Semiconductor Industry Service
1984–1985 Newsletters

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1984-1985 SIS Newsletter Index

The 1984-1985 SIS NEWSLETTER INDEX is a quick reference guide to the titles and tables in our newsletters. It is structured as follows:

- Titles and tables are organized by keyword and company.
  - Pages 2-4 are a company list, e.g., Intel, Motorola.
  - Pages 5-18 are a subject list, e.g., MPU, Dynamic RAM.
- The month and year follow each title listing in the Index. Refer to the month's menu to locate the newsletter or table. Newsletter titles and tables are filed by month published.

We will update this Index quarterly.

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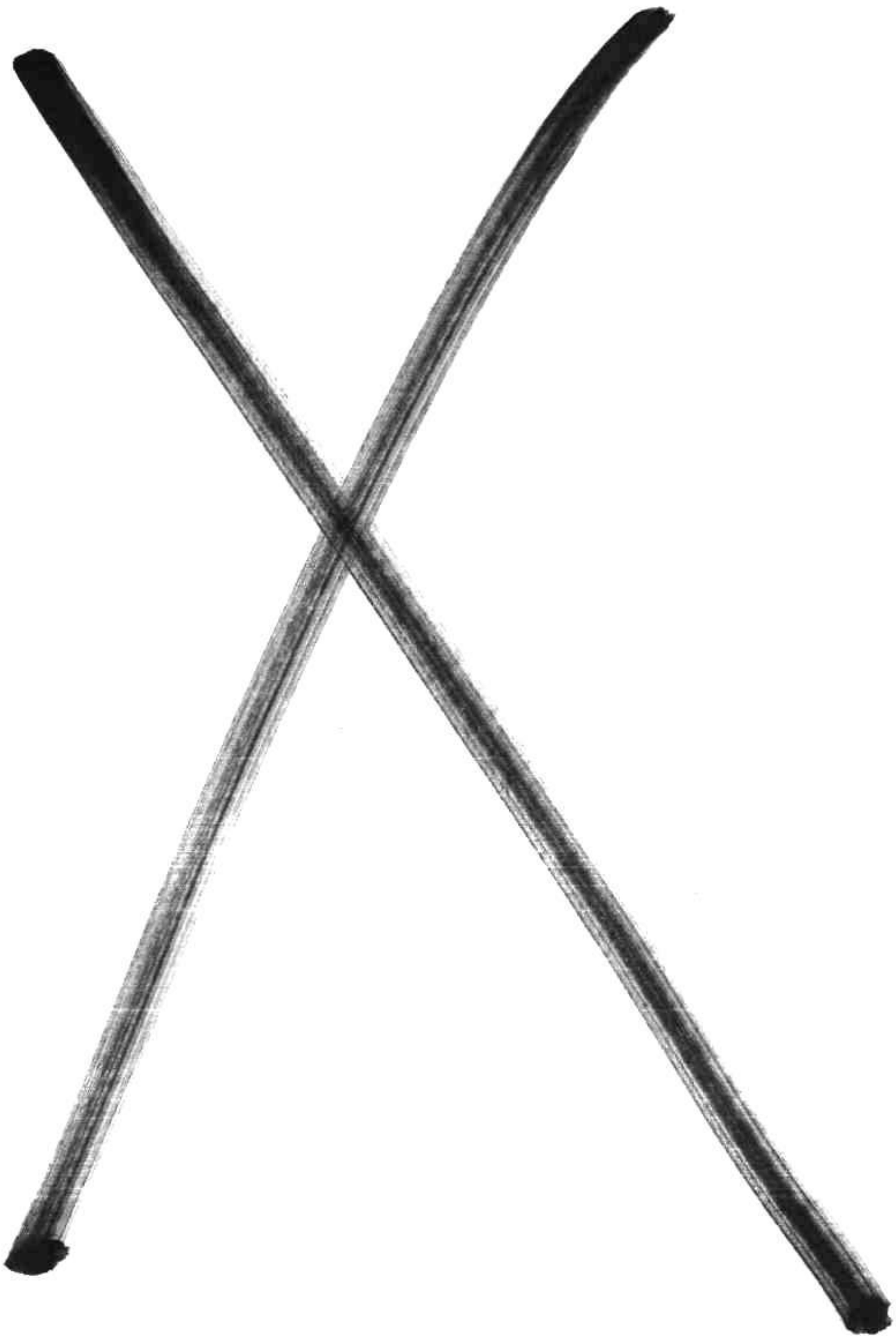

January Newsletters

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- Wafer-Scale Integration - The New Direction of VLSI
- Fujitsu and Texas Instruments Announce Alternate Sourcing of Gate Arrays
- Surface Mount Technology

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: January

WAFER-SCALE INTEGRATION - THE NEW DIRECTION OF VLSI

SUMMARY

Wafer-scale integration: Although it is an idea that may not be new, it is a technology whose time has come. Recent improvements in processing and yield enhancement techniques make it possible.

IC chips are currently mounted in packages in which the ratio of package area to chip area is typically 10 to 1 or more. This wasted space carries over to the PC board when the packages are assembled to form systems. It is therefore logical to consider techniques for connecting chips on the wafer in order to increase the packaging density.

Wafer-scale integration (WSI) combines hundreds of dedicated circuits on a wafer to provide a significant system function. Advantages of WSI compared to PC board systems are shorter propagation delay times, greater reliability, and lower costs.

The approaches to WSI are varied. Trilogy Systems of Cupertino, California, uses functional blocks containing two-dimensional arrays of hundreds of small processing areas connected with a network of programmable switches, along with local redundant storage to improve yield. Trilogy uses ECL gates for high speed, and the wafer heat sink is required to dissipate up to 50 watts/cm^2.

Two start-ups are Mosaic Systems of Troy, Michigan, and Wafer Scale Integration of Santa Clara, California. Both companies will use CMOS technology and redundant storage to improve yields. Mosaic's approach is concerned with a clever kind of packaging and routing system, whereas Wafer Scale Integration will use standard cells for nonvolatile memories using 2μ CMOS process.

New technologies for IC processing are being researched at laboratories around the world. The most interesting concept is that a programmed laser can be used to perform all processing steps needed to make high-density ICs over a large wafer.

Applications for WSI range from PCs to mainframes and to large volatile and nonvolatile memories.

A comparison of WSI memory with PC board memory of the same capacity reveals the following:

- WSI requires one-tenth the area of a PC board
- The interconnect leads in WSI will be one-third to one-fifth the length of leads for PC boards
- The price of WSI memory will be about 0.45 times the price of board memory

INTRODUCTION

The interconnection of dedicated circuits on a wafer to provide a functioning system is called wafer-scale integration (WSI). The wafer can be regarded as a single giant chip with significant system capabilities. DATAQUEST believes WSI is an important new technology that is likely to be more prominent in the future.

Some of the reasons for interest in WSI:

- Increased speed, resulting from shorter interconnection lengths
- Improved system reliability, resulting from fewer interconnections
- Reduced cost per function, resulting from economies of scale
- Versatility plus compatibility with either serial or parallel data processing

For WSI to be sucessful requires reasonable solutions to many difficult new problems, so that in processing there will be a high probability of obtaining one functioning system per wafer. The problems include:

- Yield and parameter control over large areas
- System architecture and circuit design
- CAD design and circuit performance simulation
- Packaging and heat dissipation
- The development of new logic and testing techniques

APPROACHES TO WSI

Gene Amdahl's five-year-old company, Trilogy Systems Corporation in Cupertino, California, is dedicated to WSI as an approach to system design. The wafers are organized by zones or blocks, each dedicated to a specific computer (system) function, i.e., RAM, ROM, drivers, etc. Within the blocks are hundreds of small sites distributed in a two-dimensional array. The spaces between the storage areas (sites) are occupied by a network of programmable switches with local redundant storage for each site. By virtue of the small area of the sites, the probe yield is significantly improved even though the block may be as large as one centimeter square. During testing, a CAD system puts redundancy into operation for each local site if needed. The layout of blocks employs a high degree of symmetry to shorten interconnects and reduce the effects of small thermal gradients. Trilogy has developed special testers and techniques for both series and parallel testing. ECL gates are used, switching in times as short as 0.3 ns but requiring the liquid-cooled heat sink in contact with the wafer to handle up to 50 watts/cm^2, with an elevation in temperature of 50 to 60°C.

The two-dimensional array with programmable switching networks can also be configured to algorithms suitable for mostly parallel data processing for digital signal processing applications, including vector and matrix multiplication, convolutions, transforms, etc. These are called systolic arrays. The data flow through the array so that at the end of the cycle each processing element has contributed its proper input to the solution of the problem.

Mosaic Systems Inc. of Troy, Michigan, is a start-up with a simple approach to WSI fabrication. Mosaic's approach to WSI is in terms of packaging rather than innovative circuit design. In one form of packaging, two metal grids are aligned at right angles at the top and bottom of a disk of amorphous silicon. In the open spaces in the grid system, ICs are bonded to the metal lines. Programmable electrical fusing is used to connect the ICs. Mosaic uses CMOS technology to reduce heating problems.

Another approach is used by Wafer Scale Integration, a start-up in Santa Clara, California. This company is building a standard cell library for nonvolatile memories using 2μCMOS designs. Using an advanced CMOS process, the company will produce custom devices and special memories. Redundancy will be used to boost yields to high values for memory systems on wafer.

