, we expect a sharp decline in NRE charges. We expect these charges ultimately to be less than what is currently charged today for conventional turnaround times. This price erosion is expected as early as 1987; by 1988, NRE charges could be 20 percent below today's rates.

Unbundled NRE

As Quick ASIC gains a significant share of the total ASIC market, users will want to see what they are paying for, which means that ASIC suppliers will be asked to itemize NRE charges and production charges. This is a natural outcome since some suppliers will concentrate on prototypes, while others will support production orders. From the user's point of view, this is also more acceptable, since often the funding of a ASIC project comes from two distinct sources: the engineering team controls the development funding and corporate production controls the production orders. This also implies that the prototype supplier and the foundry that does the manufacturing must form alliances to ensure proven designs flow smoothly from prototypes to production.

A Wide Variety of Technologies

DATAQUEST believes that we are entering a period where a variety of technologies will be used for attaining Quick ASIC. Our Semiconductor Equipment and Materials Service has noted a sharp increase in capital expenditures devoted to the development of fast-turnaround, small-production lots, and we expect some of this equipment to be used to supply fast prototypes. The key driving force is cost, which is directly related to throughput. The Quick ASIC suppliers that can produce prototype parts the fastest with the lowest capital investment will ultimately win out. What is certain is that this segment will get a great deal of attention from equipment makers, ASIC suppliers, and semiconductor users.

Less Demand for PCBs

Today, hundreds of PCB manufacturers make their livings supplying low-volume PCBs for breadboarding. These suppliers will experience a major change in their business as their customers start using gate arrays or PLDs instead of standard SSI/MSI logic. In the long term, the number of PCBs required to support the breadboarding will decline as more and more of the system integrates onto fewer ASICs. These PCB suppliers will also have to adjust to the proliferation of package configurations used in gate arrays and the very-short-turnaround times required.

Perhaps in the long term Quick ASIC will be the only way to get a custom chip, and the design engineers and their companies will be able to get a product out with a little less anxiety and stress.

Brand A. Parks
Andrew M. Prophet

SUIS Code: Newsletters
1986-13

EUROPEAN FAST STATIC RAM PRICING SURVEY (CMOS)

DATAQUEST estimates that in 1985 the worldwide fast static RAM market was US$360 million. Of this total, Europe's share was almost 14 percent or US$50 million. The fast static RAM marketplace has been attracting an increasing number of manufacturers because of its steady growth and relative stability. This newsletter reports on the status of the market pricing. Inputs for 1K and 10K quantities for the week beginning 1 March 1986 were received from seven manufacturers. The results of our survey are shown in Table 1.

PRICING TODAY

At the 16K static RAM 10K level, the results indicated:

- The more than 60 percent premium for the 45ns part versus the 55ns part clearly demonstrates the added value attributed to the lower-yielding variants.

- Surprisingly, a much smaller premium was asked for when comparing 36ns and 25ns parts with 45ns parts. In the case of the 16Kx1, the price of the 35ns part averaged 12.5 percent above the 25ns, and in the 4Kx4, the 35ns commanded a 3 percent premium over the 45ns part.

- The 2Kx8 and 4Kx4 organizations were priced at 28 percent and 17 percent, respectively, above the 16Kx1 (using the 45ns part as a reference).

- A wide pricing spread between high and low bids was apparent especially at the high speeds. The highest bid received for the standard 16Kx1 (55ns) was 33 percent higher than the lowest. In the case of the 4Kx4 (25ns), the top bid was more than three times the lowest bid.

The 64K analysis was limited because only a few inputs were received for 16x4 configurations and 64x1 devices faster than 45ns.

- The 64Kx1 (55ns) was a factor of 3.88 times more expensive than the 16Kx1 (55ns). Despite this, DATAQUEST believes that the pressure for users to obtain a lower cost per bit by upgrading is not nearly as intense as in the DRAM marketplace, where a factor of better than five times has to be achieved before users will upgrade to the higher-density device.

- Although a low number of bids was received for 64K parts, almost all the manufacturers will be releasing new 64K parts throughout 1986. The Japanese manufacturers are being especially prolific, e.g., Fujitsu intends to introduce seven parts and Toshiba, five.

PRICING TRENDS

Manufacturers report that a number of factors are influencing pricing, as follows:

- The 1985 backlash--The more popular parts--notably the 16x1--were overinventoried in 1985 and the price fell correspondingly. The prices are now stabilizing as demand comes into alignment with supply.

- More participants--The marketplace is becoming more and more crowded as the established producers--AMD, Fujitsu, Hitachi, Inmos, Intel, Mitsubishi, NEC, and Toshiba--are joined by new start-ups or new programs in established producers. Among the new companies are Alliance Semiconductor, Cypress, IDT, Lattice Semiconductor, Mosel (a Taiwanese company), Triad (a new start-up out of Inmos Corporation), Visic, Vitelic, VLSI Technology, and via licensing arrangements NMB Semiconductor, Seiko, Sharp, and Sony. This increased participation will probably accelerate the price erosion in the marketplace.

- Demand for more complex, faster parts--Manufacturers operating at the leading edge of the technology are managing to improve their total kit price by offsetting price reductions in the more mature parts against the premiums obtained for products such as very high-speed devices (25ns), special feature parts, dual port RAMs, or RAMs with separate I/Os.

DATAQUEST ANALYSIS

The overriding impression we received from our survey was that the fast static RAM marketplace is much more stable than its DRAM counterpart. Cost/performance improvement is being obtained through improvements in system architecture and design rather than by the addition of bulk memory. The market is also more niche oriented; i.e., product differentiation, ingenuity in design, and market identification play important roles in outpointing the competition. Consequently, many manufacturers are finding it a marketplace where margins can be made and sustained.

Mark Giudici
Jim Beveridge

Table 1

16K/64K FAST STATIC RAM (CMOS) PRICING
(In U.S. Dollars)

	2Kx8 45ns		16Kx1 55ns		16Kx1 45ns		16Kx1 35ns		4Kx4 55ns	
	1K	10K	1K	10K	1K	10K	1K	10K	1K	10K
High	10.21	8.99	4.59	3.79	6.58	6.29	13.14	7.35	5.75	4.39
Low	5.99	4.98	3.15	2.86	3.29	3.00	5.72	4.29	3.43	3.07
Median	8.11	6.99	4.11	3.34	6.44	5.46	8.65	6.15	4.81	3.94

	4Kx4 45ns		4Kx4 45ns		4Kx4 25ns		64Kx1 55ns		64Kx1 45ns	
	1K	10K	1K	10K	1K	10K	1K	10K	1K	10K
High	12.25	11.02	9.30	7.35	15.96	12.14	22.98	17.46	28.08	21.35
Low	3.50	3.15	3.72	3.58	3.93	3.72	11.44	10.01	12.87	11.44
Median	7.36	6.38	7.51	6.56	8.54	6.95	16.23	12.97	20.19	17.45

Source: DATAQUEST
May 1986

SUIS Code: Newsletters
1986-12

FINAL 64K DRAM DUMPING PENALTY DECISION AND YOU

The U.S. Department of Commerce made its final decision on the dumping penalties for 64K DRAMs on April 24, 1986. The dumping penalties listed in Table 1 will become effective June 2, pending a final ITC decision. Until that date, the preliminary penalties apply to all affected shipments--please refer to our SUIS April 15 Research Bulletin, "Semiconductor Dumping: What Is and What Is Not Affected."

Table 1

64K DRAM FINAL DUMPING PENALTY PERCENTAGES

Companies Affected	Preliminary Percentage	Final Percentage	Percentage Difference
Hitachi	18.49%	11.87%	(6.62%)
Mitsubishi	94.00%	13.43%	(80.57%)
Oki	12.52%	35.34%	22.82%
NEC	8.93%	22.76%	13.83%
All Others	38.83%	20.75%	(18.08%)

Source: DATAQUEST
April 1986

If the ITC decides that the U.S. 64K DRAM industry has been injured, the overall prices for 64K DRAMs initially will rise in response to the ruling adjustments and the widening yen/dollar exchange ratio. Prices are then expected to flatten gradually as the 64K DRAM product matures in its life cycle. The moderation evidenced in the above final penalty determination is also expected in the upcoming final decisions scheduled for 256K DRAMs (August 1) and all EPROMs (July 30). The overall reduction in penalties is a result of improved data inputs and revised cost formulas.

This moderation will temper EPROM and 256K DRAM prices from the price hike reaction to the preliminary decisions made in mid-March. This downward pressure in prices will go against a 30 percent appreciation of the yen to the dollar since the first investigations were made, and will result in a temporary price rise through the third quarter of this year for EPROMs and 256K DRAMs. However, as costs continue to decline and the exchange rate stabilizes, prices for Japanese parts will start to go down again by the fourth quarter of this year.

Mark Giudici

SEMICONDUCTOR DUMPING: WHAT IS AND IS NOT AFFECTED

The U.S. Department of Commerce's preliminary semiconductor dumping rulings (64K DRAM--December 11, 1985, EPROM--March 13, 1986, and 256K/1Mb DRAM--March 19, 1986) are markedly affecting all the companies involved with these parts. (Please see the SUIS newsletter "Semiconductor Prices and Dumping: Who Pays the Bill?" published March 28, 1986.) This Research Bulletin discusses what is and what is not covered by the current dumping penalties for each device type affected.

ITEMS COVERED BY THE DUMPING RULING

The following items are covered by the dumping ruling:

- 64K DRAM--Individual parts completely fabricated, assembled, and tested in Japan and shipped to the United States as finished goods are subject to the penalty.
- 256K/1Mb DRAM--Finished parts, die, and wafers imported to the United States from Japan are subject to the penalty, which is based on the declared value of the parts, die, and/or wafers when entering U.S. customs. 1Mb DRAMs are subject to the same penalty by company as 256K DRAMs.
- All EPROMs--All stages of manufacture of Japanese-fabricated EPROMs are subject to penalty regardless of where they are assembled or tested.

All of the above completely finished Japanese parts purchased in Japan or outside of Japan by a U.S. company and shipped directly to the United States as individual devices are subject to the penalty, which is payable by the importing party.

ITEMS NOT COVERED BY THE DUMPING RULING

The following items are not covered by the dumping ruling:

- 64K DRAM--Japanese die, wafers, and finished parts assembled or tested outside of Japan are not subject to the penalty.

- 256K/1Mb DRAM--Japanese-fabricated die or wafers that are assembled or tested outside of Japan are not subject to the penalty.

- All EPROMs--All stages of manufacture of EPROMs are subject to the penalty.

The above finished parts are exempt from the dumping penalty if they are "substantially transformed" via non-Japanese assembly into PC boards, SIP memory modules, or complete systems prior to shipment into the United States. Products completely manufactured in the United States by Japanese companies (i.e., NEC Roseville) are exempt from duty penalty.

NEAR-TERM OUTLOOK

We anticipate that the final dumping percentages due out in May will be adjusted slightly downward, with some parts receiving higher penalties. We also expect the overall penalty percentage spread among companies to shrink. We believe that these things will happen because:

- Japanese companies will supply accurate manufacturing data, knowing that the U.S. government means business.

- The manufacturing cost formulas will be refined.

- Late cost data will be supplied that were not available at the time of the original study.

All major Japanese manufacturers foresee their ASPs rising in the wake of the Department of Commerce's decision. The price hikes are seen as a combination of dollar/yen adjustments and dumping charges passed on to the user. Most domestic suppliers are following this general trend by gradually raising their prices. Lead times are holding fairly steady across the board with some lengthening occurring for the higher-speed parts and surface-mount packages. The introduction of a 1Mb product will not be affected by the dumping penalties and is expected by most manufacturers to follow past DRAM experience curves.

LONG-TERM IMPLICATIONS

As mentioned in an earlier SUIS newsletter ("Prices and Stability Form Tentative Alliance," April 11, 1986), we expect near-term prices to rise, with price reductions in the higher-density DRAM and EPROM products resuming late this year. This string of decisions increases the attractiveness of offshore assembly and test and will probably accelerate this form of cost cutting. Long-term contracts should be made now for the 64K EPROM since this part is expected to continue gradually rising in price beyond fourth quarter 1986 as higher-density EPROMs become the industry standard.

Mark Giudici
Lane Mason

SUIS Code: Newsletters
1986-10

PRICES AND STABILITY FORM TENTATIVE ALLIANCE

Growing demand, dumping penalties, and the reduced value of the dollar all are affecting IC pricing. This newsletter summarizes the major highlights gleaned from the recently completed DATAQUEST Quarterly Price Survey (QPS).

SUMMARY

The semiconductor procurement sequence described in the SUIS April 4, 1986, User Update is currently flattening the steep price reductions experienced in 1985. Overall prices continue to drop slowly as experience curve cost savings materialize. The 74HC logic family is almost at price parity with the 74LS family except in the higher-density MSI/octal range. However, some mature standard logic prices are rising slowly as ASIC redesigns reduce volume, and DRAMs and EPROMs are registering short-term price rises/firming due to government-imposed dumping penalties. We expect these aberrations to be short lived as the affected product's costs come down the experience curve. (For more information on this subject, see the SUIS March 28, 1986, User Update, "Semiconductor Dumping and Prices: Who Pays the Bill?") We expect the 256K to 1Mb DRAM price-per-function lines to cross in late 1987 or early 1988. The increased value of the Japanese yen is subtly firming prices for all Japanese parts, and these price increases are being matched by U.S. manufacturers.

The contract prices shown in Table 1 summarize the major trends in this industry. These trends are further discussed in the Price Trends Notebook Update, which our clients will soon receive.

Application-specific integrated circuit (ASIC) price trends are projected for the first time, as these parts gain market acceptance. Figure 1 illustrates the 1986 price per gate (without packaging) by gate count relationship of the three major CMOS gate array technologies.

Between the two volume CMOS technologies (3 and 2 micron), the price-per-gate crossover point is 2,000 gates. As the more efficient 2-micron

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process comes down the experience curve, the gate count for this crossover point will continually decline. Due to the scarcity of volume manufacturers and its state-of-the-art nature, the 1.5-micron CMOS cost per gate currently commands a premium price. But, as the process matures, its speed and density attributes will become more affordable. The crossover point between the 1.5- and 2-micron processes is expected to occur beyond 1988.

DATAQUEST ANALYSIS

Negotiations of long-term contracts for 64K EPROMs should begin now. Prices for the more mature standard logic devices will continue to rise as shipment volumes decline. The near-term perturbations in DRAM and 256K and larger EPROM pricing will level off by year-end 1986 and should not be seen as a long-term trend. Prices and lead times for these parts will stabilize over the next six to nine months as market forces again reexert themselves. The future overall price declines expected require close communications/alliances between vendors and buyers in order to minimize the potential for allocations and lengthening lead times.

Mark Giudici

Table 1

SEMICONDUCTOR PRICE TRENDS

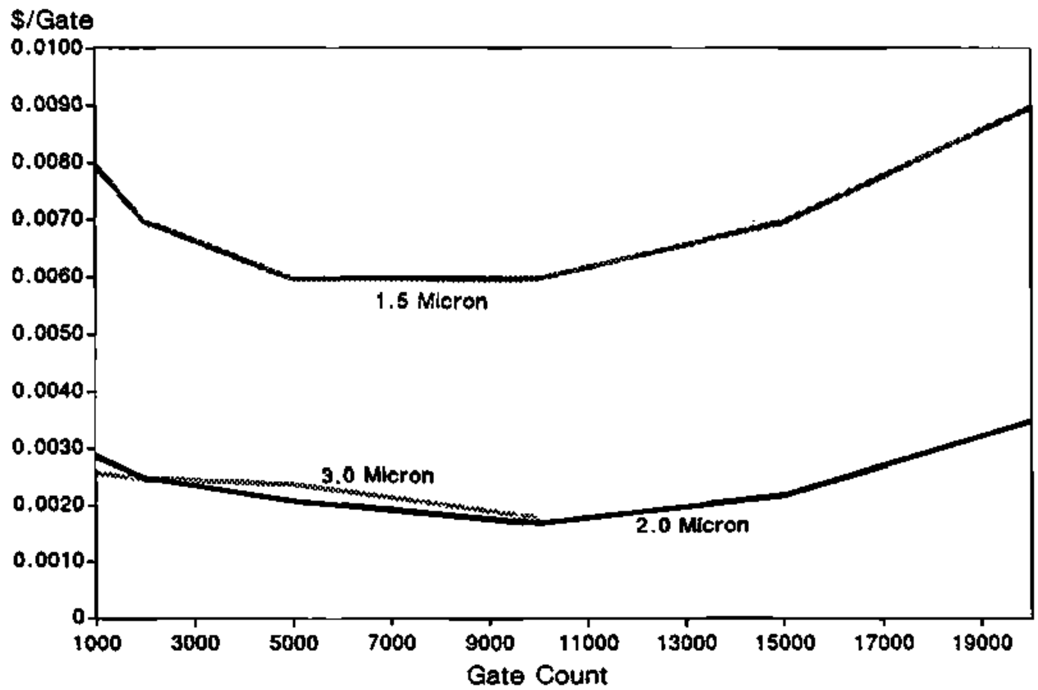
	Prices		
Device	Current	Year-End 1986*	Year-End 1987*
64K DRAM	$ 1.10	$ 1.15	$ 1.10
256K DRAM	$ 2.25	$ 2.15	$ 1.80
1Mb DRAM	$ 50.00	$18.50	$ 7.75
64K EPROM	$ 2.35	$ 2.50	$ 2.75
256K EPROM	$ 4.35	$ 3.85	$ 3.30
8088	$ 5.50	$ 5.10	$ 4.50
68008	$ 9.00	$ 9.00	$ 8.50
8086	$ 8.25	$ 7.50	$ 6.60
68000	$ 10.00	$ 8.00	$ 7.00
80186 8 MHz	$ 13.00	$11.00	$10.00
68020 16 MHz	$200.00	$95.00	$65.00
74LS74	$0.14-$0.17	$0.16-$0.22	$0.17-$0.23
74S74	$0.22-$0.29	$0.22-$0.30	$0.24-$0.30
74HC74	$0.15-$0.22	$0.18-$0.24	$0.19-$0.25
74AS74	$0.27-$0.33	$0.27-$0.33	$0.28-$0.35

*Estimated

Source: DATAQUEST
April 1986

Figure 1

1986 CMOS GATE ARRAY PRICE PER GATE



Source: DATAQUEST
April 1986

SEMICONDUCTOR INDUSTRY UPDATE: FIRST SIGNS OF SHORTAGES APPEAR

The 1986 semiconductor recovery has shifted into second gear. And as predicted in our September 16, 1985, "Industry Update" (Newsletter 1985-16), we are starting to see the first signs of strain, particularly in standard TTL logic products. In spite of the well-publicized excess capacity in the industry, we expect the next two years to unfold in much the same way as has occurred in past recoveries. The usual sequence of events is as follows:

1. Sensing increased business activity at their customer base, distributors start ordering to build inventory to support growing future demand.

2. This buildup threatens to consume the inventories of semiconductor manufacturers that have been conserving cash by holding down production and minimizing inventory.

3. Lead times lengthen, threatening some panic buying to assure adequate supply as products become harder to get.

4. Medium-size OEM customers enter the fray, adding their increasing demand for product--first to replenish depleted inventories, then to support growing production rates.

5. Finally, large computer and telecommunications companies begin buying again, adding to demand and driving the industry to a supply-limited situation as semiconductor companies are unable to start up manufacturing facilities as fast as customer demand for product increases.

6. This drives up prices, which results in a strong (and inflated) second year of industry performance, ultimately leading to a reversal in performance and a subsequent recession.

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The industry is currently at Step 3 and is moving to Step 4. According to inputs we have been gathering from various sources, we see the following signals:

- The well-publicized allocation of standard bipolar logic (74LS) by Signetics, Motorola, and National is occurring.

- Lead times are lengthening for programmable logic products (PALs), particularly for higher-performance products and selected microperipheral devices.

- Signs of panic buying have not yet appeared. Broker prices are still low on most products, and brokers are aggressively pursuing customers rather than vice versa. The exception to this is DRAMs and EPROMs, where broker prices are higher due to U.S. government trade actions against Japanese manufacturers.

- Current procurement plans for the largest electronics companies in the United States indicate that they will increase purchases 5 to 6 percent in 1986 over 1985, with most of the increase occurring in the second half of 1986.

- Advanced technologies are already beginning to reach capacity limits. This is occurring with 1.5-micron CMOS technology that is currently being used for large gate arrays and standard cell ASIC products, 32-bit microprocessors and microperipherals, high-performance static RAMs, and very high-density memories (256K and 1-Mbit DRAMs, 512K and 1-Mbit EPROMs, 256K SRAMs).

THE BOTTOM LINE

The well-publicized excess capacity of 1985 would lead us to believe that product should be readily available for the next three years. But, we have already seen that this is not the case in the first six months of the current recovery. No matter how much physical plant is in place, manufacturers can only add people at a limited rate. It takes at least three to six months to train new production workers once they are hired. Since recoveries generally occur in stages, semiconductor companies are reluctant to increase production until a recovery is assured. They want to avoid the distributor bubble that occurred in 1982. This normally happens at Step 4 of the recovery process.

The situation is not yet clear, because the general OEM view is that while orders have improved to the point of returning to consumption rates, they are not growing due to increased end demand for systems. Any quick change in demand in the second half of 1986 will press demand for commodity logic above current capacity, extend lead times further, and result in further shortages, as it will take semiconductor manufacturers three to six months to increase production in response to a quick change.

WHO WILL FARE BEST IN THIS CYCLE?

Companies that have developed effective demand forecasting and capacity reservation programs with their suppliers will be able to minimize the effects of the business cycle on their material flows. We are collecting a file of information about company programs for managing material flow. If you are interested in finding out what other companies are doing, call our Hot Line (408) 993-1440, or send a telex and we will send you transcripts of speeches made at recent DATAQUEST conferences on this subject.

Stan Bruederle

SUIS Code: Newsletters
1986-9

SEMICONDUCTOR INDUSTRY UPDATE:
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Stan Bruederle

SUIS Code: Newsletters
1986-8

SEMICONDUCTOR DUMPING AND PRICES: WHO PAYS THE BILL?

SUMMARY

After many months of investigation, the U.S. Department of Commerce found Japanese suppliers of EPROMs and 256K DRAMs guilty of price dumping. Individual dumping penalties are listed in Table 1.

Table 1

DUMPING PENALTIES

Company	64K DRAM	EPROM	256K DRAM
Hitachi	18.49%	30.0%	20.0%
Toshiba	38.83%*	21.7%	50.0%
Fujitsu	38.83%*	145.0%	75.0%
NEC	8.93%	188.0%	108.0%
Mitsubishi	94.00%	63.1%*	40.0%*
Oki	12.52%	63.1%*	40.0%*
Overall	38.83%	63.1%	40.0%

*General levy against all Japanese manufacturers other than the companies specifically named

Source: DATAQUEST
March 1986

These margins represent the percentage by which each company's price was judged to have undercut its fully loaded cost of manufacturing plus an 8 percent profit margin. Effective March 13, 1986, the makers of EPROMs and 256K DRAMs listed in Table 1 will be required to post bonds to cover dumping duties on all EPROMs and 256K DRAMs imported from Japan. The 64K DRAM penalties that were decided on December 9, 1985, as well as general economic trends have already impacted current 64K DRAM ASPs. Depending on the final ruling by the U.S. International Trade Commission, these penalties may or may not be refunded. The companies charged with dumping may appeal one year after the final ruling, which is expected no later than May 1986.

THE RULING

Japanese semiconductor manufacturers will have to pay dumping penalties for the March 1986 through May 1987 time frame. As long as their prices do not fall below "fair market value," the companies affected will be able to petition the return of these funds in May 1987. The U.S. Department of Commerce has defined fair market value as manufacturing cost plus 8 percent profit. Passing along penalties to users of semiconductors is not an issue as long as prices are set at or above fair market value. The weakening dollar versus the yen will tend to compound the situation.

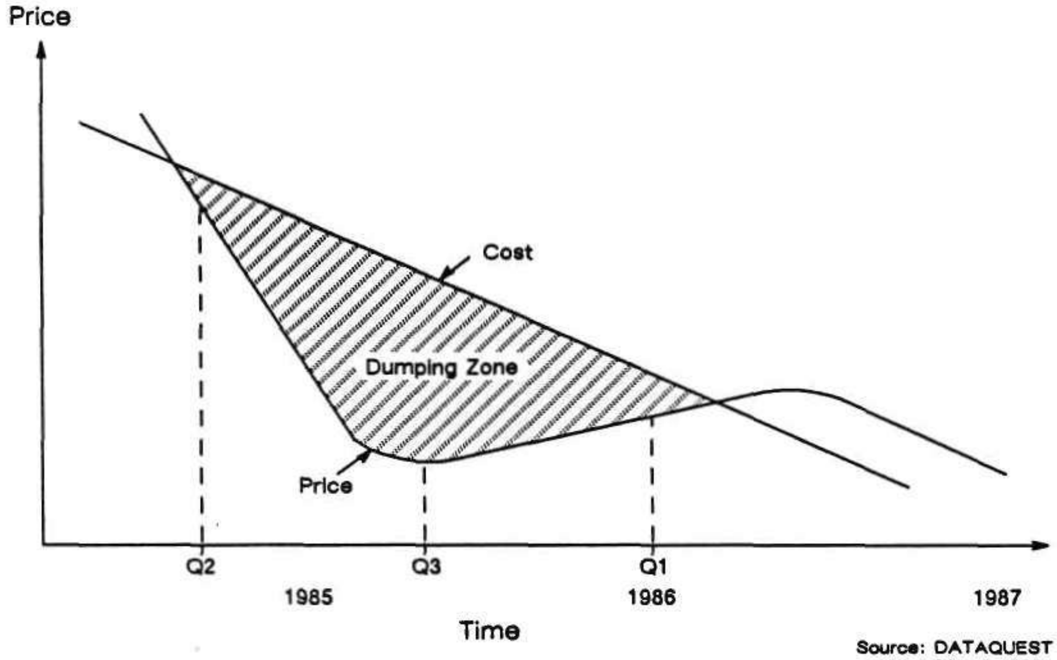
We believe that the dumping charges will accelerate the ongoing trend of price firming that began in the fourth quarter of 1985. Relative market stability and the perceptual benefits of a formal U.S. trade posture also came out of these rulings. Availability of parts is not affected by these dumping decisions.

Low-density EPROM pricing will be affected the most by these rulings, since these parts have been dumped longer than 128K or 256K EPROMs. DATAQUEST foresees price increments of up to 25 to 35 percent for 16K to 64K EPROMs and of up to 10 to 15 percent for 128K devices over the next two quarters. Prices for 256K EPROMs and DRAMs will gradually rise 5 percent over the next six months. The normal experience curve will then allow prices to resume a gradual decline. DATAQUEST expects to see honest contract prices of between $3.50 and $4.00 for 256K EPROMs by the end of this year. Honest pricing for 256K DRAMs will range between $2.20 and $2.50 by year end.

Figure 1 illustrates why prices of early life cycle products (256Ks) should not rise dramatically. Due to the mechanics of the U.S. Department of Commerce's investigatory process, which required more than nine months, much of the dumping violation has been corrected by the marketplace. Threats of pending litigation also contributed to the general price firming. Violations still occurring will be corrected within the next six months, after which the experience curve will again guide prices lower.

Figure 1

PRICE DUMPING AND COSTS



Source: DATAQUEST
March 1986

COMMON QUESTIONS ASKED

Q. What products are affected by these rulings?

A. All EPROMs and 256K DRAM devices and non-value-added portions of these devices (i.e., wafers) sold directly from Japan.

Q. What is the general rule regarding affected Japanese imports?

A. If "substantial transformation" of the identified parts takes place outside of either the United States or Japan, then the transformed unit can enter the United States without incurring the dumping penalty.

Q. Are U.S. companies with Japanese headquarters (i.e., NEC Roseville) or U.S. companies with Japanese factories (i.e., TI Japan) affected by these rulings?

A. No.

Q. Will offshore purchasing and/or assembly of the Japanese parts in question circumvent the dumping penalty?

A. Yes.

Q. Will gray marketeers (i.e., Cal Abco) have to pay dumping penalties?

A. Yes.

Q. Are 1Mb DRAMs included in these dumping rulings?

A. Yes, but no penalties were defined, due to limited cost data. Historical cost analysis illustrates that initial prices of new-generation DRAMs traditionally are below cost. (See our January 29, 1986, Research Newsletter entitled "DRAM Prices: Stable and Rising".) This ruling may delay design-in of 1Mb DRAMs due to excessively high prices based on fair market value.

Q. Are "imbedded products" (boards, subassemblies, etc.) subject to the rulings?

A. No. Board stuffing constitutes "substantial transformation" of the raw material.

Q. Are these rulings a long-term solution for the U.S. semiconductor industry?

A. DATAQUEST sees both the recent rulings in favor of U.S. semiconductor manufacturers as providing a 6- to 12-month recovery period to become more competitive, but more importantly, we consider them as setting a precedent of seeking governmental redress where once none was needed.

Q. How will the dumping charges be applied to Japanese imports?

A. For each company involved, the declared value of the devices shipped from Japan will be multiplied by each company's respective penalty percentage. The U.S. Department of Commerce will monitor prices relative to the declared values submitted from March 1986 to May 1987, to determine whether further dumping has occurred. If no dumping has taken place, the respective company can petition the return of its penalty escrow fund. If dumping or partial dumping has occurred, the U.S. Treasury will retain the percentage of dumping penalties relative to the volume of shipments shipped below fair market value between March 1986 and May 1987.

IMPACT OF DECISION--WHO'S CRYING NOW?

U.S. and Japanese participants in the semiconductor marketplace are listed below, along with an indication of how each fared regarding the outcome of the dumping ruling.

Industry	Gains (+)	Losses (-)
U.S. Semiconductor Manufacturers	+	
Japanese Semiconductor Manufacturers		-
U.S. Semiconductor Users		-
Japanese Semiconductor Users	+	

U.S. and Japanese users of semiconductors can be further broken down into large and small users. Since large U.S. users can install or already have Japanese procurement offices, they can bypass all or most of the dumping surcharges. Smaller companies that lack offshore purchasing offices may be forced to substantially transform these devices offshore if they are to maintain or increase their profit margins.

Another possibility arises if capacity becomes limited for any of these parts. Large U.S. companies with offshore procurement centers may be allocated parts, as small Japanese companies would take precedence over "exports" that do not reflect the higher prices for exports. This potential for a two-tiered pricing system is reminiscent of the 1983 through 1984 DRAM situation. The result then was that many small companies did not survive.

MARKET IMPLICATIONS

The recent antidumping ruling can be viewed by U.S. users of semiconductors in two ways. It can be seen as a short-term price rise that will even out over time as the market balances itself, or it can be seen as accelerating the U.S. manufacturers' ongoing cost-cutting trend of buying and assembling offshore. Unless elemental changes occur in U.S. business structure and mentality that will reward long-term commitments to higher productivity, offshore flight will continue to the long-term detriment of all.