New technologies for IC processing are being explored at laboratories around the world. The most interesting concept is that a programmed laser can be used to perform all processing steps needed to make high-density ICs over a large wafer at one processing station. The recent development of high-power excimer lasers operating at wave lengths in the far ultraviolet has advantages over other energy sources, including other lasers. Functioning transistors have been made by writing directly on silicon with the laser without the use of photo resist. The goal is to put millions of transistors on a wafer. Another attractive feature of this processing method is that the laser can be used to test and correct faults during processing, thus assuring high yields.

APPLICATIONS AND MARKETS

We expect WSI to be applied to computers ranging in size from PCs to mainframes. There will also be applications for large-capacity RAMs and ROMs.

It is interesting to compare cost/performance characteristics for large RAM units mounted on a wafer to conventional circuits mounted on a PC board.

Table 1 shows the comparison of wafer area, PC board area, and costs projected to December 1986 for a memory of 5 megabytes composed of 160 blocks of 256K bits. The WSI model for calculation is based on a block containing a two-dimensional array of elements. Redundancy is used to improve yield by methods outlined in the DATAQUEST Research Newsletter, "Redundancy Update," dated 29 December 1982. We expect the yields for wafer and board memories to be about 0.6 by December 1986. From the pricing model in the same newsletter, we estimate a price for the WSI wafer of approximately 2.5 millicents/bit. The board-mounted memory price is estimated to be 2.2 times greater, due to the additional circuits required for drivers and for board assembly and test costs.

CONCLUSION

WSI memory has the following advantages over board memory:

- Shorter circuit interconnections
- Greater reliability
- Smaller size
- Lower cost

Thomas Holland

Table 1

PRICE-PERFORMANCE COMPARISON OF WAFER AND PC BOARD MEMORIES

	WSI	Board
Capacity	5 Mbytes	5 Mbytes
Memory Block	256K bits	256K bits
Number of Blocks	160	160
Block Area	0.074 in^2	0.06 in^2
Chip Carrier Area	N.A.	0.6 in^2
Wafer/Board Area	11.8 in^2	100 in^2
Relative Component Cost	100%	120%
Relative PC Board Interconnect Cost	0%	100%
Total Relative Cost	100%	220%

N.A. = Not Applicable

Source: DATAQUEST
January 1984

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: January

FUJITSU AND TEXAS INSTRUMENTS ANNOUNCE ALTERNATE SOURCING OF GATE ARRAYS

Texas Instruments (TI) and Fujitsu Limited have entered into an alternate sourcing agreement covering the design, manufacture, and marketing of the following Fujitsu bipolar and CMOS gate arrays:

CMOS	Bipolar
C-440H	B-240
C-770H	B-350
C-1275H	B-600
C-2000H	B-1100
C-2600VH	
C-3900H	
C-3900VH	
C-8000VH	

Under the provisions of this agreement, Fujitsu will grant TI a nonexclusive, worldwide license to manufacture and market CMOS and bipolar arrays. In return, TI will provide Fujitsu with its Transportable Design Utility (TDU), which is a CAD system for quick gate array design. This agreement will allow a TI customer to source a gate array with Fujitsu. Fujitsu customers, in turn, will be able to obtain gate arrays from TI without converting their circuit description to TI's Transportable Interactive Design Automation Language (TIDAL™).

DATAQUEST believes that both firms have taken a significant step toward standardization of a very rapidly expanding market. Currently, there are 68 firms actively engaged in the gate array market and we expect 1984 to be a year when many firms will move to strengthen their alternate sources. The user community, the workstation manufacturers, and the semicustom chip suppliers are all feeling a need for a common interface. As the year unfolds, pressure for an industry-wide standard will mount.

Andrew Prophet

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: January

SURFACE MOUNT TECHNOLOGY

In order to reduce end-product size, a growing number of system manufacturers are implementing surface mounting of semiconductor packages.

In 1983, more than 9,000 part numbers were available in surface mountable packages. Prices for some of these packages are rapidly moving to parity with more typical package types. Surface mountable packages include:

- Small outline (SO) packages
- Leaded and leadless chip carriers
- Quad packs
- SO transistors and diodes
- Ceramic chip capacitors
- Resistors fabricated with thick- and thin-film techniques

In surface mounting, interconnect traces are screen printed onto the surface of the PC board. The components are put into position with automated pick-and-place equipment. Components can either be glued down or held in place, prior to solder reflow, by the slightly adhesive solder paste.

Surface mount technology offers overall board size reduction of as much as 50 percent, cost savings, and improved reliablility. These improvements are due to the following:

- Components can be mounted on both sides of the board.
- The number of board layers is reduced.
- Plated through-holes are eliminated.
- Assembly is fully automated.

- Placement equipment runs at higher throughout rates than is possible with insertion equipment.

- Inductive effects are decreased because package leads are shorter.

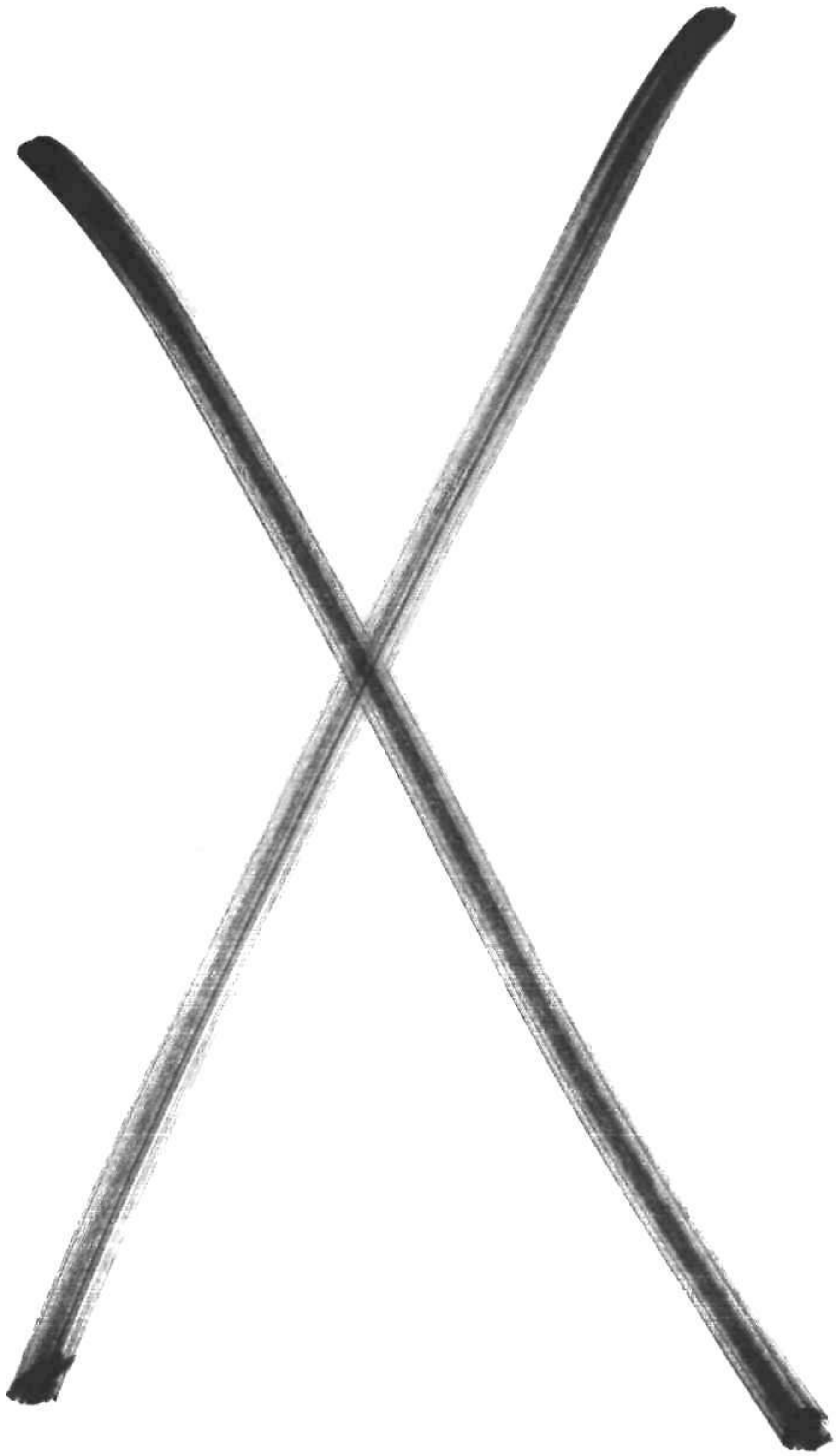
- Shorter distances between components allows elimination of some of the semiconductors usually required for driving capacitive loads.

- A surface mount assembly line requires fewer pieces of equipment and less manufacturing space because certain types of equipment, such as lead clinching machines, are not necessary.

- Cost-effective onshore assembly is possible as the process can be fully automated.

Companies offering products in which a premium is placed on small size will need to adopt surface mount assembly technology in order to remain competitive. Some products already incorporating surface mounting include the Kodak Disk Camera, Convergent Technology's Workslate, computer disk drives, and medical monitoring or drug delivery systems that are worn by the patient.

Gail Kelton-Fogg



February Newsletters

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

- EPROM, EEPROM, and ROM Shipments 1983 Year-End Review
- Continued Microcontroller and Microprocessor Market Growth Create Shortages
- Preliminary 1983 Market Share Estimates

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: February

EPROM, EEPROM, AND ROM SHIPMENTS
1983 YEAR-END REVIEW

DATAQUEST's Semiconductor Industry Service recently published the EPROM, EEPROM, and ROM Shipments Service Section, which can be found in the Products and Markets notebook. This Newsletter highlights some of the information from the new service section. For more details, please contact the SIS notebook holder in your organization.

SUMMARY

The EPROMs market grew more than 50 percent from 1982 to 1983--$795 million compared to $525 million. EEPROMs grew 60 percent over the same time period, to $103 million. However, mask ROMs declined 24 percent, from $718 million in 1982, to $545 million in 1983. Table 1 gives the quarterly revenues for 1983 and totals for 1982 and 1983.

Table 1

ESTIMATED MOS NON-VOLATILE MEMORY MARKET
(Millions of Dollars)

	1982	1983				
	Year	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
EPROMs	$ 525	$160	$173	$207	$255	$ 795
EEPROMs	64	18	25	28	32	103
Mask ROMs	718	148	132	123	142	545
Total	$1,307	$326	$330	$358	$429	$1,443
U.S. Mfrs. SOM	71%	68%	64%	60%	59%	61%
Japanese Mfrs. SOM	28	31	35	39	40	38
European Mfrs. SOM	1	1	1	1	1	1
Total	100%	100%	100%	100%	100%	100%

Source: DATAQUEST
February 1984

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EPROMS

Early in the second quarter of 1983, the demand for EPROMs began to strengthen considerably, and the market continued strong through the year-end. Since that time, demand has been strong at all densities from 16K to 256K. Table 2 shows the quarterly unit shipment totals for each density in the EPROM market. Markets for high-density 128K and 256K devices remain relatively undeveloped, while the more mature 16K and 32K devices have proven to be stable in units and volume.

Table 2

ESTIMATED WORLDWIDE MOS EPROM SHIPMENTS
(Thousands of Units)

	1982					1983				
Density	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
8K	645	430	480	300	1,855	270	250	145	75	740
16K	11,400	10,990	10,250	10,190	42,830	10,130	11,100	12,540	13,130	46,900
32K	8,500	10,985	12,180	12,450	44,115	13,310	14,875	15,600	15,275	59,060
64K	1,470	3,210	5,685	7,765	18,130	10,400	13,250	18,210	24,800	66,660
128K	3	15	55	155	228	520	1,115	1,925	2,995	6,555
256K					0	5	10	50	145	210

Source: DATAQUEST
February 1984

CMOS EPROMs

During the first half of 1983, Eurotechnique, Fujitsu, and National Semiconductor were the only manufacturers that had CMOS EPROMs on the market. Late in the second quarter, Hitachi announced availability of 64K CMOS EPROMs and Rockwell announced 32K devices. In the fourth quarter, Signetics began shipping its high-performance 64K device and Toshiba sampled its 256K CMOS EPROM. CMOS EPROMs continue to get a substantial price premium over their NMOS counterparts--sometimes 100 percent--but total business volume is still exceedingly low, probably less than $15 million in the first half of 1983, and an estimated $25 million in the second half.

Prospects for 1984

Capacity increases and the production ramp-up of plastic packaged EPROMs (OTPs) are the critical issues surrounding EPROM market development in 1984. Although lead times and prices were reasonably stable through the third and fourth quarters of 1983, we expect Intel's much-discussed 6-inch line in Albuquerque, which produces the company's 256K EPROM and the 11,000-square mil 64K die (for plastic packages), to significantly impact the market by the second half of 1984.

EEPROMS

EEPROMs made significant strides toward wide availability, standardization, and volume shipments as Intel, Seeq, and Xicor increased their stakes in this emerging market. Unit shipments for 16K EEPROMs for the 1983 year totaled 1,890,000, up considerably over 1982's total of 562,000. Fourth quarter 1983 shipments totaled 650,000 16K EEPROM units, up 176 percent from fourth quarter 1982's 235,000 units.

Xicor began volume shipments of its X2816A, which incorporates 5-volt programming and latches. In the third quarter, Intel began shipping its own 5-volt programmable part, the X2817A, to supplement its earlier 16K EEPROMs. Seeq increased its production of 16Ks steeply throughout the year, and often employed aggressive pricing.

The low-density end (less than 2K bytes) of the market grew about 55 percent in 1983--from about $30 million in 1982 to $47 million in 1983. This growth was largely the result of new efforts made by a few manufacturers that are focusing on the low-density end of the business.

Higher-density devices--32Ks from Seeq and NCR, and 64Ks from Seeq and Xicor--appeared in the second half of 1983. The 64K devices, with die sizes of 35,000 and 42,000 square mils, respectively, established the feasibility of using current technologies to build higher-density devices.

Prospects for 1984

The EEPROM market promises to undergo strong growth and continued chaotic development during 1984, with systems using EEPROMs going into volume production, new start-ups introducing EE parts, and new EE products being introduced by mainline MOS memory suppliers. In the next 18 months, 14 different 64K EEPROMs are scheduled for introduction.

ROMS

After two years of growth in excess of 50 percent per year, the mask ROMs market has weakened continuously since year-end 1982. The market is still undergoing considerable readjustments. The traditional mask ROM business in EDP, telecom, word processors, and other display devices, has begun to strengthen along with the economy and small systems--home and personal computers have grown tremendously.

Few manufacturers were able to hold their year-end 1982 shipment levels of 64Ks in the face of declining shipment rates into the video games market. After extremely strong unit growth throughout 1982 (Table 3), sales of 64Ks peaked at year-end 1982, and have been almost flat since. The 32K ROM market was even harder hit due to the migration to higher-density devices, and the increasing amount of ROMs sold as loose die, which reduced ASPs and value added for ROMs manufacturers.

The largest supplier of 128K ROMs continued to be NEC Corporation. In 1983, Mostek and Toshiba were the largest suppliers of 256K ROMs, primarily on the strength of their business into the IBM PC, which has been replacing 64K ROMs with 256K devices.

Table 3

ESTIMATED WORLDWIDE MOS ROM SHIPMENTS
(Thousands of Units)

	1982					1983				
Density	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
64K	6,400	10.395	15.430	24,220	56,445	24,270	22,000	23,635	27,015	96,920
128K	378	485	592	768	2,223	1,278	2,005	3,502	5,787	12,572
256K	30	50	100	220	400	390	710	1,175	2,360	4,635

Source: DATAQUEST
February 1984

Prospects for 1984

By year-end 1983, the impact of declining sales into the video game business had worked through and, for the market as a whole, growth had resumed. However, by 1985, we should see a continuation of the EPROM encroachment on ROM markets that was seen so often in 1981-1982.

MOS NON-VOLATILE MEMORY OUTLOOK--1984

The complexion of the MOS Non-Volatile/Read-Only Memory market has changed markedly since one year ago, and we expect continued repercussions throughout 1984. While 1983 ended with stable (and often somewhat inflated) prices, capacity increases, especially in EPROMs, will help supply to meet the present market demand.

Katy Guill
Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: February

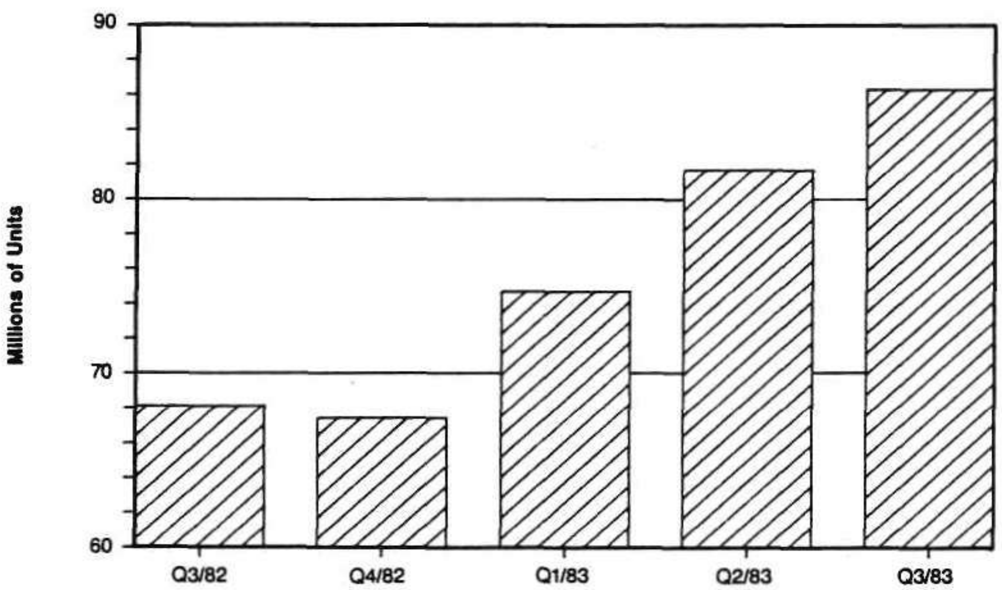
CONTINUED MICROCONTROLLER AND MICROPROCESSOR MARKET GROWTH CREATES SHORTAGES

SUMMARY

The past turmoil in personal and home computers was reflected in the shipments of microprocessors during the third quarter of 1983. Overall, as shown in Figure 1, the microcontroller and microprocessor market grew only 5.6 percent because of substantial declines caused by poor sales and product cancellations within the personal and home computer industry.