Mark Giudici
Lane Mason

SUIS Code: Newsletters
1986-8

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March 1986

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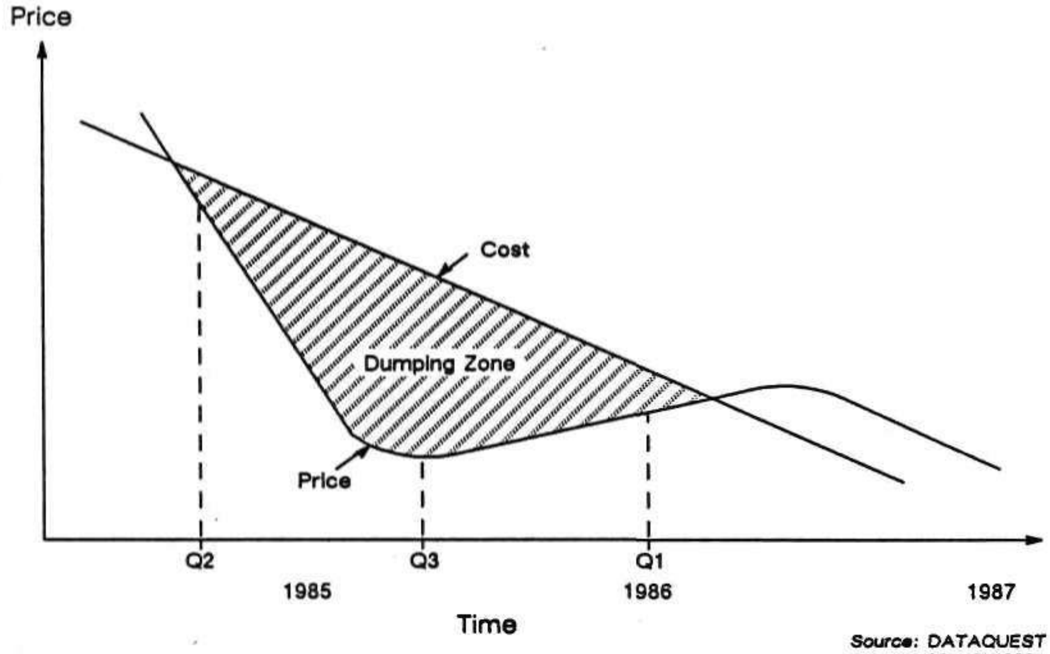

Source: DATAQUEST
March 1986

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Q. What products are affected by these rulings?

A. All EPROMs and 256K DRAM devices and non-value-added portions of these devices (i.e., wafers) sold directly from Japan.

Q. What is the general rule regarding affected Japanese imports?

A. If "substantial transformation" of the identified parts takes place outside of either the United States or Japan, then the transformed unit can enter the United States without incurring the dumping penalty.

Q. Are U.S. companies with Japanese headquarters (i.e., NEC Roseville) or U.S. companies with Japanese factories (i.e., TI Japan) affected by these rulings?

A. No.

Q. Will offshore purchasing and/or assembly of the Japanese parts in question circumvent the dumping penalty?

A. Yes.

Q. Will gray marketeers (i.e., Cal Abco) have to pay dumping penalties?

A. Yes.

Q. Are 1Mb DRAMs included in these dumping rulings?

A. Yes, but no penalties were defined, due to limited cost data. Historical cost analysis illustrates that initial prices of new-generation DRAMs traditionally are below cost. (See our January 29, 1986, Research Newsletter entitled "DRAM Prices: Stable and Rising".) This ruling may delay design-in of 1Mb DRAMs due to excessively high prices based on fair market value.

Q. Are "imbedded products" (boards, subassemblies, etc.) subject to the rulings?

A. No. Board stuffing constitutes "substantial transformation" of the raw material.

Q. Are these rulings a long-term solution for the U.S. semiconductor industry?

A. DATAQUEST sees both the recent rulings in favor of U.S. semiconductor manufacturers as providing a 6- to 12-month recovery period to become more competitive, but more importantly, we consider them as setting a precedent of seeking governmental redress where once none was needed.

Q. How will the dumping charges be applied to Japanese imports?

A. For each company involved, the declared value of the devices shipped from Japan will be multiplied by each company's respective penalty percentage. The U.S. Department of Commerce will monitor prices relative to the declared values submitted from March 1986 to May 1987, to determine whether further dumping has occurred. If no dumping has taken place, the respective company can petition the return of its penalty escrow fund. If dumping or partial dumping has occurred, the U.S. Treasury will retain the percentage of dumping penalties relative to the volume of shipments shipped below fair market value between March 1986 and May 1987.

IMPACT OF DECISION--WHO'S CRYING NOW?

U.S. and Japanese participants in the semiconductor marketplace are listed below, along with an indication of how each fared regarding the outcome of the dumping ruling.

Industry	Gains (+)	Losses (-)
U.S. Semiconductor Manufacturers	+	
Japanese Semiconductor Manufacturers		-
U.S. Semiconductor Users		-
Japanese Semiconductor Users	+	

U.S. and Japanese users of semiconductors can be further broken down into large and small users. Since large U.S. users can install or already have Japanese procurement offices, they can bypass all or most of the dumping surcharges. Smaller companies that lack offshore purchasing offices may be forced to substantially transform these devices offshore if they are to maintain or increase their profit margins.

Another possibility arises if capacity becomes limited for any of these parts. Large U.S. companies with offshore procurement centers may be allocated parts, as small Japanese companies would take precedence over "exports" that do not reflect the higher prices for exports. This potential for a two-tiered pricing system is reminiscent of the 1983 through 1984 DRAM situation. The result then was that many small companies did not survive.

MARKET IMPLICATIONS

The recent antidumping ruling can be viewed by U.S. users of semiconductors in two ways. It can be seen as a short-term price rise that will even out over time as the market balances itself, or it can be seen as accelerating the U.S. manufacturers' ongoing cost-cutting trend of buying and assembling offshore. Unless elemental changes occur in U.S. business structure and mentality that will reward long-term commitments to higher productivity, offshore flight will continue to the long-term detriment of all.

Mark Giudici
Lane Mason

SUIS Code: Newsletters
1986-7

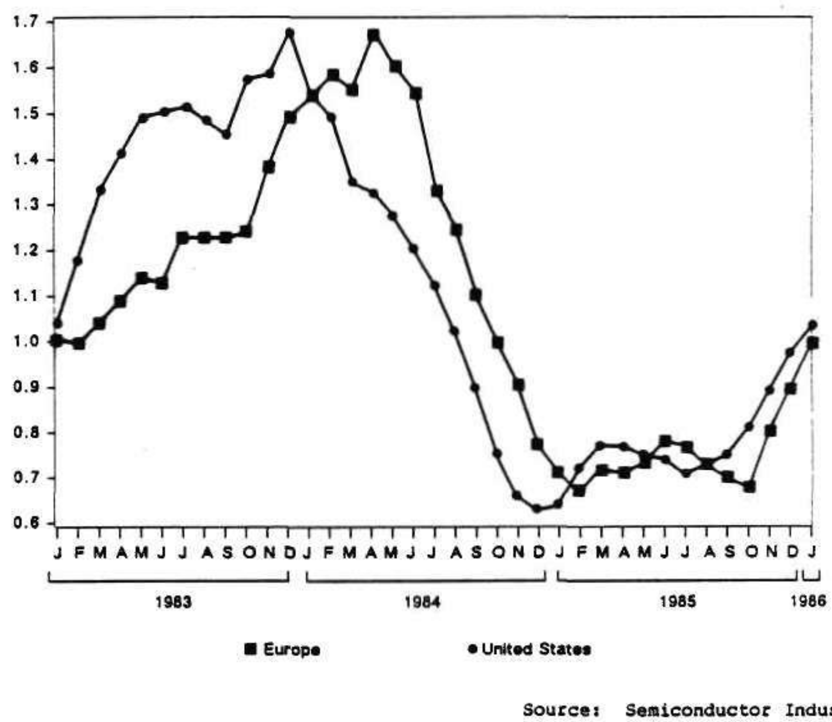
WEST EUROPEAN MARKET UPDATE
THE BOOK-TO-BILL IS NUMBER 1

SUMMARY

January was the month when the book-to-bill ratio reached the magic number 1. In Europe, unity was achieved for the first time in 15 months; in the United States, 1.04 was reported. Figure 1 depicts the book-to-bill ratio for the period from January 1983 to January 1986.

Figure 1

SEMICONDUCTOR BOOK-TO-BILL RATIO
UNITED STATES AND EUROPE



Source: Semiconductor Industry Association
DATAQUEST
March 1986

Dataquest Incorporated, a company of The Dun & Bradstreet Corporation
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DATAQUEST has considered the dynamics of the marketplace from the perspective of both users and manufacturers.

THE SITUATION AT THE USERS

Major users (with the notable exception of a large North European concern) are reporting that inventories have been reduced to acceptable levels. There remain some mix and profile problems, however, as not all of the purchasing excesses of 1984/1985 have been flushed out of the system. It is anticipated that this cleaning process will continue throughout the first half of 1986. A point of concern to the users is that running with the current lean inventories coupled with the residual mix problems is creating immediate internal-specific product shortages, which means that short-term demands on the vendors are increasing. Equipment build rate is being maintained and the economic indicators point to steady growth throughout the remainder of 1986.

Distribution is rebooking in order to restock and better align inventory with demand; the outlook is cautiously optimistic. Margins are running an average of 25 percent, discretes and linear are slightly better, and digital logic and memory are in the 20 to 25 percent range.

SITUATION AT THE MANUFACTURERS

Lead times are stretching out. Low-power Schottky logic, which sales engineers were finding difficult to place six months ago, is now on 8 to 10 weeks lead times, while octals are on 10 to 12 weeks lead times and the trend is upward.

Dynamic RAMs are on extending lead times, with the remaining manufacturers reacting to a combination of cost pressure and (in the case of the Japanese vendors) political pressure. The result is that 64K prices are now $0.90+, and 256K prices are edging above $2.

Considering book-to-bill ratios at the product level, we expect the major commodity product families to experience a positive book-to-bill for the first quarter of 1986. The good news is that this expected ratio change is due to the increase in the numerator rather than a decline in the denominator. Some manufacturers are reporting that the billings on the more volatile portions of their portfolios could be up as much as 25 to 30 percent in the first half of 1986 over the second half of 1985. In absolute terms, this almost brings them up to the first half of 1985 levels.

DATAQUEST FORECASTS

Table 1 lists DATAQUEST's estimates for West European semiconductor shipments by major technology for 1983 through 1986, and for 1990.

Figure 2 shows DATAQUEST estimates for quarterly shipments into Western Europe for 1985 through 1986. Shipments for 1985 and beyond are valued in constant dollars at average 1985 European exchange rates. (See Exchange Rate Quarterly Newsletter of February 26 in ESIS Volume IV).

By considering the current bookings level, industry backlog, and estimates on aging of current and forecast bookings, DATAQUEST has arrived at the quarterly split shown in Figure 2.

DATAQUEST estimates that the first quarter of 1986 will be the lowest billing point of the cycle at US$1,042 million, down 2.1 percent from the fourth quarter of 1985.

The book-to-bill ratio is now on its way up. Short-term demand is definitely increasing, prices are hardening, and a number of commodity backlogs are being reevaluated. DATAQUEST estimates that the recovery in billings will begin in the second quarter, with US$1,130 million, and continue through to the fourth quarter with US$1,476 million. Overall, DATAQUEST expects 1986 European semiconductor shipments to exceed those of 1985 by 6.3 percent--US$4,923 million in 1986 versus US$4,632 million in 1985.

DATAQUEST ANALYSIS

DATAQUEST estimates that only 73 percent of the installed worldwide production capacity will be utilized in 1986; furthermore, we do not expect full utilization to be achieved until the end of 1987. However, users should be aware that although excess production capacity exists, it is unmanned due to the substantial layoffs in 1985. This means that a personnel hiring and training cycle requiring a minimum of three months has to elapse before the capacity can be utilized. Thus, capacity in the industry is to all intents and purposes fixed for the next six months.

Lead times are stabilizing to more normal levels, and prices are recovering to the 1982/1983 values.

DATAQUEST believes that there is enough operational capacity to satisfy demand. To ensure that extremes in the demand/supply relationship are avoided, accurate, detailed demand forecasting and intelligent inventory control from both manufacturers and users is absolutely essential. Cooperation between users and vendors aimed at improving inventory control will, as well as improving operational efficiency, ensure that once the book-to-bill oscillation is under control, it stays controlled.

Analyzing industry records back to 1957 shows that without exception, a year of decline is followed by a least three years of sustained positive growth. Table 1 lists DATAQUEST's 1990 forecast for total semiconductor shipments as US$9,809 million, taking 1985 as a base year for a compound annual growth rate of 16.2 percent. This is consistent with the industry's long-term annualized growth rate over the last 30 years and reflects DATAQUEST's confidence in both continued product innovation and semiconductor penetration into emerging applications and markets.

Mark Giudici
Jim Beveridge

NOTE

Before going to press, we received news that the book-to-bill for February is 1.10, which is further confirmation that business is on the way up.

Table 1

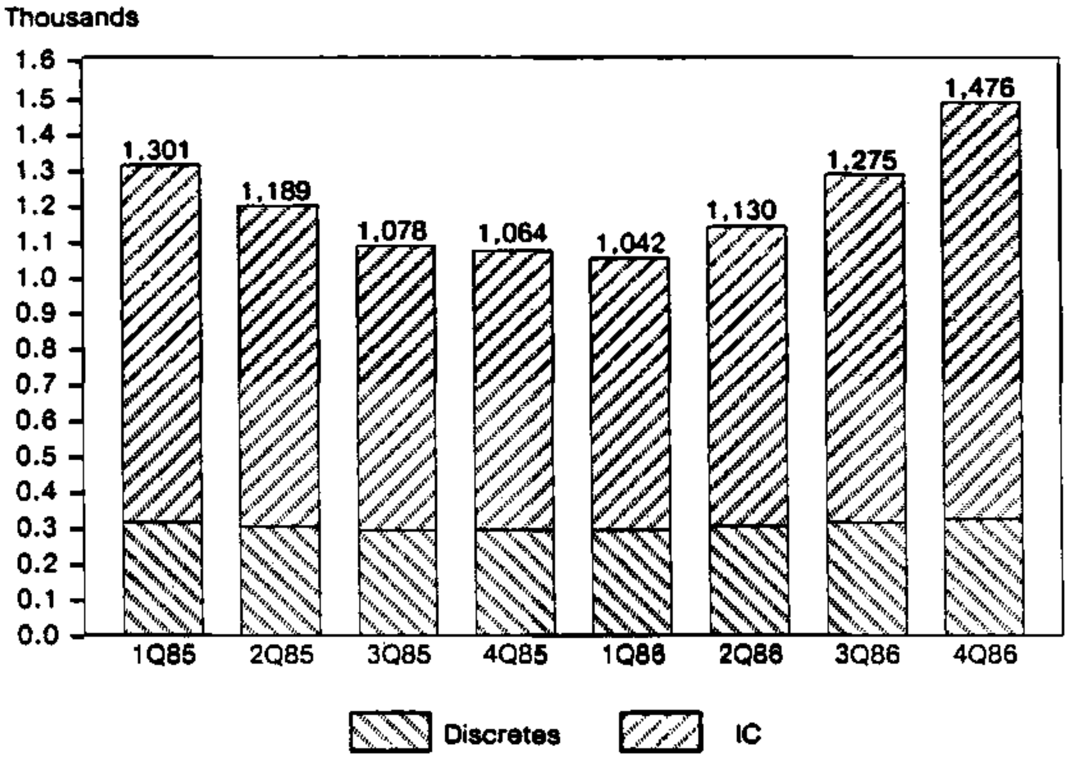
ESTIMATED EUROPEAN SEMICONDUCTOR SHIPMENTS
1983-1986 AND 1990
(Millions of Dollars)

Technology	1983	1984	1985	1986	1990
Total Semiconductor	$3,370	$4,805	$4,632	$4,923	$9,809
Integrated Circuits	$2,323	$3,634	$3,443	$3,679	$8,266
Bipolar Digital	483	724	694	695	1,262
MOS	1,227	2,092	1,855	2,074	5,494
Linear	613	818	894	910	1,510
Discretes	$ 866	$ 963	$ 960	$ 995	$1,161
Optoelectronics	$ 181	$ 208	$ 229	$ 249	$ 382
Weighted European Currency (Assumed per U.S. dollar) (Base 1978 = 100)	143.8	162.5	168.5	168.5	168.5

Source: DATAQUEST
March 1986

Figure 2

ESTIMATED EUROPEAN SEMICONDUCTOR QUARTERLY SHIPMENTS
1985-1986
(Thousands of Dollars)



Source: DATAQUEST
March 1986

SUIS Code: Newsletters
1986-6

1985 MICROPROCESSOR MANUFACTURER RANKINGS

SUMMARY

The top 10 companies shown in Table 1 accounted for more than 77 percent of the microprocessor market, and 6 of the 10 had revenues of more than $100 million each. In 1985, Intel, NEC, and Motorola remained numbers 1, 2, and 3, respectively. AMD lost significant market share in 1985, changing positions from number 4 in 1984 to number 9. Five of the top 10 microprocessor manufacturers were Japanese, the other five were U.S. manufacturers. Total worldwide microprocessor revenue decreased 15.9 percent in 1985 from 1984. Any microprocessor manufacturer whose revenue decreased more than 15.9 percent lost market share.