Figure 1

ESTIMATED WORLDWIDE SHIPMENTS OF MICROPROCESSORS AND MICROCONTROLLERS



Source: DATAQUEST
February 1984

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

The book-to-bill ratio for microcontroller and microprocessor products was 4 to 1 or higher. Lead times typically have stretched between 20 and 40 weeks, with delivery of some parts quoted at 52 weeks. Manufacturers and distributors are refusing to book orders beyond a year and are choosing their customers. New start-up companies have found that the vigorous economy is a mixed blessing that provides growth opportunities on one hand, but offers restrictive component shortages on the other hand.

INDUSTRY TRENDS

Shipments

Worldwide shipments of microcontrollers and microprocessors grew from an estimated 81.7 million units in the second quarter of 1983 to approximately 86.3 million units in the third quarter of 1983, for an overall growth of 5.6 percent. Microcontrollers grew 7.9 percent from 61.9 million units to 66.8 million units in the third quarter, while microprocessors decreased 1.8 percent from 19.8 million units to 19.4 million units. Although overall growth was lower than for previous quarters, shipments of newer-generation products grew approximately 20 percent.

Lead Times

Lead times for most microcontroller and microprocessor components presently range from 20 to 40 weeks. Users who are doing business directly with manufacturers are frustrated and cautious about future supplies, but suppliers are usually meeting their committed or allocated delivery schedules. In many situations, better business relationships are developing between customers and their suppliers. Manufacturers are realistically communicating their capabilities and are asking their customers for accurate forecasts of their needs. Some manufacturers are not accepting orders beyond their ability to deliver, while others have developed allocation methods that are made clear to customers at the time of order. DATAQUEST believes that this kind of communication will continue and that it represents a maturing process that will add stability to the industry.

Other users, however, are now learning the real cost of their opportunistic buying patterns of the past, because suppliers are giving priority to customers who remained loyal during the recent bad years. Some new start-ups are also having difficulty with the present supply situation because they have not had enough time to establish good business relationships with microprocessor suppliers. These companies may not be able to capitalize on the current boom because their growth will be restricted by limited component availability.

Pricing

Average selling prices rose by 5 percent to 10 percent during the third quarter of 1983. Part of this increase was due to shipments of higher-cost packages, faster speed grades, and parts with wider temperature range that buyers accepted in place of standard components. Furthermore, manufacturers raised prices during the second quarter so purchase agreements are being renewed at higher prices. During the third quarter ASPs began to reflect those price increases.

Leading Products

Five 8-bit microprocessors accounted for nearly 85 percent of the 8-bit microprocessor market during the third quarter. Although the overall 8-bit MPU market decreased approximately 1.8 percent, most of the leading products grew by more than 5 percent. The fastest growing 8-bit MPU is the 8088, which grew by more than 28 percent. The single exception is the 6502, which declined significantly because of substantially lower sales of home computers and games using this device. Estimated shipments for leading 8-bit microprocessors are shown in Table 1.

Table 1

ESTIMATED SHIPMENTS FOR LEADING 8-BIT MICROPROCESSORS
(Thousands of Units)

	Q2/1983		Q3/1983		Percent of Growth from
	Units	Percent of Shipments	Units	Percent of Shipments	Q2 to Q3
Z-80	6,515	36.2%	6,840	38.8%	5.0%
650X	4,210	23.4	2,709	15.4	(35.7%)
8085	2,212	12.3	2,660	15.0	20.2%
6802	1,300	7.3	1,414	8.0	8.8%
8088	985	5.5	1,265	7.2	28.4%
Others	2,751	15.3	2,756	15.6	0.2%
Total	17,973	100.0%	17,644	100.0%	(1.8%)

Source: DATAQUEST
February 1984

Although 16-bit MPUs declined slightly during the third quarter, the newer products grew by more than 26 percent, as shown in Table 2. The fastest growing product in this group is the 80186, which grew by more than 133 percent.

Table 2

ESTIMATED SHIPMENTS FOR SECOND-GENERATION 16-BIT MICROPROCESSORS (Thousands of Units)

	Q2/1983		Q3/1983		Percent of Growth from Q2 to Q3
	Units	Percent of Shipments	Units	Percent of Shipments	
8086	478	62.2%	585	60.1%	22.4%
80186	18	2.3	42	4.3	133.3%
68000	150	19.5	200	20.5	33.3%
Z8000	98	12.7	117	12.0	19.4%
16032	25	3.3	30	3.1	20.0%
Total	769	100.0%	974	100.0%	26.7%

Source: DATAQUEST
February 1984

DEFINITIONS

The following definitions apply to the terms used in this DATAQUEST Research Newsletter. They should help the reader understand the quantitative data and supporting text that follows. Our definitions are:

- Allocation--When demand for a product exceeds the supply, manufacturers adopt various methods to allocate the parts fairly among all purchasers. Usually each buyer will receive the same percentage of the parts scheduled for delivery each month. Some manufacturers also give consideration to how far in advance the order was placed; if an order has been delinquent; legal obligations; and profit margins.

- Shipments--Unit shipments are estimates of actual product movements to all market channels including:

  - Manufacturer's internal usage (boards and systems)

  - Distribution (stocking distributor and user shipments)

  - OEMs and end users (domestic and international)

Actual user consumption may be lower than the estimated unit shipments due to distributor stocking and the manufacturer's internal usage inventories. Since MCUs are generally not sold through distributors due to the logistical requirements of the on-chip ROM, our estimated MCU shipments should approach actual user consumption. MPUs, however, are distributor-oriented products, and estimated shipments could exceed actual user consumption by from 10 percent to 30 percent, depending upon the product maturity and the inventory cost impact on the distributor.

- Microcontroller (MCU)--DATAQUEST defines a microcontroller as a single-chip component that contains ROM, EEPROM, or EPROM storage; RAM; Input/Output circuits; and a CPU function. Microcontrollers should be capable of standalone operation. Many microcontrollers are offered in ROM-less versions for prototype development. These devices are included in microcontroller shipment data since unit volumes are usually small.

- Microprocessor (MPU)--DATAQUEST defines a microprocessor as either a single-chip component or a collection of architecturally dependent devices that function as the CPU in a system. The microprocessor could contain some Input/Output circuits, but generally cannot operate in a standalone fashion.

Mel Thomsen
Jan Rey

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: February

PRELIMINARY 1983 MARKET SHARE ESTIMATES

The year 1983 recorded dynamic growth for semiconductors. Most product categories experienced dramatic growth with the strongest being MOS Digital Technology. The MOS Memory and MOS Logic areas grew significantly at 38.0 and 33.9 percent, respectively. The greatest strength was seen in microprocessors, however, which grew approximately 50.0 percent. In the MOS Technology area, exceptional growth was seen in CMOS, which increased 52.1 percent. Substantial growth was also seen in the Linear category, at 24.6 percent. Slower growth was evident in the Discrete/Opto area as shown in Table 1, primarily due to slow growth in Discretes.

Table 1

ESTIMATED WORLDWIDE MARKET GROWTH
(1982 to 1983)

Total Semiconductor	25.8%
Total IC	32.8%
MOS	39.5%
Total Discrete/Opto	7.7%

Source: DATAQUEST
February 1984

SEMICONDUCTOR MARKET SHARES

For the top 30 semiconductor manufacturers, revenues increased by 26.6 percent. The company mix by regional base includes 9 Japanese companies with an average revenue increase of 42.5 percent, 5 European companies with an average increase of 1.8 percent, and 16 U.S. companies with an average increase of 24.8 percent. European companies actually experienced stronger growth than the 1.8 percent noted, but due to reporting in U.S. dollars, which have been exceptionally strong against European currencies, the rate appears artificially low. The top 8 companies in the total semiconductor category remained unchanged in rank positioning. Remarkable, however, was AMD's move from fourteenth place in 1982 to tenth place in 1983. Other notable shifts can be seen in Table 2, for example, Matsushita, Sanyo, Mostek, SGS-Ates, Oki, and TRW.

Table 2

1983 LEADERS IN SEMICONDUCTORS - 1983 VERSUS 1982
(Millions of Dollars)

Rank 1983	Rank 1982	Company	1982	1983	% Change
1	1	Texas Instruments	$ 1,305	$ 1,638	25.52%
2	2	Motorola	1,219	1,547	26.91%
3	3	NEC	1,075	1,413	31.44%
4	4	Hitachi	877	1,181	34.66%
5	5	Toshiba	714	983	37.68%
6	6	National	673	845	25.56%
7	7	Intel	625	775	24.00%
8	8	Fujitsu	465	688	47.96%
9	10	Matsushita	426	600	40.85%
10	14	AMD	329	505	53.50%
11	9	Philips	457	469	2.63%
12	11	Fairchild	410	450	9.76%
13	13	Mitsubishi	338	440	30.18%
14	12	Signetics	340	435	27.94%
15	15	Siemens	329	333	1.22%
16	18	Sanyo	241	329	36.51%
17	19	Mostek	220	315	43.18%
18	17	RCA	273	303	10.99%
19	16	General Instrument	313	293	(6.39%)
20	20	Sharp	192	279	45.31%
21	23	SGS-Ates	175	230	31.43%
22	27	Oki	129	229	77.52%
23	25	Harris	156	198	26.92%
24	21	ITT	190	185	(2.63%)
25	24	AMI	156	153	(1.92%)
26	28	TRW	120	144	20.00%
27	22	Thomson	176	141	(19.89%)
28	26	TELEFUNKEN elect.	143	134	(6.29%)
29	30	MMI	70	133	90.00%
30	29	Analog Devices	101	124	22.77%
		Total	$12,237	$15,492	26.60%

Source: DATAQUEST
February 1984

INTEGRATED CIRCUITS MARKET SHARES

The ranking of the leading integrated circuit (IC) manufacturers has shifted considerably throughout the listing of the top 30 participants. Many of the Japanese companies moved upward in the listing. This reflects stronger growth in the Japanese market early in 1983 and the strong worldwide growth of the Dynamic RAM market where Japanese manufacturers have major market shares. In addition, the strengthening of the yen during the year added an apparent 5.8 percent to the growth in dollar sales of Japanese companies. Of the 30 leading IC manufacturers listed in Table 3, 9 are Japanese with an average revenue growth of 47.0 percent, 3 are European with an average growth of 19.6 percent, and 18 are U.S.-based with an average growth of 24.7 percent. Total change for the top 30 companies listed is approximately 32.7 percent.