GEOGRAPHIC MARKET SHARES

Geographic market shares shifted slightly from 1984 to 1985, as shown in Table 2. Market shares for Japanese, Western European, and Rest of World companies rose, while market share for U.S. companies decreased slightly.

GROWTH RATES

The manufacturers with the highest growth rates in the microprocessor segment are shown in Table 3. Only six companies had positive growth during the year. The company with the greatest growth was Taiwan's United Microelectronic (UMC), followed closely by a European company, Thomson.

REGIONAL MARKET SHARES

Tables 4 through 8 rank the worldwide microprocessor suppliers by total revenue by region.

Total worldwide microprocessor revenue was down 15.9 percent in 1985 from 1984. Any microprocessor manufacturer whose revenue decreased more than 15.9 percent during 1985 lost market share. U.S. manufacturers took the hardest hit during the year, with revenues decreasing 19.1 percent. Japanese manufacturers were also affected by the 1985 downturn with a revenue decrease of 13.4 percent. Western European and Rest of World companies had a strong year with increases of 4.3 percent and 54.6 percent, respectively. Typically, Western European economic conditions lag those in the United States by one year. Korean microprocessor manufacturers entered the market with phenomenal growth during 1985, equal to the unprecedented high growth in 1984.

Brand A. Parks
Janet Rey-Oncel

Table 1

TOP 10 1985 MICROPROCESSOR MANUFACTURERS
(Millions of Dollars)

1984 Rank	1985 Rank	Company	Revenue 1984	Revenue 1985	Growth
1	1	Intel	$743	$670	(9.8%)
2	2	NEC	$411	$375	(8.8%)
3	3	Motorola	$256	$255	(0.4%)
5	4	Matsushita	$119	$111	(6.7%)
6	5	Hitachi	$120	$110	(8.3%)
7	6	Fujitsu	$121	$106	(12.4%)
10	7	Mitsubishi	$156	$ 97	(37.8%)
9	8	Texas Instruments	$117	$ 94	(19.7%)
4	9	AMD	$202	$ 88	(26.1%)
8	10	National Semiconductor	$115	$ 85	(26.1%)

Table 2

GEOGRAPHIC MICROPROCESSOR MARKET SHARES

	1984	1985
United States	59.1%	56.8%
Japan	37.0	38.2
Western Europe	3.6	4.4
Rest of World	0.3	0.6
Total	100.0%	100.0%

Source: DATAQUEST
February 1986

Table 3

TOP GROWTH 1985 MICROPROCESSOR MANUFACTURERS
(Millions of Dollars)

	Revenue 1984	1985	Growth
United Microelectronic	$ 4	$ 7	75.0%
Thomson	$23	$40	73.9%
Harris	$52	$58	11.5%
ITT	$10	$11	10.0%
Matra-Harris	$11	$12	9.0%
Sanyo	$35	$36	2.9%

Source: DATAQUEST
February 1986

Table 4

PRELIMINARY WORLDWIDE 1985 MICROPROCESSOR MARKET SHARE RANKINGS
(Millions of Dollars)

	1984	1985	Growth
Intel	$ 743	$ 670	(9.83%)
NEC	411	375	(8.76%)
Motorola	256	255	(0.39%)
Matsushita	119	111	(6.72%)
Hitachi	120	110	(8.33%)
Fujitsu	121	106	(12.40%)
Mitsubishi	156	97	(37.82%)
Texas Instruments	117	94	(19.66%)
AMD	202	88	(56.44%)
National	115	85	(26.09%)
Toshiba	70	69	(1.43%)
Zilog	88	59	(32.95%)
Harris	52	58	11.54%
Sharp	71	46	(35.21%)
Oki	46	43	(6.52%)
Mostek	55	40	(27.27%)
SMC	50	40	(20.00%)
Thomson	23	40	73.91%
Sanyo	35	36	2.86%
Signetics	75	35	(53.33%)
Philips	29	29	0.00%

(Continued)

Table 4 (Continued)

PRELIMINARY WORLDWIDE 1985 MICROPROCESSOR MARKET SHARE RANKINGS
(Millions of Dollars)

	1984	1985	Growth
RCA	$ 34	$ 28	(17.65%)
Rockwell	32	26	(18.75%)
Sony	26	26	0.00%
SGS	31	20	(35.48%)
Siemens	19	16	(15.79%)
Seiko	18	15	(16.67%)
Matra-Harris	11	12	9.09%
GI	15	11	(26.67%)
ITT	10	11	(10.00%)
Western Digital	12	11	(8.33%)
Fairchild	17	10	(41.18%)
Japan Others	11	9	(18.18%)
NCR	12	8	(33.33%)
ROW Others	6	8	33.33%
AMI	8	7	(12.50%)
United Microelectronic	4	7	75.00%
Intersil	5	5	0.00%
Hughes	3	3	0.00%
Eurosil	2	2	0.00%
GTE	3	2	(33.33%)
Inmos	0	2	N/A
Rohm	2	2	0.00%
VLSI	0	2	N/A
Erso	0	1	N/A
Exel	0	1	N/A
Gold Star	1	1	0.00%
Commodore	0	0	N/A
Eurotechnique	0	0	N/A
Ferranti	1	0	(100.00%)
Synertek	15	0	(100.00%)
U.S. Others	5	7	40.00%
Total	$3,257	$2,739	(15.90%)

Source: DATAQUEST
February 1986

Table 5

PRELIMINARY 1985 WORLDWIDE
MARKET SHARE RANKINGS OF U.S. MANUFACTURERS
(Millions of Dollars)

	1984	1985	Growth
Intel	$ 743	$ 670	(9.83%)
Motorola	256	255	(0.39%)
Texas Instruments	117	94	(19.66%)
AMD	202	88	(56.44%)
National	115	85	(26.09%)
Zilog	88	59	(32.95%)
Harris	52	58	11.54%
Mostek	55	40	(27.27%)
SMC	50	40	(20.00%)
Signetics	75	35	(53.33%)
RCA	34	28	(17.65%)
Rockwell	32	26	(18.75%)
GI	15	11	(26.67%)
ITT	10	11	(10.00%)
Western Digital	12	11	(8.33%)
Fairchild	17	10	(41.18%)
NCR	12	8	(33.33%)
AMI	8	7	(12.50%)
Intersil	5	5	0.00%
Hughes	3	3	0.00%
GTE	3	2	(33.33%)
VLSI	0	2	N/A
Exel	0	1	N/A
Commodore	0	0	N/A
Synertek	15	0	(100.00%)
Others	5	7	40.00%
Total	$1,924	$1,556	(19.13%)

Source: DATAQUEST
February 1986

Table 6

PRELIMINARY 1985 WORLDWIDE
MARKET SHARE RANKINGS OF JAPANESE MANUFACTURERS
(Millions of Dollars)

	1984	1985	Growth
NEC	$ 411	$ 375	(8.76%)
Matsushita	119	111	(6.72%)
Hitachi	120	110	(8.33%)
Fujitsu	121	106	(12.40%)
Mitsubishi	156	97	(37.82%)
Toshiba	70	69	(1.43%)
Sharp	71	46	(35.21%)
Oki	46	43	(6.52%)
Sanyo	35	36	2.86%
Sony	26	26	0.00%
Seiko	18	15	(16.67%)
Rohm	2	2	0.00%
Others	11	9	(18.18%)
Total	$1,206	$1,045	(13.35%)

Source: DATAQUEST
February 1986

Table 7

PRELIMINARY 1985 WORLDWIDE
MARKET SHARE RANKINGS OF WESTERN EUROPEAN MANUFACTURERS
(Millions of Dollars)

	1984	1985	Growth
Thomson	$ 23	$ 40	73.91%
Philips	29	29	0.00%
SGS	31	20	(35.48%)
Siemens	19	16	(15.79%)
Matra-Harris	11	12	9.09%
Eurosil	2	2	0.00%
Inmos	0	2	N/A
Ferranti	1	0	(100.00%)
Eurotechnique	0	0	
Total	$116	$121	4.31%

Table 8

PRELIMINARY 1985 WORLDWIDE MARKET SHARE
RANKINGS OF REST OF WORLD MANUFACTURERS
(Millions of Dollars)

	1984	1985	Growth
United Microelectronic	$ 4	$ 7	54.55%
Erso	0	1	N/A
Gold Star	1	1	0.00%
Others	6	8	33.33%
Total	$11	$17	54.55%

Source: DATAQUEST
February 1986

Nielsen Dataquest USER UPDATE

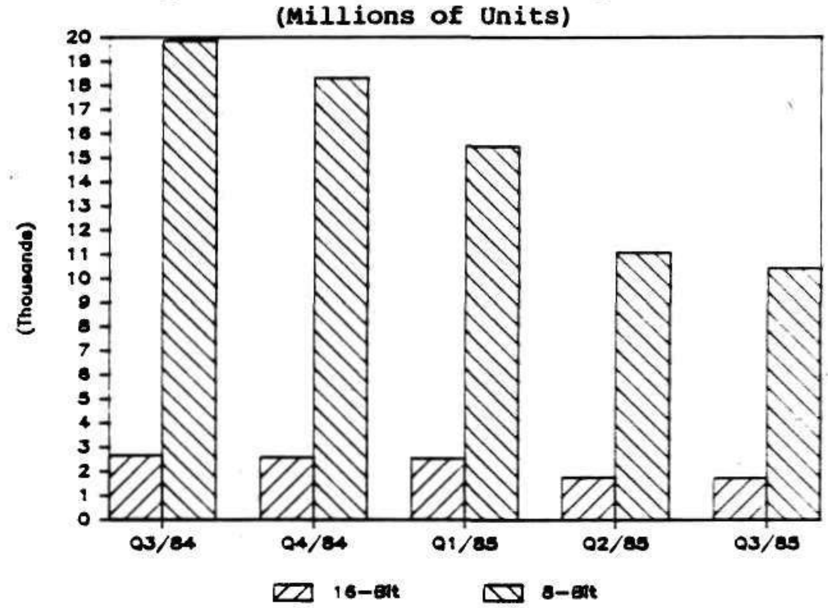
SUIS Code: Newsletters
1986-5

THIRD QUARTER 1985 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the third quarter of 1985, worldwide microprocessor and microcontroller unit shipments decreased approximately 3.0 million units or 3.6 percent from second quarter 1985. Estimated shipments of all microcontroller devices totaled approximately 81.3 million units. Shipments of 4-bit MCUs remained flat and 8-bit MCU shipments decreased 7.4 percent. Estimated shipments of all microprocessor devices totaled approximately 12.5 million units. Shipments of 16-bit MPUs were down approximately 1.9 percent, while 8-bit MPU shipments decreased approximately 4.2 percent. Figure 1 shows MCU and MPU unit shipments from the third quarter of 1984 through the third quarter of 1985.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS THIRD QUARTER 1984 THROUGH THIRD QUARTER 1985 (Millions of Units)



Source: DATAQUEST
March 1986

Table 1 shows the quarterly revenue for microcontrollers and microprocessors from the third quarter 1984 through the third quarter 1985.

Table 1

TOTAL MICROCONTROLLER AND MICROPROCESSOR REVENUE
THIRD QUARTER 1984 THROUGH THIRD QUARTER 1985
(Millions of Dollars)

	Q3/84	Q4/84	Q1/85	Q2/85	Q3/85
MCU	$380.9	$372.2	$293.9	$255.6	$260.0
MPU	161.0	169.9	131.0	102.0	96.0
Total	$541.9	$542.1	$424.9	$357.6	$356.0

Source: DATAQUEST
March 1986

Table 2 shows the change in total microcontroller unit shipments from the second quarter of 1985 through the third quarter of 1985.

Table 2

TOTAL MICROCONTROLLER UNIT SHIPMENTS
SECOND QUARTER 1985 THROUGH THIRD QUARTER 1985
(Thousands of Units)

	Q2/1985		Q3/1985		Percent
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
4-Bit	44,809	53.1%	44,649	54.9%	(0.0%)
8-Bit	39,462	46.8	36,549	45.0	(7.4%)
16-Bit	55	0.1	56	0.1	1.8%
Total	84,326	100.0%	81,254	100.0%	(3.6%)

Source: DATAQUEST
March 1986

Table 3 shows the change in total microprocessor unit shipments from the second quarter of 1985 through the third quarter of 1985.

Table 3

TOTAL MICROPROCESSOR UNIT SHIPMENTS
SECOND QUARTER 1985 THROUGH THIRD QUARTER 1985
(Thousands of Units)

	Q2/1985		Q3/1985		Percent Growth
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Q2 to Q3
8-Bit	11,170	86.0%	10,699	85.7%	(4.2%)
16-Bit	1,780	13.7	1,746	14.0	(1.9%)
Others	37	0.3	40	0.3	8.1%)
Total	12,987	100.0%	12,485	100.0%	(3.9%)

Source: DATAQUEST
March 1986

Table 4 shows the change in the shipments of the leading 8-bit MPUs from the second quarter of 1985 through the third quarter of 1985.

Table 4

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
SECOND QUARTER 1985 THROUGH THIRD QUARTER 1985
(Thousands of Units)

	Q2/1985		Q3/1985		Percent Growth
Device	Units	Percent of Shipments	Units	Percent of Shipments	Q2 to Q3
Z80	3,309	29.6%	3,535	33.0%	6.8%
8085	3,429	30.7	2,636	24.6	(23.1%)
6802	1,155	10.3	1,102	10.3	(4.6%)
8088	674	6.0	724	6.8	7.4%
6809	770	6.9	690	6.5	(10.4%)
Others	1,833	16.5	2,012	18.8	9.8%
Total	11,170	100.0%	10,699	100.0%	(4.2%)

Source: DATAQUEST
March 1986

Table 5 shows the changes in estimated shipments of 16-bit microprocessors from the second quarter of 1985 through the third quarter of 1985.

Table 5

16-BIT MICROPROCESSOR SHIPMENTS
SECOND QUARTER 1985 THROUGH THIRD QUARTER 1985
(Thousands of Units)

	Q2/1985		Q3/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
68000	447	25.1%	406	23.3%	(9.2%)
80286	375	21.1	405	23.2	8.0%
8086	388	21.8	400	22.9	3.1%
80186	260	14.6	215	12.3	(17.3%)
Z8000	97	5.5	97	5.6	-
32016	75	4.2	75	4.3	-
Others	138	7.7	148	8.4	7.3%
Total	1,780	100.0%	1,746	100.0%	(1.9%)

Source: DATAQUEST
March 1986

Table 6 shows the changes in estimated shipments of 8-bit microcontrollers from the second quarter of 1985 through the third quarter of 1985.

Table 6

8-BIT MICROCONTROLLER SHIPMENTS
SECOND QUARTER 1985 THROUGH THIRD QUARTER 1985
(Thousands of Units)

	Q2/1985		Q3/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
8049	7,117	18.0%	6,382	17.5%	(10.3%)
6805	4,755	12.1	4,490	12.3	(5.6%)
8048	5,259	13.3	4,186	11.5	(20.4%)
8051	4,045	10.3	4,036	11.0	(0.2%)
Others	18,286	46.3	17,455	47.7	(4.5%)
Total	39,462	100.0%	36,549	100.0%	(7.4%)

Source: DATAQUEST
March 1986

Table 7 shows market share by technology for 8-bit microcontroller and microprocessor devices from the third quarter of 1984 through the third quarter of 1985, and indicates increased shipments of 8-bit CMOS microcontrollers and microprocessors.

During third quarter 1985, approximately 79 percent of all 8-bit CMOS MCU shipments and approximately 43.0 percent of all 8-bit CMOS MPU shipments were Japanese manufactured and shipped. Even though U.S. manufacturers ship more 8-bit CMOS MPUs--approximately 1.0 million units--their Japanese counterparts shipped six times as many or approximately 5.9 million 8-bit CMOS MCUs. DATAQUEST believes that as CMOS technology progresses, the Japanese position will become stronger than it is now in both the MPU and MCU market segments.

Table 7

MARKET SHARE BY TECHNOLOGY FOR MICROCONTROLLERS AND MICROPROCESSORS
THIRD QUARTER 1984 THROUGH THIRD QUARTER 1985

Device	Tech	Q3/84	Q4/84	Q1/85	Q2/85	Q3/85
8-Bit MCU	CMOS	9.7%	15.3%	16.9%	20.4%	20.3%
8-Bit MCU	NMOS	90.3	84.7	83.1	79.6	79.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	10.3%	11.6%	12.0%	15.2%	17.2%
8-Bit MPU	NMOS	89.7	88.4	88.0	84.8	82.8
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
March 1986

ANALYSIS

DATAQUEST estimates that revenue from microprocessor and microcontroller shipments for third quarter 1985 was $356 million, flat from the second quarter of 1985. For the remainder of the year, the impact of declining prices and unit volumes will continue, with a slight upturn in the fourth quarter. Revenue shipments for fourth quarter 1985 are expected to be $403 million, with the year's MPU/MCU revenue shipments at $1,542 million, down 23 percent from 1984 revenue.

OUTLOOK FOR 1986

- CMOS technology will be the dominant growth area.
- Growth will resume in 1986.
- Inventories will stabilize.
- Prices will be firmer.
- There will be pressure to finalize second-source agreements for 32-bit MPUs.
- More high-integration chips will be available on the market.
- Personal computers will be used as workstations.
- Integration of office factory automation will be planned.
- Lap-top computers will be an emerging market.

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SUIS Code: Newsletters
1986-4

OUTLOOK FOR THE EUROPEAN SEMICONDUCTOR INDUSTRY

EXECUTIVE SUMMARY

In 1975, the European companies' worldwide market share stood at 18 percent. Since that time, this share has steadily eroded, reaching an all-time low in 1984 of 11 percent. In 1975, three European companies ranked among the top 10 world suppliers. Today, only Philips retains a top 10 ranking.

Given this stark scenario, what possibilities lie in store for the European semiconductor industry? Further decline to eventual novelty value, or renewed strength and international competitiveness? The obvious answer would be the former of the two options; however, we do not believe that this will transpire. Since 1980, there has been a fundamental change in the competitive European environment. For this reason, the latter outlook is the more likely scenario, and indeed the first results are already starting to emerge.

BACKGROUND--WHERE ARE WE COMING FROM?

The European semiconducutor market has always been an open market, with the U.S. semiconductor companies traditionally supplying between 50 and 60 percent of the total demand. At the outset, however, the European companies established an early foothold in the emerging semiconductor technology and indeed have several world firsts to their credit. Despite this, they in general failed to keep pace with their U.S. counterparts. Traditionally, the companies were part of large, vertically integrated industrial and/or electrical companies, a fact that gave rise to the following set of characteristics:

- In-house requirements dominating their product and market strategies
- Inherent bureaucracy forcing slow business reactions and decision making

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- Strong aversion to business risk

- Strong technology and R&D focus

- Protected home market

These characteristics resulted in a market strategy that focused on domestic demand as the number 1 priority, with the Rest of Europe and the Rest of World markets relegated to a somewhat detached second and even a more distant third place, respectively. Serving non-domestic markets was generally viewed as opportunistic--a place to sell excess products or capacity--rather than as a valid market in its own right.

The problems associated with a narrow market base, lack of international product strategy, and lack of competitiveness started to surface with the advent of the commodity IC in the 1960s. In general, the European semiconductor companies failed to keep pace with the product and manufacturing advances, which were dominated at that time by the U.S. companies. Some did attempt to compete in these areas, but most failed to achieve the necessary volume required to compete effectively.

Before long, the combination of strong (internationally focused) marketing, aggressive pricing, and low-cost, volume manufacturing capability resulted in the U.S. companies dominating this rapidly emerging market. By the mid-1970s, most of the European companies had conceded this market to the increasingly dominant U.S. semiconductor industry.

In many ways, the situation then is reminiscent of the present U.S. and Japanese semiconductor industry confrontation on commodity MOS ICs. Given this background, it is hardly surprising that the 1970s saw Europe's share of the worldwide semiconductor market decline. With few exceptions, the European semiconductor companies either were forced into niche markets or into markets that were relatively unattractive to other suppliers because of duty or other cost disadvantages, or because of low-volume demand.

EUROPE IN THE 1980s

By 1980, Europe's decline was endemic, so much so that even the European governments were showing concern. At the same time, a new breed of European manager was starting to emerge, one more entrepreneurial in nature, willing to take risks, internationally focused, and altogether more flexible and pragmatic than his predecessors.

It was not only Europe's semiconductor industry that was in trouble, its whole electronics industry was becoming increasingly uncompetitive, in many instances saved only by protectionist measures or captive markets.

In part, this very demise of Europe's electronics industry can be directly attributed to the failure of Europe's semiconductor industry to support it. Denied timely access to the latest semiconductor technology, Europe's equipment manufacturers were relegated to using obsolescent technology in their equipment designs. In contrast, because the latest in IC technology was readily available in the United States, the local U.S. companies could incorporate these into their designs much earlier to win and control key markets through feature, cost, price, and performance advantages.

The demise of Europe's computer industry is a classic example of just such a market lost to the United States through such means.

A fourth element also came into play--the meteoric rise of the U.S. dollar against the local European currencies since 1980. This provided the European companies with an instantaneous manufacturing cost advantage over their U.S. counterparts.

Along with the increasing recognition that too much reliance on non-European technology was putting Europe's electronics companies at risk came the appreciation that timely access to technology was not in itself sufficient. What was needed in addition was a different market strategy, one based on improved international competitiveness and trading openly in world markets.

Nowhere was this more evident than in the European semiconductor industry, where it was obvious that the small domestic markets were unable to support effectively a strong semiconductor base. And yet, without a strong local semiconductor base, the European electronics industry was committed to further decline. A series of events has unfolded that has paved the way for a significant change in the European environment. Already the downward trend has been arrested substantially, and some key statistics have even started to reverse direction.

For example, 1985 saw the European semiconductor companies' worldwide market share increase--for the first time in more than 10 years--from 11 percent to 12 percent, as shown in Figure 1. Based on the existing committed and scheduled capital and R&D investments of, for example, European Silicon Structures (ES2), Ferranti, Matra-Harris, MEDL, Mietec, Philips, SGS, Siemens, and Thomson, this trend is likely to continue throughout this decade. By 1990, the European companies' share should reach at least 15 percent, possibly even more.

Since 1981, Plessey, Ferranti, SGS, and Thomson have all outperformed the worldwide semiconductor market growth, although in three of these years the world semiconductor markets were steeped in deep recession (see Figure 2).

Figure 1

EUROPEAN COMPANIES WORLDWIDE MARKET SHARE PROJECTION
(Percent of Dollars)

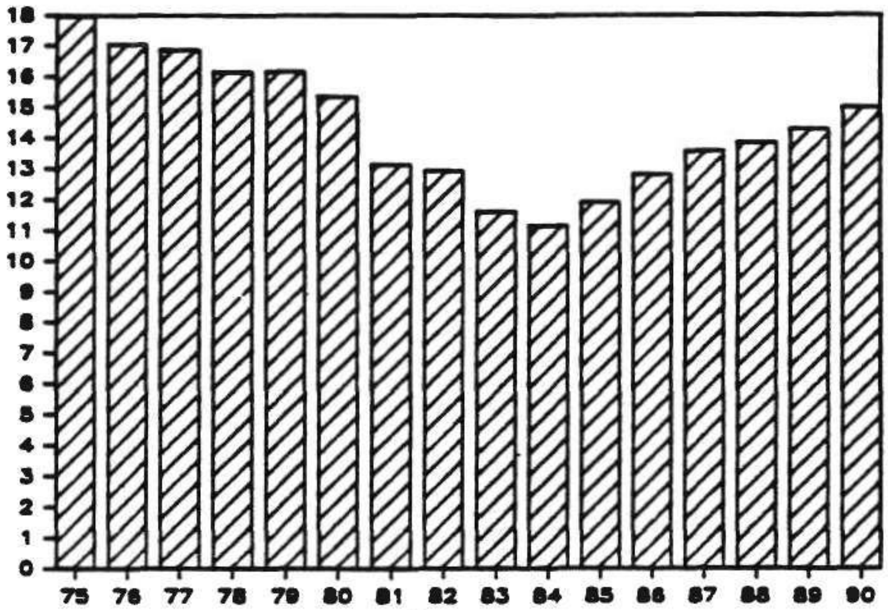
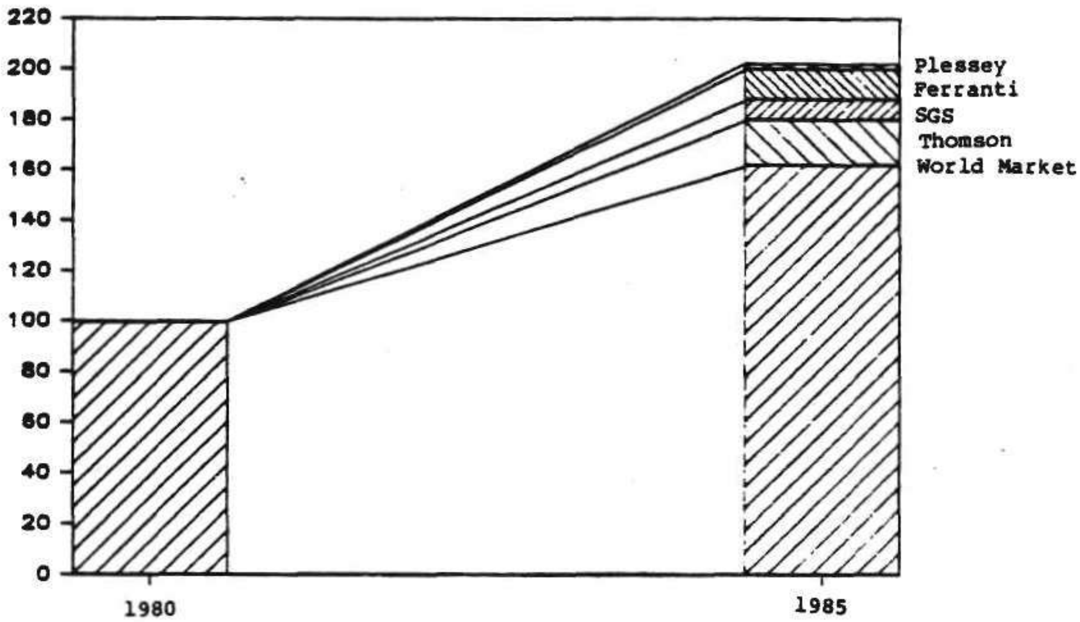


Figure 2

RELATIVE GROWTH IN SEMICONDUCTOR SHIPMENTS
(Base 1981 = 100)



Source: DATAQUEST
March 1986

Significantly, the value of product exported by the European companies to non-European countries has risen from 27 percent in 1979 to 36 percent in 1985. Despite this increase, the penetration of this market still represents only 5 percent share. A mere doubling of this figure to 10 percent, which in itself is not too aggressive a target, would increase the European companies' worldwide market share to 16 percent and their exports to 50 percent, while maintaining their present 40 percent share of the European market. None of these hypotheses are unreasonable--on the contrary, all are readily achievable.

Many European companies are already demonstrating the courage and determination necessary to make it happen. Thomson's recent acquisition of Mostek's assets in the United States is a good example. Acquired at a bargain price, Mostek's assets provide Thomson with a substantial increase in MOS capability together with an established U.S. sales and marketing effort just when the semiconductor market is starting to show positive signs of recovery.

Similarly, through a self-build strategy, SGS, one of the early forerunners of the new European initiative, is also uniquely positioned to capitalize on the impending market upturn. SGS has invested substantially in five new 125mm wafer fabrication lines since 1983 in addition to its partially completed 150mm line in Phoenix, Arizona.

EUROPE--THE WAY AHEAD

We believe that with the plans and strategies that are already in place, the European companies can readily regain their 1980 worldwide market share by 1990. Two fundamental changes are taking place:

- Companies are forming across the border alliances.
- European start-ups are increasing.

Strategic Alliances

The major European semiconductor companies are developing strategic alliances that will enable them to target worldwide markets in a cost-effective manner. An example of this is the Philips-Siemens Mega-project. This alliance will result in Europe having a state-of-the-art process capable of building 4-Megabit DRAMs and 1-Megabit SRAMs. Both Philips and Siemens have a large internal demand for such devices in their consumer, computer, and telecommunications products. This volume will provide the opportunity to rapidly ramp down the cost learning curve so as to compete successfully in the world marketplace.

In addition, Thomson, France, and MEDL, U.K., have announced a development project to cooperate on application-specific ICs (ASICs), a market estimated at around $4 billion worldwide by 1990. Plessey and Ferranti are already among the fastest-growing companies in this sector, which represents one of the major growth market opportunities for the European semiconductor companies.

Similar agreements exist between Thomson and Oki; SGS and Toshiba, and LSI Logic; and Philips and Texas Instruments.

The seeds of cooperation across national and international barriers have already been sewn, both at the component and end-equipment levels. We believe that this trend will continue. There is no place for blinkered nationalism in the global markets of the 1990s.

European Semiconductor Start-Ups

Along with strategic alliances, the second fundamental change under way is the emergence of the European semiconductor start-up. Though not as prolific as in the United States, the momentum is growing. Matra-Harris, Mietec, Inmos, and Integrated Power Semiconductors have already made substantial progress in their respective fields and, more recently, a new venture, ES2, was launched.

Led by a pan-European team of highly experienced semiconductor veterans, ES2's target market is the fast turnaround ASICs. The financing for ES2 is European, $65 million in total, and the operations span the European continent with a factory planned in France, headquarters in Germany, and R&D in the United Kingdom.

Integrated Power Semiconductors (Scotland) is a technology leader in developing "intelligent" power ICs; Mietec (Belgium) is focusing on ASICs for the automotive, industrial and telecommunications markets, specializing in high-voltage, high-drive, mixed technology ICs; Inmos is pioneering the concept of parallel processing with the Transputer, a 32-bit highly integrated microprocessor building block; and Matra-Harris is specializing in high-performance CMOS ICs.

These up-and-coming companies form a vital part of the future European growth. They will need encouragement and support to make it through to the big league and take their place in the world markets. And no one is under any illusions as to the enormity of the task ahead.

DATAQUEST ANALYSIS

The world semiconductor industry is currently undergoing great changes. Part of these changes will involve a period of natural selection--those companies that can adapt to the new realities will survive and prosper. More and more it is the quality of management and strength of financing that will determine the eventual winners and losers.