Table 3

1983 LEADERS IN ICS - 1983 VERSUS 1982
(Millions of Dollars)

Rank 1983	Rank 1982	Company	1982	1983	% Change
1	1	Texas Instruments	$1,155	$ 1,535	32.90%
2	3	NEC	791	1,093	38.18%
3	2	Motorola	791	1,060	34.01%
4	6	Hitachi	607	912	50.25%
5	5	National	620	790	27.42%
6	4	Intel	625	775	24.00%
7	8	Fujitsu	427	618	44.73%
8	7	Toshiba	428	613	43.22%
9	11	AMD	329	505	53.50%
10	9	Signetics	340	435	27.94%
11	10	Fairchild	333	373	12.01%
12	12	Matsushita	249	367	47.39%
13	13	Mitsubishi	244	337	38.11%
14	15	Mostek	220	315	43.18%
15	14	Philips	230	246	6.96%
16	23	Oki	121	216	78.51%
17	17	RCA	185	216	16.76%
18	21	Sanyo	146	204	39.73%
19	19	Harris	156	198	26.92%
20	16	General Instrument	203	180	(11.33%)
21	18	Siemens	160	178	11.25%
22	22	SGS-Ates	126	177	40.48%
23	24	Sharp	115	164	42.61%
24	20	AMI	156	153	(1.92%)
25	29	MMI	70	133	90.00%
26	25	Analog Devices	101	124	22.77%
27	27	Synertek	88	96	9.09%
28	26	ITT	90	90	0.00%
29	30	Intersil	62	83	33.87%
30	28	Rockwell	80	83	3.75%
		Total	$9,248	$12,269	32.67%

Source: DATAQUEST
February 1984

DISCRETE/OPTO MARKET SHARES

Of the top five manufacturers in the Discrete/Opto market, four are Japanese. Motorola remains the leader with estimated revenues of $487 million for 1983. The average growth for the leading 30 manufacturers in this category is 6.9 percent. Most of the rapid growth experienced by the individual companies shown in Table 4 is due to Optoelectronics (Optos). The entire Optoelectronics industry grew by an estimated 23.1 percent in comparison to 4.0 percent for Discretes. The strength in Optos is coming from the Japanese.

Table 4

1983 LEADERS IN DISCRETE/OPTO - 1983 VERSUS 1982
(Millions of Dollars)

Rank 1983	Rank 1982	Company	1982	1983	% Change
1	1	Motorola	$ 428	$ 487	13.79%
2	2	Toshiba	286	370	29.37%
3	3	NEC	284	320	12.68%
4	4	Hitachi	270	269	(0.37%)
5	6	Matsushita	177	233	31.64%
6	5	Philips	227	223	(1.76%)
7	7	Siemens	169	155	(8.28%)
8	14	Sanyo	95	125	31.58%
9	20	Sharp	77	115	49.35%
10	10	General Instrument	110	113	2.73%
11	13	General Electric	100	109	9.00%
12	15	Mitsubishi	94	103	9.57%
13	8	Texas Instruments	150	103	(31.33%)
14	16	TRW	89	101	13.48%
15	12	ITT	100	95	(5.00%)
16	19	Hewlett-Packard	80	90	12.50%
17	17	RCA	88	87	(1.14%)
18	18	Int'l Rectifier	82	84	2.44%
19	11	TELEFUNKEN elect.	107	83	(22.43%)
20	22	Unitrode	71	78	9.86%
21	21	Fairchild	77	77	0.00%
22	9	Thomson	122	77	(36.89%)
23	27	Fujitsu	38	70	84.21%
24	24	Westinghouse	53	58	9.43%
25	23	National	53	55	3.77%
26	25	SGS-Ates	49	53	8.16%
27	26	Semikron	40	36	(10.00%)
28	28	Litronix	33	35	6.06%
29	30	Solitron	24	28	16.67%
30	29	Varo	28	27	(3.57%)
		Total	$3,601	$3,859	7.16%

Source: DATAQUEST
February 1984

MOS MARKET SHARES

Overall MOS market share is estimated to have increased by 39.5 percent in 1983. In the rankings of the top nine MOS manufacturers shown in Table 5, the Japanese made significant inroads in position. NEC displaced Intel as number one in sales volume by growing approximately 43.7 percent. Hitachi appears to have moved to number 3 position; however, if one discounts the exchange rate effect, Motorola remains third followed closely by Hitachi.

Table 5

1983 LEADERS IN MOS - 1983 VERSUS 1982
(Millions of Dollars)

Rank 1983	Rank 1982	Company	1982	1983	% Change
1	2	NEC	$ 547	$ 786	43.69%
2	1	Intel	573	720	25.65%
3	5	Hitachi	390	638	63.59%
4	3	Motorola	425	607	42.82%
5	4	Texas Instruments	400	572	43.00%
6	6	Toshiba	311	458	47.27%
7	7	Fujitsu	280	418	49.29%
8	9	Mostek	220	315	43.18%
9	8	National	235	300	27.66%
10	12	AMD	146	224	53.42%
11	15	Oki	106	197	85.85%
12	13	Mitsubishi	137	189	37.96%
13	17	Matsushita	89	160	79.78%
14	11	AMI	156	153	(1.92%)
15	10	General Instrument	183	152	(16.94%)
16	16	Sharp	100	145	45.00%
17	14	RCA	108	133	23.15%
18	18	Synertek	88	96	9.09%
19	21	Philips	61	87	42.62%
20	19	Rockwell	80	83	3.75%
21	20	Siemens	64	80	25.00%
22	29	NCR*	28	75	167.86%
23	26	Zilog	44	70	59.09%
24	25	SGS-Ates	45	68	51.11%
25	24	Harris	46	66	43.48%
26	30	Inmos	26	58	123.08%
27	22	ITT	56	56	0.00%
28	27	Signetics	38	55	44.74%
29	23	Fairchild	50	48	(4.00%)
30	28	Sanyo	28	47	67.86%
		Total	$5,060	$7,056	39.45%

*Merchant Market only

Source: DATAQUEST
February 1984

NOTE

Estimated growth rates relating to the product categories are based upon DATAQUEST's market share analysis, a bottom up approach. Slight modifications might be noted in further studies of 1983, due to the time factor involved in preliminary reporting. An analysis of regional sales and factory shipments, both historic and forecasted, is presently being prepared.

The 1983 Preliminary Market Share Estimates are presently available with the SIS notebook holder of your company. For further detail on any of the company revenue statistics mentioned, please refer to the attached list of Market Share Tables.

Barbara Van

Attachment A

INDEX OF TABLES

March

March Newsletters

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Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

THE MACINTOSH--A SIGNIFICANT DESIGN WIN FOR MOTOROLA'S 68000

SUMMARY

Apple Computer announced its latest personal computer--the Macintosh--on January 24, 1984. A member of Apple's new 32-bit "Supermicro" family, the Macintosh represents a new level of user-friendliness, achieved through extensive bit-mapped graphics combined with a hand-held "mouse" pointing device. The Macintosh uses the Motorola 68000 and is the first high-volume personal computer based on this powerful, 16/32-bit microprocessor. Figure 1 shows Apple's Macintosh with all the announced accessories, including numeric keypad, external disk drive, printer, modem, and carrying case.

Figure 1

APPLE COMPUTER'S MACINTOSH WITH ACCESSORIES

Source: Apple Computer, Inc.

HARDWARE FEATURES

The Macintosh has 128K Bytes of RAM memory using 64Kx1 industry-standard devices. The RAM section of the logic board is laid out to easily accept 256Kx1 dynamic RAMs (512K Byte capacity) when they become available on a production basis. DATAQUEST believes that they changeover to 256Kx1 DRAMs is a critical issue for the Macintosh and may delay availability of strategically important software packages, such as Lotus 1-2-3, that are extremely RAM-intensive.

The Motorola 68000, also used in Mac's big sister, Lisa, provides all of the processing resource for the extensive bit-mapped graphics, peripheral interface, and file maintenance. At first glance, using the 68000 sounds like overkill for a small personal computer, but the Macintosh has proven that today's user wants, as Steve Jobs (Apple chairman) says, "a radical improvement in ease of use" for "a truly, friendly desktop appliance," and the 68000 seems perfectly suited to that function. Table 1 gives the Macintosh's specifications.

Table 1

MACINTOSH PRODUCT SPECIFICATIONS

Central Processor	Motorola 68000 (7.8336 MHz)
Memory	128K Bytes Dynamic RAM 64K Bytes ROM
Disk	Sony 3.5-inch "Hard Shell" 410K Bytes (formatted)
Display	Samsung 9-inch, high-resolution, B/W, 512 x 342 pixels (bit-mapped)
Keyboard	58 keys, 2-key rollover, S/W mapped optional numeric keypad
Mouse	Mechanical tracking, 90 pulses/inch
Sound	Four voices
Clock/Calendar	CMOS with battery backup
Communications	Two RS-232/RS-44 serial ports 230.4 Kbaud maximum 920 Kbaud (external clocking)
Weight	8.9 kg (19.5 lbs)

Source: DATAQUEST
March 1984

SYSTEM PACKAGING

The Macintosh uses a simple but elegant packaging design that minimizes the number of functional modules, for lower manufacturing costs, while maximizing reliability and service. Figure 2 shows a partially assembled Macintosh with CRT, disk drive, and PC boards installed. There are only two printed circuit boards: the analog board, for power supply, audio speaker, and CRT interface; and the logic board (four-layer), for microprocessor, memory, and peripheral interface circuits.

Figure 2

PARTIALLY ASSEMBLED MACINTOSH

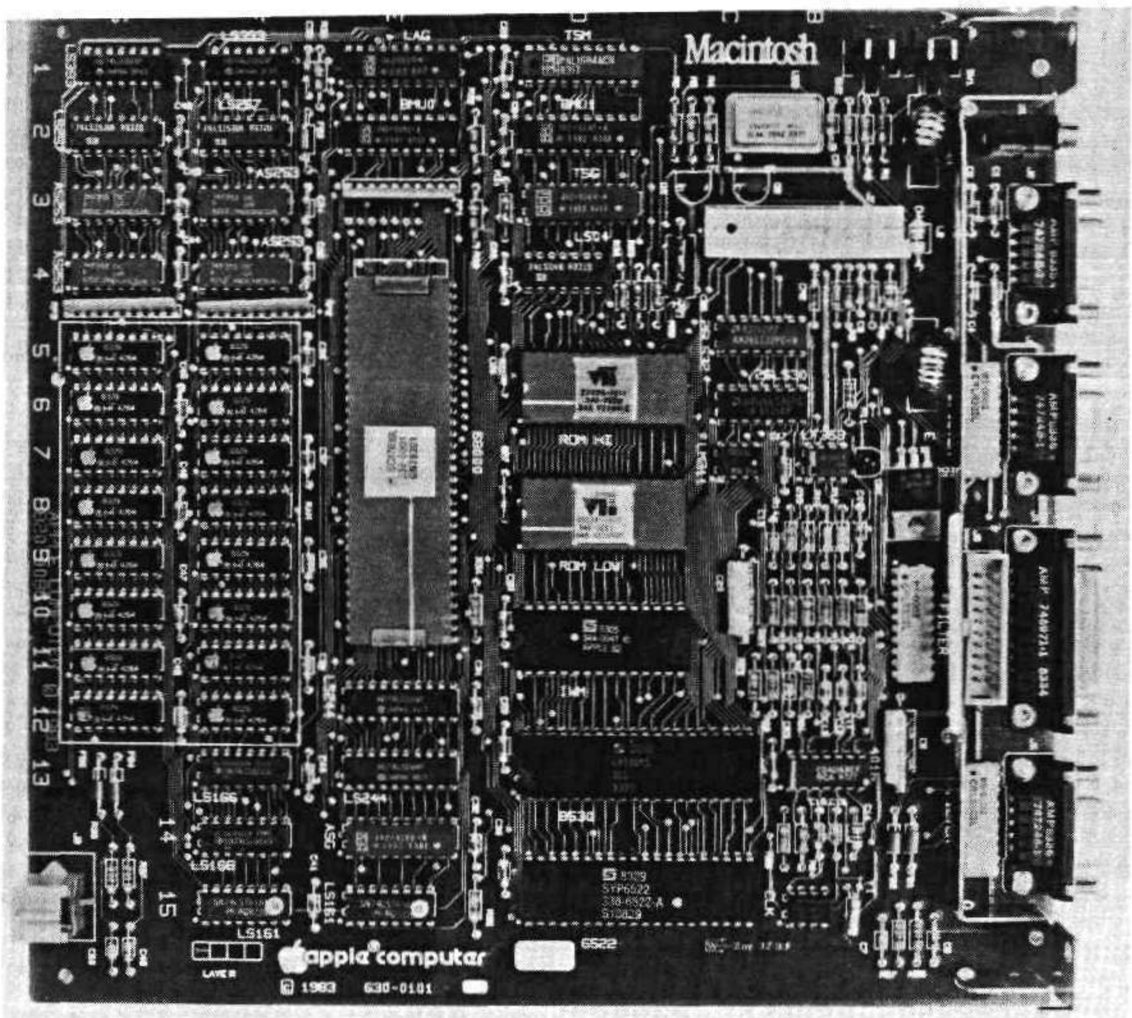
Source: Apple Computer, Inc.

INTEGRATED CIRCUIT PACKAGING

Apple uses conventional, DIP (dual-in-line) integrated circuits in the design of the Macintosh to assure timely supply and to take advantage of the proven quality/reliability of standard components. DATAQUEST believes that using surface mounting, leadless chip carriers, and pin-grid packaged integrated circuits in Apple's Macintosh could significantly reduce manufacturing costs and increase reliability. Figure 3 shows the Macintosh logic board.

Figure 3

MACINTOSH LOGIC BOARD



Source: Apple Computer, Inc.

MANUFACTURING

Apple Computer has built a highly automated Macintosh factory in Fremont, California. The 160,000-square-foot, $23 million facility is reported to be one of the most advanced manufacturing facilities in North America. The factory can complete a Macintosh every 27 seconds, or approximately 1,000 Macintoshes per shift. Initial production problems associated with debugging such a sophisticated facility contributed to an availability problem shortly after the successful introduction of the Macintosh. DATAQUEST believes, however, that Apple has solved these problems and that production is quickly ramping to full throttle.

Apple Computer is using an inventory control technique called "just-in-time" that could have a significant effect on the semiconductor industry. "Just-in-time" relies on a very solid relationship between a limited number of carefully selected suppliers and the component user so that the user can confidently maintain only 2 to 5 days of inventory instead of the traditional, costly 45- to 60-day levels. In essence, the suppliers' trucks at the component user's loading docks replace the user's warehouse. This results in substantially reduced inventory costs to the user, but it puts a significant requirement on the supplier, especially the semiconductor supplier, to reliably deliver very high-quality component products on time. DATAQUEST estimates that the cost savings of "just-in-time" to the component user can result in a payback period for automated factories of just 2 to 3 years and could stimulate further construction of such facilities.

INTEGRATED CIRCUIT CONTENT

The Macintosh uses conventional ICs, as shown in Table 2. This approach provides a solid growth base for future enhancements and features while riding the learning curve of production maturity. DATAQUEST believes that Apple will make use of application-specific IC (ASIC) technology in the form of custom and gate array ICs to reduce costs and board area and to improve reliability. CMOS devices will certainly play a key role in the evolution of the Macintosh, providing additional features without increasing power supply requirements.

DATAQUEST believes that Apple and other personal computer manufacturers will quickly convert to surface-mount packaging once this technology is proven and cost effective. DATAQUEST estimates that the surface area of the Macintosh logic board could be reduced more than 50 percent by converting to surface-mount packaging.

DATAQUEST estimates that the value of the integrated circuits in Apple's Macintosh is between $150 and $170. Based on a forecast of 435,000 Macintosh system shipments for calendar 1984, (See the SCIS newsletter, "APPLE'S BIG MAC: ONE "ALL-BEEF" MICRO, SPECIAL DOS, WINDOWS, MOUSE, GRAPHICS, ICONS IN A SIMPLY SUPER BOX," dated February 10, 1984 for further details.) The Macintosh could account for more than $74 million worth of ICs in 1984. It is interesting to note that the IC content of the Macintosh represents 32 to 40 percent of the estimated manufacturing cost of $425 to $475 (see the previously mentioned newsletter for details). DATAQUEST believes that small personal computers such as the Macintosh will maintain higher IC content value ratios because of the feature-content requirements of this market and the trend toward reduced footprint size.

Table 2

MACINTOSH IC CONTENT

Type	Part Number	Description	Quantity
CPU	68000	Motorola 16/32-bit MPU	1
RAM	N/A	Dynamic RAM (64Kx1)	16
ROM	N/A	Mask ROM (32Kx8)	2
SIO	8530	Zilog SCC (2-channel)	1
FDC	N/A	Custom Floppy Control	1
PIO	6522A	Multifunction I/O	1
PAL	N/A	MMI Prog. Array Logic	5
TTL	74LS	Logic	19
Total			46

N/A = Not Available

Source: DATAQUEST
March 1984

CONCLUSION

Apple Computer's Macintosh is a very important product for both the systems and semiconductor industries. The innovative manufacturing techniques, user-friendliness, and compact size of the Macintosh have set new standards for competitors and have provided the Motorola 68000 with its first, truly high-volume application. DATAQUEST believes that the broad visibility the Macintosh will give the 68000 could significantly stimulate design-in of this powerful microprocessor.