Europe may in the past have been outmanufactured and outmarketed, but it is determined not to be outmaneuvered. There is no shortage of the raw materials for success. Today's European managers are inherently every bit as resourceful, pragmatic, opportunistic, and hungry as their U.S. and Japanese counterparts. European R&D programs are on a par with the best in the world. European financial institutions have the funds for investment, and European governments can implement the necessary fiscal and social reforms.

But, most importantly, the realization that sustained economic growth depends on Europe having a world class electronics industry has dawned. Europe now has the will to grow substantial market share in the world semiconductor market. The first results are already starting to emerge.

Mark Giudici
Malcolm Penn

SUIS Code: Newsletters
1986-3

WORLD CONSUMPTION UPDATE: WORLD SEMICONDUCTOR CONSUMPTION REBOUNDS IN 1986

WORLD OVERVIEW

In 1985, semiconductor sales were down sharply in all major regions of the world. Of the four major regions--North America, Japan, Europe, and Rest of World (ROW)--North American sales showed the strongest decline at 27.0 percent. DATAQUEST believes that the worst is behind us, however. We expect growth in the first quarter of 1986 in all world regions, including North America. This projected first quarter growth should point the industry on the way to recovery and allow it to realize world growth of 16.4 percent in 1986. We believe that 1987 will be an exceptional year in all regional markets, with the world averaging 32.6 percent growth.

JAPAN BECOMES THE LARGEST MARKET

Our regional forecast points to some startling news in market size. As shown in Table 1, the Japanese market is projected to exceed the North American market in 1986.

Table 1

REGIONAL GROWTH RATES AND MARKET SHARE
(In Percent)

	Yearly Growth			Market Share		
	1985	1986	1987	1985	1986	1987
North America	(27.0%)	10.8%	34.9%	38.8%	36.9%	37.5%
Japan	(2.8)	28.4	30.6	34.8	38.4	37.8
Europe	(3.6)	6.3	29.8	18.7	17.1	16.7
ROW	(16.6)	14.7	37.1	7.7	7.6	8.0
Total	(15.0%)	16.4%	32.6%	100.0%	100.0%	100.0%

Source: DATAQUEST
March 1986

The U.S. market is expected to pick up some share again in 1987, although it is not expected to recover its former status. Note that much of the growth that Japan realizes in 1986 is due to currency exchange. Japan gains about 19.0 percent merely from currency exchange because of a strengthening yen to dollar. Our forecast also indicates that European consumption will decline as a percentage of the total between 1985 and 1987. The European market, however, gained considerable market share in 1985 relative to its 1984 level. That market is actually leveling to a normal growth cycle. Our data also indicate that the ROW region will grow slightly to 8.0 percent in 1987.

END MARKETS KEY TO MARKET STRENGTHS AND WEAKNESSES

The severity of regional market declines in 1985 was determined largely by each region's end-market focus. The computer/data processing market was exceptionally weak and, consequently, hurt those markets focusing heavily on this area. More stable were the applications areas of consumer electronics and telecommunications.

North America/U.S. Market

With a heavy 40 percent emphasis on computers, the North American market witnessed the most severe decline of all regional markets. The U.S. market noted a sales decline of 27.0 percent. Key to the weakness of the computer market was the computer OEMs' misjudgement of actual consumption. A buying/production cycle was created at the computer level that impacted component suppliers. Inventory in 1984 was accumulated far in excess of actual needs. This inventory is now perceived to be leveling to a more normal volume, which will lead to steady booking and shipment activity. Booking and shipment levels appear to be correcting in many product areas. It is this expectation that points to a 3.9 percent North American market growth in the first quarter of 1986. DATAQUEST believes that normal inventory depletion will continue the quarterly growth pattern through 1986, for a yearly total of 10.8 percent. In 1987, we expect quarterly growth to continue. We believe that 1987 will be a year of strong growth (34.9 percent) in the U.S. market. In terms of levels of consumption, however, it is not until 1987 that we expect consumption to return to the level of 1984.

Japanese Market

The Japanese market was among the more favorable in terms of the 1985 market decline. A heavy emphasis on consumer applications was largely responsible for this stability. DATAQUEST identifies the sales decline in the Japanese market at a modest 2.8 percent in 1985. As stated earlier, we expect the Japanese market to surpass the U.S. market in dollar volume in 1986. The exchange rate is responsible for a good portion of this increase. In yen, the Japanese market is expected to grow about 9.4 percent. Current exchange notes that the U.S. dollar is worth about 203 yen, down significantly from 1985's average of about 237 yen. Our current forecast, incorporating the yen valuation, shows the Japanese market growing 28.4 percent in 1986, far beyond the world average of 16.4 percent. In 1987, we expect Japanese market growth to be on a par with the world, at 32.6 percent.

European Market

With end-market focus primarily in the relatively stable and growing area of telecommunications, the European market was not as seriously affected as either the North American market or ROW market. The European market declined by approximately 3.6 percent in 1985. This modest decline allowed Europe to pick up market share relative to the world in 1985. It is expected, however, that this market share will revert to its normal level of about 16.6 percent (in 1984) of total sales. Note that Table 1 overstates Europe's market share because Europe gained over 2.0 percentage points in total market size in 1985. The decline in total percentage shown for years 1986 and 1987 brings Europe back to its 1984 market share of 16.6 percent.

ROW Market

The ROW region, like the Japanese market, focuses primarily on consumer-oriented products, a market that was relatively stable in 1985. Yet the ROW region also sees a large amount of activity from foreign and North American companies building computer equipment abroad. It is the balance of these factors that caused a market decline of 16.6 percent in 1985. As in other regions, we expect quarterly growth to be effective throughout 1986 and 1987. DATAQUEST projects ROW growth at 14.7 percent in 1986 and 37.3 percent in 1987.

WORLD PRODUCT TRENDS

In our quarterly world product forecast shown in Table 2, we project that MOS products will make a comeback in 1986. MOS and bipolar digital were the areas most strongly affected in 1985; both were down approximately 21 percent. The product area that noted the strongest decline, however, was MOS memory, which dropped about 36.3 percent worldwide. In this memory area, steep quarterly growth is required to pull it up from its 1985 trench. We believe that this growth is realistic and forecast that MOS memory will be up 12.0 percent in 1986. MOS microprocessor devices and MOS logic are also expected to show good growth that will continue to build momentum into 1987. Our estimated MOS technology growth in 1987 is a lofty 49.5 percent, raised through high recovery expectations for MOS memory and MOS micro devices. Bipolar products are also projected for growth, but they are not as dramatic in percentage terms as MOS digital products. Other product areas of linear, discrete, and optoelectronics that did not decline severely in 1985 are not expected to ramp up as quickly as harder hit product areas.

Mark Giudici
Barbara A. Van
Howard Z. Bogert

Table 2

ESTIMATED WORLDWIDE QUARTERLY SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1985	Q1/86	Q2/86	Q3/86	Q4/86	1986	% CHG 1985-86
Total Semiconductor	24737	6354	6862	7389	8178	28783	16.4%
Total IC	18858	4751	5176	5642	6334	21903	16 1%
Bipolar Digital	3778	895	962	1053	1172	4082	8.0%
Memory	595	143	154	167	178	642	7.9%
Logic	3183	752	808	886	994	3440	8.1%
MOS Digital	10313	2551	2834	3147	3653	12185	18.2%
Memory	4008	903	1048	1186	1446	4583	14 3%
Micro Devices	2751	735	792	857	971	3355	22.0%
Logic	3554	913	994	1104	1236	4247	19.5%
Linear	4767	1305	1380	1442	1509	5636	18 2%
Discrete	4691	1258	1323	1370	1450	5401	15.1%
Optoelectronic	1189	345	363	377	394	1479	24.4%

	Q1/87	Q2/87	Q3/87	Q4/87	1987	% CHG 1986-87
Total Semiconductor	8657	9240	9827	10439	38163	32.6%
Total IC	6800	7339	7920	8439	30498	39.2%
Bipolar Digital	1233	1275	1302	1299	5109	25.2%
Memory	179	183	188	194	744	15.9%
Logic	1054	1092	1114	1105	4365	26.9%
MOS Digital	3973	4332	4746	5156	18207	49 4%
Memory	1584	1733	1928	2103	7348	60.3%
Micro Devices	1071	1192	1325	1467	5055	50 7%
Logic	1318	1407	1493	1586	5804	36.7%
Linear	1594	1732	1872	1984	7182	27.4%
Discrete	1445	1471	1468	1540	5924	9.7%
Optoelectronic	412	430	439	460	1741	17.7%

Source: DATAQUEST
March 1986

Nielsen Dataquest USER UPDATE

SUIS Code: Newsletters
1986-2

THE 32-BIT MICROPROCESSOR BIG PICTURE: VENDORS AND USERS COME TO GRIPS WITH COMPLEXITY

SUMMARY

The race to support 32-bit microprocessor (MPU) users is going full bore. Innovation has continued despite the industry's staggering performance over the last 16 months. The evidence is evident from the number of 32-bit MPU suppliers currently on the market and those that are poised to enter it.

Along with this race goes an increasingly complex decision-making process for the user. Technically, the engineering group must select a product family that meets the design specifications of the end product. Top-level management, including marketing, must decide if the features and performance will position the system properly in the market. The operations/manufacturing groups must acquire and implement this advanced semiconductor in a reliable and cost-effective manner.

Currently, more than 13 suppliers have 32-bit MPUs in one form or another. These suppliers include system companies such as Digital Equipment and NCR. In any case, performance is the spotlight issue. Users will face a potentially formidable task: choosing and making a complex design work with one of these microprocessor families.

This newsletter will provide an overview of the issues pertaining to the 32-bit MPU market and how they affect the potential users. An in-depth evaluation of this subject can be found in the recently published 32-bit microprocessor report in the Product Analysis service section of the SUIS Volume 1 notebook. Subsequent newsletters will highlight further developments as they occur.

The topics to be addressed here are:

- The current supplier roster
- Basic technical comparisons
- The market outlook and trends

CURRENT SUPPLIERS: NOW AND FUTURE

The vendor list grows rapidly. Table 1 shows ten current manufacturers with proprietary architectures and lists their production schedules. As the table indicates, there is a mixture of technologies and origins. Although the majority are U.S. vendors, the number of European and Japanese entries is likely to increase.

Table 1

32-BIT MICROPROCESSOR AVAILABILITY

Manufacturer	Device	Process	Sample	Production
AMD	29300	Bipolar	Q4/1984	Q4/1985
AT&T	WE 32200	CMOS	Q3/1986	-
	WE 32100	CMOS	Q2/1985	Q4/1985
	WE 32000	CMOS	Q1/1981	Q1/1981
Fairchild	CLIPPER	CMOS	Q3/1985	Q1/1986
Hitachi	HD 63020	CMOS	Q4/1986	Q1/1987
Inmos	T414	CMOS	Q4/1984	Q3/1985
Intel	80386	CMOS	Q4/1985	Q3/1986
	lAPX 423	NMOS	Q3/1981	Q1/1982
Motorola	68020	CMOS	Q2/1984	Q1/1985
National	32332	NMOS	Q4/1985	Q2/1986
	32032	NMOS	Q4/1983	Q2/1984
NEC	V70	CMOS	Q1/1987	-
TI	32032	NMOS	Q4/1983	Q2/1984
Zilog	Z80,000	NMOS	Q1/1986	-

Source: DATAQUEST
March 1986

The European Connection

Inmos is pioneering a unique area in microcomputing. Its Transputer incorporates a RISC-like (Reduced Instruction Set Computer) architecture with local RAM storage and inter-CPU channels for communications. Inmos is focusing on very high-performance applications where many Transputers will be interconnected. This forms an intricate multiprocessor structure wherein each CPU device executes its own task. These are not typical general-purpose microprocessors--the ASP will reflect this fact. Expect the Transputer devices to be at the high end of the ASP range at about $400.

Other European companies will most likely be involved in second-source agreements as time proceeds. An example of this is Thomson Semiconductor. Now that it has purchased Mostek, we expect a strong influence to be exerted to execute a second-source deal for Motorola's 68020.

The Japanese Are Coming

The Japanese semiconductor manufacturers are making strong headway in the total microprocessor segment. In 1985, five of the top ten MPU suppliers were Japanese. There is no doubt that these companies will make a strong showing in the 32-bit arena as well. Table 1 shows NEC with its forthcoming V70 MPU, but there are about six other Japanese suppliers that have designs in the works.

Other 32-Bit MPU Suppliers

The following list shows suppliers that are either just now entering the market or will be soon. Complete specification data are not available yet, but will be published in later newsletter updates.

- Digital Equipment Corporation
- Fujitsu
- Hitachi
- Mitsubishi
- NCR
- Oki
- Sony
- Thomson/Mostek
- Toshiba
- WaferScale International

TECHNICAL COMPARISONS

From an architectual standpoint, most of the MPUs stress several common aspects and/or concepts. A review of these products' software-related features (Table 2) and the hardware-related features (Table 3) provides insight into their commonalities and key attributes.

Table 2

SOFTWARE-RELATED FEATURES

Manufacturer	Product	General-Purpose Registers	Address Modes	Instruction Types	Debug/Trace	Address Space (Physical)	Virtual Memory	Execution Levels
AT&T Tech.	32100	9 (32 bit)	13	183	Via traps	4 gigabytes	4 gigabytes	4
Fairchild	CLIPPER	32 (32 bit)	9	114	Via traps	4 gigabytes	4 gigabytes	2
Inmos	T414	3 (32 bit)	1	All programming done in HLL	Via ANALYSE input	4 gigabytes	N/A	N/A
Intel	80386	8 (32 bit)	11	151	6 regs	4 gigabytes	64 terabytes	4
Motorola	68020	16 (32 bit)	18	105	Via traps/regs	4 gigabytes	4 gigabytes	2
National	32032	8 (32 bit)	9	128	Via traps/regs	16 megabytes	16 megabytes	2
	32332	8 (32 bit)	9	128	Via traps/regs	4 gigabytes	4 gigabytes	2
Zilog	Z80,000	16 (32 bit)	9	253	Via traps	4 gigabytes	4 gigabytes	2

N/A = Not Applicable

Source: DATAQUEST
March 1986

Table 3

HARDWARE-RELATED FEATURES

Manufacturer	Product	Bus Type	MMU	Cache	Multiprocessor Support	Segmented Addressing	Paged Addressing	Pipeline (Queue)	Dynamic Bus-Sizing	I/O Addressing
AT&T Tech.	32100	Nonmultiplexed	WE32101	Instruction (64 words)	Yes	Yes	Yes	8-byte queue	No	Memory mapped
Fairchild	CLIPPER	Multiplexed	2 chips (in module)	Data and instruction (part of MMU)	Yes	No	Yes	4-stage pipeline	No	Memory mapped
Inmos	T414	Multiplexed (memory bus)	N/A	None	Yes	N/A	N/A	2 word instruction prefetch	No	Memory mapped
Intel	80386	Multiplexed	On-CPU	None	Yes	Yes	Yes	16-byte queue	Yes	Direct and memory mapped
Motorola	68020	Nonmultiplexed	MC68851	Instruction (256 bytes)	Yes	No	Yes	3-stage pipeline	Yes	Memory mapped
National	32032	Multiplexed	32082	None	Yes	No	Yes	8-byte queue	No	Memory mapped
	32332	Multiplexed	32382	None	Yes	No	Yes	20-byte queue	Yes	Memory mapped
Zilog	Z80,000	Multiplexed	On-CPU	Data and instruction	Yes	Yes	Yes	6-stage pipeline	No	Direct and memory mapped

N/A = Not Applicable

Source: DATAQUEST
March 1986

Reduced and Complex Instruction Sets

More and more is being heard about the reduced instruction set computer (RISC) architecture. Yet it appears that a commanding majority of the 32-bit MPU devices introduced are complex instruction set computers (CISCs). The exceptions so far are Inmos and Fairchild products. The Inmos Transputer series is programmed through a high-level language called OCCAM. The company intends to modularize the application into tasks suitable for each CPU in a multiple-Transputer environment. As a result, the instructions are limited to that which the OCCAM language supports. Fairchild has the fewest discrete mnemonic instruction types and considers its CLIPPER module to be Cray-like in structure.