Ken McKenzie

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

ZILOG AND NEC SETTLE Z80 DISPUTE

SUMMARY

Zilog and NEC recently announced that they have reached a settlement in Zilog's charge that NEC copied the Z80 microprocessor and NEC's countercharge that Zilog violated NEC patents. Following the agreement, the U.S. International Trade Commission ruled favorably on a joint motion by the two companies, issuing a final decision to terminate the investigation. Both firms have also agreed to drop all pending court cases.

According to the announcement, NEC will receive a license to continue manufacturing the Z80 microprocessor. In addition, NEC will receive licenses to manufacture other Zilog products, and Zilog will receive licenses to manufacture certain NEC-designed products.

CHARGES AND COUNTERCHARGES

On June 13, 1983, Zilog filed a petition with the U.S. International Trade Commission seeking to block further Z80 imports by NEC. The petition, filed under section 337 of the Tariff Act of 1930, charged NEC Corporation of Japan and two of its U.S. subsidiaries with patent, trademark, and copyright infringement and unfair competition. Section 337 is designed to prevent unfair trade practice, and patent violations have frequently been cited as key issues. Zilog also filed a suit in the U.S. District Court in San Francisco seeking $10 million in damages from NEC.

Zilog claimed that NEC copied the Z80 in the manufacture of NEC's μPD-780. Zilog also accused NEC of fraudulent claims that its product was connected with Zilog. Zilog's claim of injury was based on the fact that it has spent many man-years and $6.5 million to develop and perfect the Z80 CPU, and that NEC, which had no development costs, was able to consistently offer the μPD-780 at prices substantially below the market price. Zilog further claimed that NEC's action resulted in millions of dollars in lost sales and profits.

NEC filed counterclaims that Zilog had knowingly violated several of NEC's U.S. patents in the design of Zilog's Z8, Z80, and Z8000 microprocessors. NEC also charged Zilog with a patent violation in the design of Zilog's Z6132 memory component. NEC claimed that these violations had caused damages amounting to over $29 million.

NEC further claimed that Zilog's Z80 patents were invalid because Zilog used improper procedures to get them and then waited five years to begin enforcing the patent rights.

Zilog's explanation for the delay was that NEC first produced the Z80 only for internal consumption in Japan and did not introduce it into the United States until later. Also, more favorable legal action was now likely, due to recent changes in the copyright laws. Zilog also claimed that attempts to reach a settlement with NEC were not successful. Consequently, court action seemed the only recourse.

SHIFTS IN MARKET SHARE

DATAQUEST believes that NEC introduced two versions of its Z80 into the U.S. market. The first design was reverse engineered but was not successful because it did not match the Zilog specifications. NEC later changed its design and began to gain market share. Table 1 shows estimated worldwide shipments of Z80 microprocessors from all suppliers. Table 2 shows those suppliers' estimated market shares. Figure 1 shows percent share of Z80 shipments for Zilog and NEC since 1976.

ADVERSARIES TO ALLIES

Within a month of announcing the end to the legal actions, the two companies announced that NEC had been granted a license to make Zilog's flagship 32-bit microprocessor, the Z80000. This is Zilog's newest and highest-technology product. It is expected to be sampled in 1985.

This announcement reflects the continuing trend for U.S. and Japanese companies to enter into license agreements and joint ventures. DATAQUEST has monitored the trend in such agreements since 1970, as shown in Figure 2. We believe this trend will continue. Three factors have caused the recent increase in license agreements and joint ventures:

- Before 1980, the Japanese government restricted foreign exchange transactions and foreign investments in Japan. This situation changed dramatically in late 1980 as a result of trade negotiations between Japan and the United States. In December 1980, Japan revised the Foreign Exchange and Trade Control Law, making joint ventures and foreign exchange easier.

- VLSI design is so complex and costly that it is impractical for every company to attempt its own design. U.S. manufacturers are recognized as the leaders in microprocessor architecture, and Japanese firms are not likely to capture that lead for many years, if ever.

- U.S. manufacturers are more aggressive in legal action against suspected patent infringements, and Japanese manufacturers are more sensitive to those issues.

Mel Thomsen

Table 1

ESTIMATED WORLDWIDE Z80 SHIPMENTS
(Thousands of Units)

	1976	1977	1978	1979	1980	1981	1982	1983
Zilog	5	95	550	1,270	2,750	4,075	4,300	7,390
NEC	0	0	30	260	530	1,525	3,900	7,210
Mostek	13	85	260	515	1,270	1,260	1,650	6,525
SGS	0	0	0	80	185	690	970	2,944
Sharp	0	0	0	0	0	140	400	2,300
Total	18	180	840	2,125	4,735	7,690	11,220	26,369

Table 2

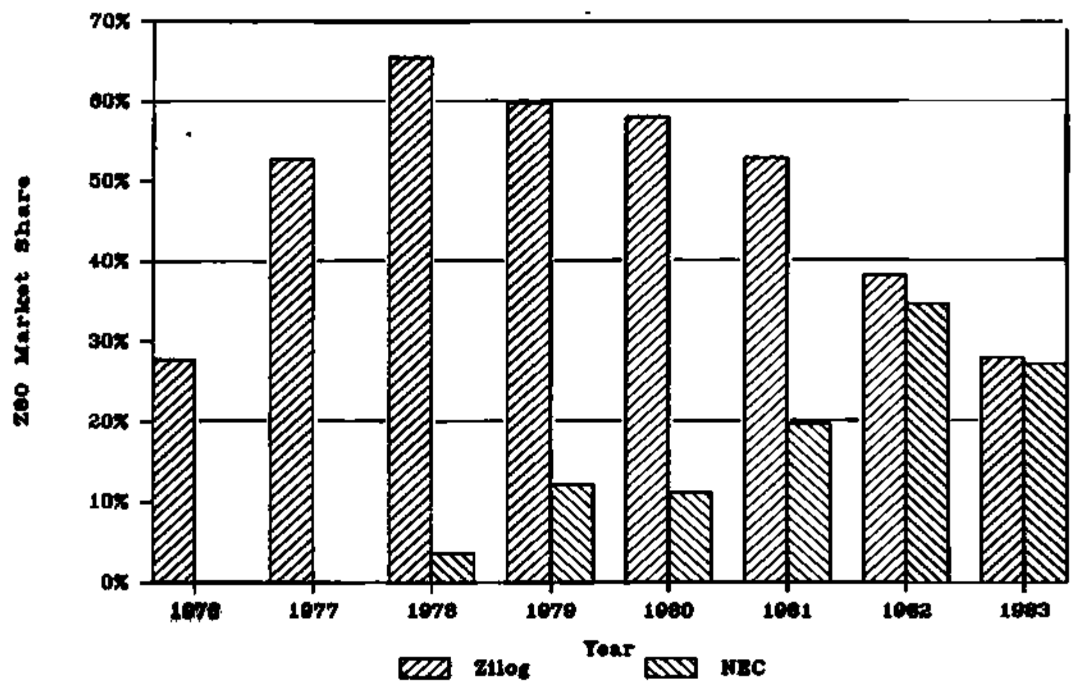
ESTIMATED Z80 MARKET SHARES

	1976	1977	1978	1979	1980	1981	1982	1983
Zilog	27.8%	52.8%	65.5%	59.8%	58.1%	53.0%	38.3%	28.0%
NEC	0.0	0.0	3.5	12.2	11.2	19.8	34.8	27.3
Mostek	72.2	47.2	31.0	24.2	26.8	16.4	14.7	24.8
SGS	0.0	0.0	0.0	3.8	3.9	9.0	8.6	11.2
Sharp	0.0	0.0	0.0	0.0	0.0	1.8	3.6	8.7
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
March 1984

Figure 1

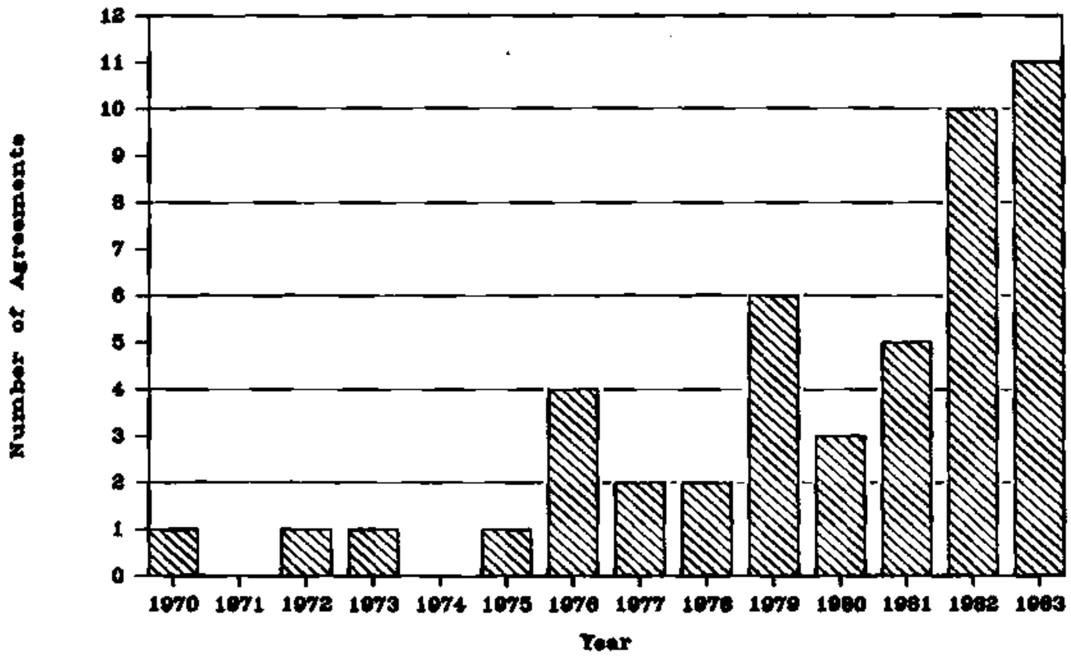
ESTIMATED ZILOG AND NEC
Z80 MARKET SHARES