The balance of the suppliers will have typical broad mixtures of instructions, ranging from simple MOVEs to more complex character-string and bit-manipulation operations.

Virtual Memory: A Requirement

All of the MPU devices support a virtual memory environment. This is especially critical as most of the MPU suppliers are targeting technical applications that would run under the UNIX operating system.

The MMU and Paged Addressing

Only two of the suppliers we interviewed felt that putting the memory management unit (MMU) on the CPU device was necessary for added performance. The others have chosen a separate MMU device as a solution, coupled by a high-speed coprocessor interface. In either case, the MMU is a complex function and must match the performance of the CPU to adequately handle the large address spaces.

To that end, paged addressing is found in all of the MPU device architectures. On-demand paging speeds up the manner in which an expansive virtual memory hierarchy is controlled.

Instruction Pipelining

The concept of a pipeline or a queue (these sometimes differ) is certainly pervasive in the 32-bit designs. The need for high throughput and the existence of more complex instruction operation codes (op codes), gave rise to this mechanism. In some cases, the queue itself is deemed more effective than a typical high-speed cache.

MARKET EXPECTATIONS AND TRENDS

By 1990, this new generation of advanced architectures will create a significantly larger market than 16-bit devices. The market will be larger in terms of revenue and investment dollars, at least for the supplier base. Table 4 shows the 32-bit microprocessor history and forecast for revenue and estimated ASPs.

Table 4

ESTIMATED 32-BIT MICROPROCESSOR REVENUE AND ASP

	1983	1984	1985	1986	1987	1988	1989	1990
Revenue ($M)	$1.60	$1.20	$ 16.80	$ 36.12	$57.79	$89.58	$134.3	$194.8
ASPs			$175	$125	$82	$64	$ 52	$ 42

Source: DATAQUEST
March 1986

The 32-bit microprocessor user, on the other hand, will contend with a myriad of products from a diverse vendor base. Designers will select from a variety of implementations including very-high-speed bit-slice MPUs and standard cells.

Technical Trends

The transition to 32-bit microprocessors may occur more rapidly than the transition from 8-bit to 16-bit microprocessors because of architectural compatibility and a higher level of user experience.

The following trends are appearing for both the devices and applications:

- CMOS technology is dominating new designs.
- Die sizes are exceeding 350 x 350 mils.
- Modular design approaches are gaining popularity.
- Off-chip cache is tightly coupled to the MPU.
- New packaging techniques are being developed.
- Testing is a major factor in manufacturing.

ASP Factors and Directions

Manufacturers of 32-bit microprocessors have entered a price competition. During the next two years, prices are expected to decrease 50 percent from their current levels. Most 32-bit MPUs will be priced at less than $100 in a few years, while their 1990 prices could be close to that of today's 16-bit microprocessors. Cost-to-performance ratios in the future will be excellent since MPUs tend to offer constant performance at a decreasing price.

The 32-bit microprocessor ASPs will be affected by factors such as: new product introductions, processor clock rates, manufacturing volume, and package complexity. The package type and pin count will have a definite effect, as a nonmultiplexed bus requires more pins. If vendors are targeting a higher-performance market area with a more complex design, they will surely be at the higher end of the ASP curve. AT&T, Fairchild, and Inmos are examples of this trend as ASPs here are in the $300 to $400 range. Intel and Motorola most likely fall in the middle between $100 and $300, while National might be on the lower end at $100 or less. DATAQUEST has heard that a few users of lower-end products were quoted prices well under $100 in late 1985. Table 4 shows DATAQUEST's ASP expectations based on all 32-bit MPU devices currently being shipped.

DATAQUEST ANALYSIS

DATAQUEST believes that users should be particularly aware of three key aspects of the 32-bit MPU area:

- Technical
- Market
- Business

Technical Aspects

The leading architectures will emerge in time. In the past, four or five architectures constituted 75 percent to 80 percent of the market for 8- and 16-bit MPUs. We expect the 32-bit microprocessors to follow the same trend. As mainstream products go, vendors such as Intel, Motorola, and National will probably be the leaders, since their architectures are upward-downward compatible. This compatibility factor prompts many users to consider the benefits of offering end products in a low-, middle-, and high-range performance/feature format. This in turn simplifies the programmer's task since the basic programming model remains constant overall.

In addition, suppliers of CMOS devices will have an edge with the user community. Although most of the current entrants are using CMOS, performance upgrades and increased function density will only be possible via CMOS technology. National and Zilog are both using NMOS processing on their MPUs. The CMOS process, necessary for further enhancements and generations, is not always implemented immediately. However, if these vendors are to remain competitive in the overall sense, they will need to shift to a total CMOS technology, perhaps keeping NMOS as a pilot technology.

Applications drive the requirement for various support components. Many system designs will need the appropriate floating-point unit coprocessor (FPU) for complex, fast arithmetic. However, with the memory address capacity of the 32-bit parts, the memory management unit will figure heavily in most applications. Hence, vendors that have a fully functional MMU matching the performance of the MPU will be a prime choice for the prospective customer.

One trend at the higher end is that of incorporating the MMU on the MPU chip. There are advantages and disadvantages to having it either on or off the MPU die. Zilog, Intel, and, in a limited manner Fairchild, stress the performance benefits and logical reasoning behind an integrated MMU. It is, however, a complex logic function that requires considerable silicon area to implement and causes some reliability concerns. Fairchild's CLIPPER is a dual-bus system module and, therefore, necessitated a partitioned MMU design. Again, this is being targeted as a very high-end supervisory engine in a niche market area.

Market Aspects

A market examination indicates that not all of the potential suppliers may survive. Many will have to become niche product vendors as various applications open up; the Fairchild CLIPPER and Inmos Transputer are currently in this category. Even Zilog's Z80,000 is something of a specialized device. It has many of the attributes of a mainstream part but its very advanced architecture and potential performance level may keep it out of the main race. Many engineers feel that it is far ahead of its time, which is not surprising as Zilog has pioneered leading-edge MPU technology since the introduction of the Z80.

One other market aspect of microprocessors is that of acceptance. Historical market data indicate a five- to six-year introduction phase before these devices begin to grow. Once the rapid growth phase is entered, they tend to ride on the peak of their product life curve for quite awhile. For example, the 8085 and Z80 devices are at least ten years old, but constituted about 33 percent and 29 percent, respectively, of total MPU shipments over the last year.

What this implies to users is that support in the form of operating software, applications software, design, and multiple-sourcing takes awhile to solidify. Large-volume shipments and stabilized lead times then become a reality.

Business Aspects

The business component is equally important in evaluating and selecting a high-impact device of this nature. Usually a top-down approach is best in determining which "family architecture" is most appropriate.

While sheer cost is usually always an issue, many other support issues come into play. Two important items are multiple sourcing and vendor track records. Second sources will be coming on for the next couple of years, while those suppliers without a proprietary architecture align themselves with a primary vendor. Texas Instruments signed very early-on with National Semiconductor for the NSC32000 series family. The TI/National relationship has been billed as a full-support agreement, which lends credence to National for its entrance into the MPU arena, and to TI for its remaining active in leading-edge technology. There is speculation and curiosity regarding the direction that companies such as Intel, Motorola (Thomson/Mostek appears probable), and AT&T will take. Currently, Zilog, NEC, and Sony are involved together, but their exact relationships are not defined.

A vendor's track record can bode positively or negatively for the user. The track record may include various aspects of the supplier's performance. Delivery, design assistance, and sheer market presence with past products and efforts tells the user base of a vendor's commitment. National has tried more than once to get into the 16/32-bit MPU market; TI and Fairchild have had no interim solutions with performance MPUs; and Zilog has been trying to deliver its advanced designs.

DATAQUEST CONCLUSIONS

Since the user's time-to-market for end products is increasingly critical as technology advances proliferate and competition toughens, a decision concerning a semiconductor computing engine (SCE) becomes equally critical. The 8-bit to 16-bit shift posed a break in technology for most users. A transition to 32-bits from 16-bits (where appropriate) should be easier, but entails more complexities than ever. The decision becomes a strategic-executive involvement with repercussions that will be felt throughout the user organization.

Brand A. Parks

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DRAM PRICES: STABLE AND RISING

The heyday of the supercheap 64K DRAM is history as prices slowly climb from their July 1985 spot price low point of $0.35 to a more stable $0.70 to $0.85 contract ASP. The embattled 256K DRAM ASP has also stabilized, settling at a contract price of $2.20 at year-end 1985. Spot prices for both of these parts are slightly lower.

64K DRAM

Several events in the past eight weeks have been responsible for the turnaround of the steep price spiral for 64K DRAMs, including:

- Texas Instruments' hard-line refusal of orders below a 90 cent ASP
- The exit from the 64K market of former heavyweights--Fujitsu, Intel, Mostek, Motorola, National, and Toshiba
- The strengthening of the Japanese yen relative to the U.S. dollar
- Dumping accusations made by the U.S. Department of Commerce

The results of these events are reflected in the quarterly shipment figures listed in Table 1.

The contract price for the 64K DRAM rapidly slid below the experience curve to a low point in the third quarter of approximately $0.70. We believe that 64K DRAM pricing will stabilize, with the price hovering around a $0.90 to $1.00 contract ASP through 1986 (see Table 2). The 64K DRAM experience price curve (see Figure 1) illustrates how approximately $1.3 billion in premiums above the experience price line gained in 1983 and 1984 have been partially offset by the approximate $300 million loss incurred in 1985.

256K DRAM

The 256K DRAM price decline has been one of the fastest declines in memory. As with the 64K DRAM, multiple forces were responsible for the 256K price slide:

- The release of the part during the worst recession in electronics history
- A wait-and-see attitude regarding the introduction of the 256K replacement--the 1-Mbit DRAM
- The 64K DRAM's being more than price competitive with the 256K part in 1985

With current prices at between $1.90 and $2.10, we expect price declines to slow as production comes into line with the order rate. We estimate variable costs to be $0.85 for the most efficient manufacturers (see Table 3). Prices should be higher than $2.00 to make a profit. The only non-Japanese manufacturer producing parts in the United States is Micron Technology. Fujitsu, Hitachi, and NEC rank as the highest producers. Prices (see Table 2) are expected to drop to $1.65 by year-end 1986. The 256K DRAM experience price curve (see Figure 2) illustrates how earlier gains made in late 1983 and in 1984 ($556 million) have been partially offset by losses in 1985 ($324 million).

1-MBIT DRAM

This year will be the first year of production for the 1-Mbit DRAM (see Figure 3). Depending on the production capability of the primary supplier, Toshiba, unit volumes could range from 6.5 million to 35 million units. The two scenarios we are closely scrutinizing are shown in Table 4. Volume production is not expected to be required until 1987, when major end users will begin ordering this part in quantity. We will keep our clients informed as to which situation occurs.

BUYER ADVISORY

DRAM prices (both unit and price per bit) are significantly below their respective experience price curves (see Figures 1, 2, and 4). The question is, How long can semiconductor manufacturers sell parts at half the expected experience curve price and remain in business?

The unit volumes required to bring prices back in line with expectations, even if prices remain at current levels, are unreasonably high (4.5 billion 64K parts at $0.90, and $1.75 billion 256K parts at $2.00). Companies that have invested in semiconductor plants that cost $100 to $200 million each and that plan on recouping their investments by selling DRAMs had better have deep pockets or be able to utilize their facilities for other technologies (i.e., gate arrays).

One of the ways companies are cutting their costs is through process and yield enhancements (Table 3). Reduced die sizes and improved techniques have substantially reduced costs to the point where efficient manufacturers can make marginal profits at prices of $0.90 and $1.90 for the 64K and 256K DRAMs, respectively.

Another way to cut costs is to strategically ship inventoried products at prices more favorable than those at the time when the product was produced. The inertia of the 1984 boom market left many semiconductor manufacturers holding excess inventory of 64K DRAMs in the first half of 1985. We estimate that 160 million 64K DRAMs have been inventoried since the first quarter of 1985 (see Table 1), with the majority of those parts having been built in Japan. We believe that this inventory will be strategically sold in 1986 as demand increases, thus leaving near-term production capacity available for other products.

OUTLOOK

We foresee DRAM prices stabilizing; in some cases (64K DRAMs) they will rise, but in all cases a slowing of the downward price trend will occur. Political pressures, the effects of international exchange rates, capacity utilization, and improved productivity all will result in stabilized near-term prices.

By the third quarter of 1986, the resumption of slow, gradual DRAM price reductions will occur. We foresee 64K DRAM contract prices going no lower than $0.80 and 256K DRAMs gravitating around $1.90 each through the first half of 1986. Acting as a bellwether for pricing, DRAM spot prices will be slightly higher than contract prices for the 64K part, while the 256K spot prices will gradually decline, signaling the market trend toward higher use and the production economies yet to be realized by this part.

We advise buyers to work closely with their preferred vendors now to prepare for a tightened 256K market in the first half of 1986 and the resumption of slower overall price reductions beginning in the third quarter of this year.

Mark Giudici

Table 1

ESTIMATED 1984 AND 1985 DRAM QUARTERLY SHIPMENTS

	1984					1985				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
64K DRAM										
Units (millions)	157.7	192.1	237.5	265.4	852.7	165.0	150.0	135.0	150.0	600.0
Percent Change	-	24.0%	18.1%	9.0%	129.1%	(37.7%)	(9.1%)	(10.0%)	11.1%	(29.7%)
May 1985 FCST 64K							235.0	240.0		
Excess inventory (DQ 5/85 FCST--1st half 1985 actuals)							70.0	90.0		
256K DRAM										
Units (millions)	2.6	6.6	11.7	17.0	37.9	20.7	30.9	56.2	86.3	194.3
Percent Change	135.0%	150.0%	99.0%	45.0%	2,129.0%	21.0%	49.0%	82.0%	54.0%	412.7%

Source: DATAQUEST
January 1986

Table 2

ESTIMATED AVERAGE SELLING PRICES (ASP) AND SPOT MARKET PRICES FOR 64K AND 256K DRAMS

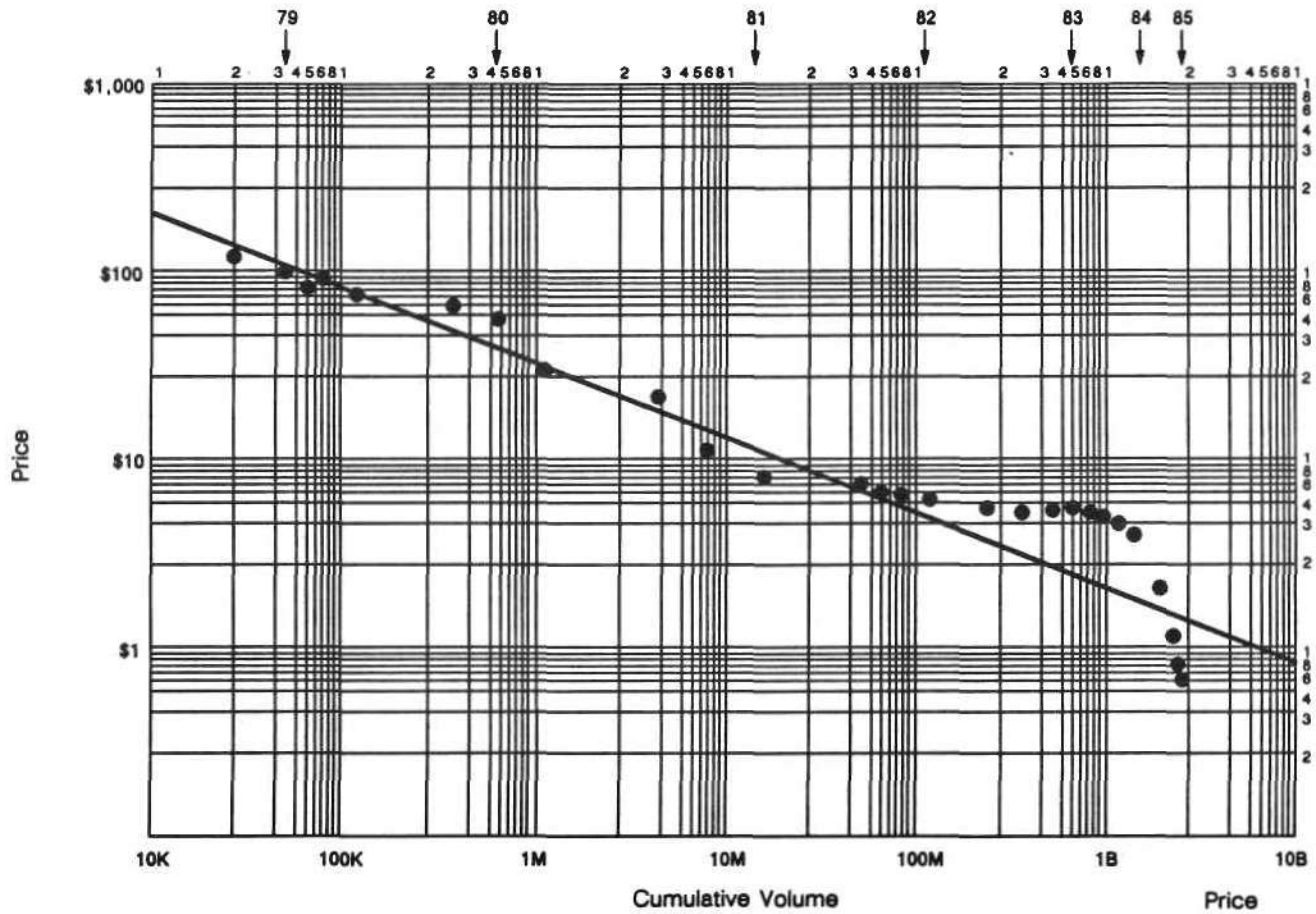
	1985					1986				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
64K DRAM										
ASP	$1.70	$1.10	$ 0.80	$ 0.80	$1.30	$ 0.90	$ 0.90	$ 0.90	$ 0.90	$ 0.90
Spot	$0.70	$0.50	$ 0.35	$ 0.50	-	$ 0.50	$ 1.10	$ 1.10	$ 1.05	-
256K DRAM										
ASP	$9.00	$7.00	$ 2.80	$ 2.20	$5.75	$ 2.00	$ 1.80	$ 1.70	$ 1.65	$ 1.70
Spot	$4.00	$3.25	$ 2.50	$ 2.00	-	$ 1.75	$ 1.50	$ 1.60	$ 1.50	-
1Mb DRAM	N/A	N/A	$160.00	$125.00	-	$50.00	$35.00	$25.00	$15.00	-

N/A = Not Applicable

Source: DATAQUEST
January 1986

Figure 1

64K DRAM EXPERIENCE PRICE CURVE



Source: DATAQUEST
January 1986

Table 3

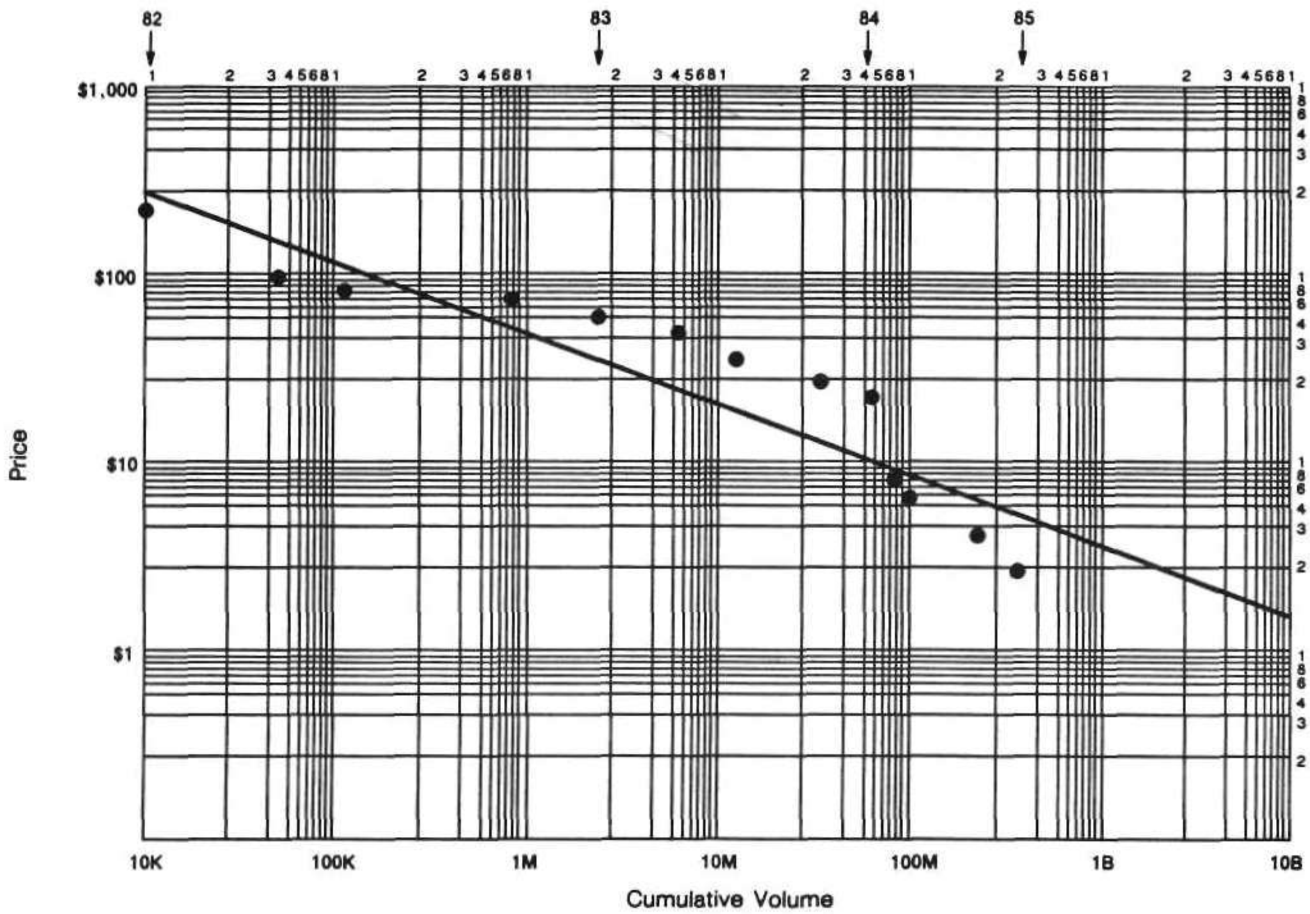
DRAM COST MODEL

	64K		256K	
	1985	1986	1985	1986
Wafer Sort				
Wafer Size (inches diameter)	5.0	5.0	6.0	6.0
Processed Wafer Cost ($)	70.0	70.0	100.0	90.0
Die Size (square mils)	25,000	25,000	45,000	38,000
Gross Die/Wafer	706	706	565	669
Unyielded Die Cost at Sort ($)	0.0991	0.0991	0.1770	0.1345
Sort Cost/Die ($)	0.0118	0.0101	0.1592	0.0534
Wafer Sort Yield (%)	86	86	75	78
Sorted Die Cost ($)	0.1297	0.1277	0.4455	0.2415
Assembly				
Assembly Cost/Die ($)	0.06	0.05	0.10	0.09
Assembly Yield (%)	0.95	0.95	0.90	0.92
Assembled Die Cost ($)	0.2334	0.2208	0.6400	0.3950
Final Test				
Test Time/Assembly (seconds)	4.0	3.5	30.0	15.0
Test Cost/Hour ($)	25	25	45	25
Test Cost/Assembly ($)	0.0049	0.0046	0.24	0.0411
Final Test Yield (%)	0.90	0.92	0.90	0.90
Tested Unit Cost ($)	0.2902	0.2664	0.7546	0.5547
Mark, Pack, and Ship				
Back-End Cost (99% yield)	0.03	0.02	0.10	0.10
Total Variable Cost/Part	0.3202	0.2864	0.8546	0.6547

Source: DATAQUEST
January 1986

Figure 2

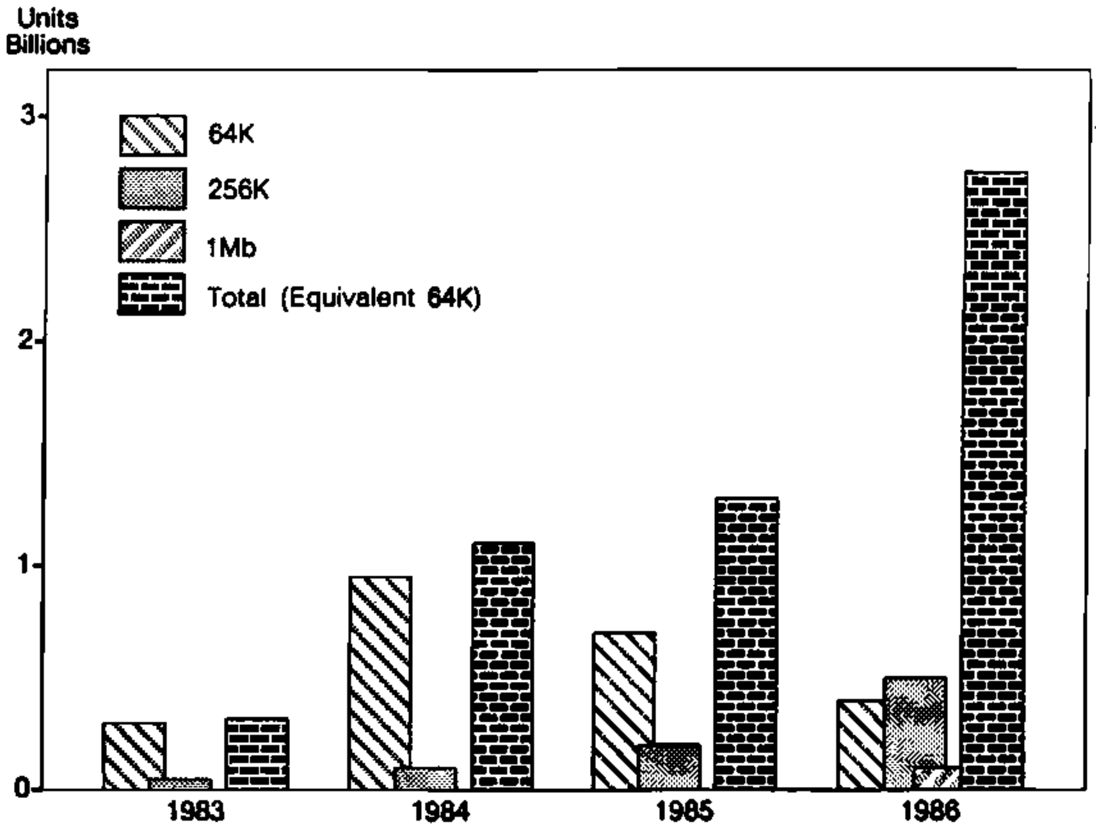
256K DRAM EXPERIENCE PRICE CURVE



Source: DATAQUEST
January 1986

Figure 3

DRAM SHIPMENTS



Source: DATAQUEST
January 1986

Table 4

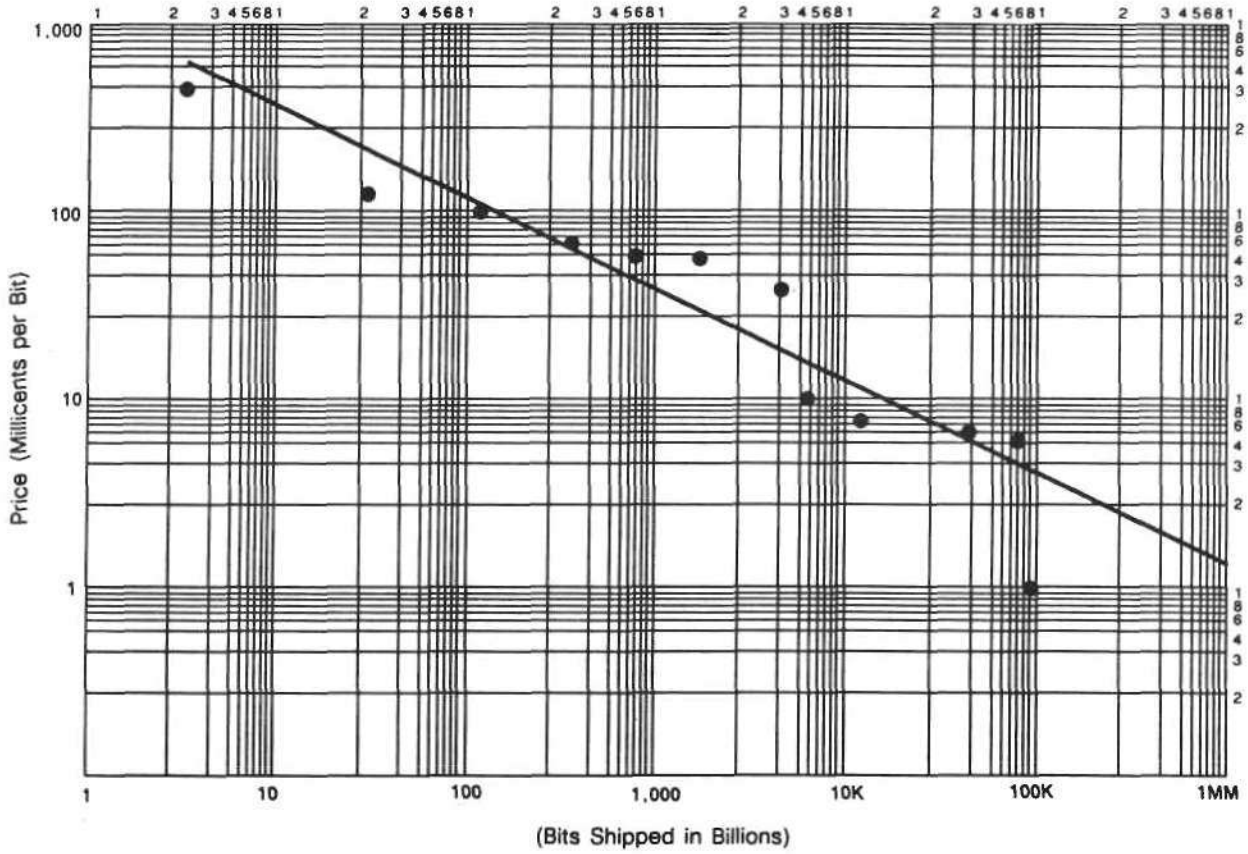
TWO 1-MBIT PRODUCTION SCENARIOS

	1986				
	Q1	Q2	Q3	Q4	Total
Scenario 1--					
Toshiba has limited production					
Units (millions)	0.50	1.00	2.00	3.00	6.50
ASP	$35.00	$30.00	$22.00	$16.00	$21.50
Scenario 2--					
Strong Toshiba ramp up					
Units (millions)	2.00	4.00	11.00	18.00	35.00
ASP	$33.00	$23.00	$16.00	$13.00	$16.20

Source: DATAQUEST
January 1986

Figure 4

DRAM EXPERIENCE CURVE



Source: DATAQUEST
January 1986