Source: DATAQUEST
March 1984

Figure 2

LICENSING AGREEMENTS AND JOINT VENTURES
BETWEEN U.S. AND JAPANESE SEMICONDUCTOR MAKERS



Source: DATAQUEST
March 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

1984 NATIONAL ELECTRONICS PACKAGING AND PRODUCTION CONFERENCE

SUMMARY

The 1984 National Electronics Packaging and Production Conference (NEPCON) was held in Anaheim, California, February 28 through March 1. NEPCON was sponsored by the Cahners Exposition Group with help from the California Circuits Association and the International Packaging Society, Inc.

Twenty technical sessions consisted of 88 papers, 85 from the United States and 3 from Europe. Table 1 compares the number of papers presented in 1983 and 1984 by region. A breakdown of the content of the technical sessions is provided in Table 2. Sixteen professional advancement courses and one high-tech workshop were also presented.

Note that while the total number of papers presented dropped 22 percent, from 113 in 1983 to 88 in 1984, the percent of surface mount technology (SMT) papers increased from 8 percent of the total in 1983 to 14.8 percent in 1984. The surface mounting sessions drew crowds of nearly 700, and the show was full of exhibits buzzing with talk about surface mounting. Several major areas were covered in the technical sessions: soldering, quality control, printed circuit boards, surface mounting, connections, hybrids, and metal recovery.

TECHNICAL SESSIONS

The solder session encompassed soldering techniques and processes, vapor-phase soldering, and wave soldering. The use of air-leveled printed circuit boards is expected to increase with the use of new air-leveling machines and by extension of the life of the solder bath. Manufacturers are looking to computerization to control the various functions of the wave soldering process. Use of vapor-phase soldering is increasing for reasons of quality, efficiency, and performance. Advantages include whole-board soldering, temperature control, fast heating, and lack of oxidation. Vapor-phase soldering is used for surface mounting and for special configurations such as flat plates and inaccessible joints.

The subject of quality control encompassed such areas as electrostatic discharge, contamination control, statistical quality control, and thermal control designs. To protect personnel and components from the detrimental effects of electrostatic discharges, resistance grounding techniques and effective management of static must be implemented. It was noted that future challenges in quality control include the control of contamination, which, in turn, will be a key factor in yield and product quality. With a drive in the industry for continual quality improvement, there is an emphasis on statistical quality control (SQC). SQC is defined as the application of statistical concepts and thinking in the form of new principles of administration to management processes, operations, people, and machines. Recently, thermal control designs have taken the form of air cooling systems and natural cooling systems. Natural cooling is a function of packaging and is used where poor reliability in contaminated areas is of concern or where air cooling systems are inappropriate.

Printed circuit board processing, multilayer wire boards, and bare-board testing produced yet another technical area of discussion. A major factor in printed circuit board processing is selection of the right substrate--film or glass--to meet imaging requirements. Developing and implementing effective process controls in imaging areas is the key to productivity and product quality improvement. The use of lasers in the printed circuit board industry is resulting in circuit densities of three to four times those of standard multilayer designs. Using blind and buried vias allows fine-line circuitry to be placed on internal layers. The need for bare-board testing has become more prevalent with the increased density in both interconnections and pin counts. Bare-board testing is a cost-effective process in that it cuts down subsequent costs of fault identification and correction.

Excluding surface mounting, which is discussed separately, the remaining technical sessions covered connections and interconnections, hybrid microelectronics, and metal recovery. State-of-the-art contacts for printed circuit board use includes development of drawn metal techniques. Drawn metal techniques result in a contact with unique geometry that permits easy insertion and high retention of leads without a need for orientation. With new microelectronic hybrid assembly and test equipment becoming commercially available, combined with the availability of miniature surface-mountable component forms, smaller and less costly hybrid electronic circuits can be accurately manufactured with increased reliability at higher production rates. What is needed to deal with the problem of metallic contamination is a method that will:

- Reduce metallic contamination below mandated limits
- Produce no heavy metal sludges
- Be economically feasible in terms of initial investment and operating costs

Surface Mount Technology

As shown in Table 3, the surface mounting sessions covered three areas of surface mounting technology: components, automation, and applications.

The major benefits of surface mount technology result from the essence of the technology--surface mount components are mounted directly on the board, which allows for space reductions, lower cost, and increased reliability.

Size reduction, because the actual component is up to 60 percent smaller, results in space usage that is 10 percent of conventional mounting. This opens up space utilization opportunities for other areas of production, which results in more function per square inch. Space reduction also reduces resistance, capacitance, and inductance, which in turn reduces noise and cross talk. Increased speed and accuracy are also realized with more efficient mounting techniques.

A potential cost reduction of 5 to 15 percent pertains to processes that incorporate passive components, gate arrays, high-pin-count LSI and VLSI, multilayer printed circuit boards, and the use of multiple boards, connectors, and cables to meet smaller size requirements.

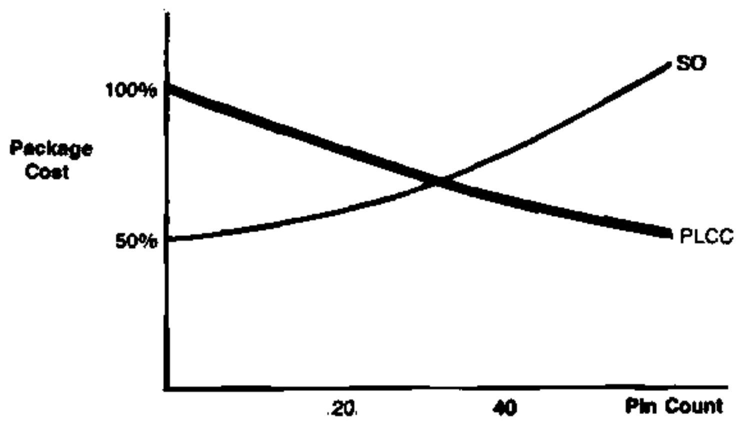
As discussed by Phil Marcoux of AWI, Inc., applications limited to cost reductions are those that are affected by the dual-in-line (DIP) and surface mount package price differential realized when similar volumes of DIP and surface mount packages are produced. For example, small-outline (SO) package costs are approximately 60 percent of the cost of DIP packages, and cost reduction is realized in packages of approximately 20 pins. Plastic leaded chip carrier (PLCC) cost is 40 to 60 percent of the cost of DIP packages, and lower cost results from pin counts greater than 28. (This cost relationship may be delayed because of the current status of silicon supply.) Figure 1 represents this pin-to-cost comparison.

Reliability is a function of fewer interconnections in passive components and shorter lead distances in IC packages. This improves thermal management during design.

The three types of surface mounting are total, mixed, and underside. Total surface mounting incorporates leaded and leadless chip carriers, capacitors, resistors, and connectors. It allows for high density and utilization of both sides of the printed circuit board. Total surface mounting can use a reflow solder process of either infrared, vapor-phase, conductive belt, or convective reflow. Mixed surface mounting is generally 75 percent surface mounted devices and 25 percent conventional and is currently the dominant surface mount type. It will continue to be so until total surface mounting matures and surface mount packages become available. Mixed surface mounting uses a two-step solder process, flow and reflow, and utilizes both board sides. Underside attachment utilizes the unused backside with a one-step solder process.

Figure 1

PLASTIC LEADED CHIP CARRIER/SMALL-OUTLINE
PIN-TO-COST COMPARISON



Source: AWI, Inc.
March 1984

<u>TRENDS</u>

Present trends in surface mounting include the following:

- Full automation
- Dual side utilization
- Size and weight reduction (active/passive devices and final product)
- Cost reduction
- More complex IC functions

Surface mounted devices will encompass 40 percent of all devices by 1990.

Packaging configurations such as the J-type, roll under, gull wing, bull lead, and flat lead will take precedence for pin counts of 20, 28, 44, 52, 68, and 84. For pin counts of greater than 84, the pin grid array (PGA) appears to be most viable.

Robert McGeary
Arden DeVincenzi

Table 1

1983/1984 PAPER PRESENTATION

Year	Total	SMT*	United States	Japan	Europe	Canada
1983	113	9	110	1	1	1
1984	88	13	85	0	3	0

*Surface Mount Technology

Table 2

TECHNICAL SESSIONS

	Session Title	United States	Europe
1.	Solder/Cleaning of Leaded Surface Mounted Components	4	
2.	Surface Mounted Components	4	
3.	Connections and Interconnections	4	
4.	Hybrid Microelectronics	4	
5.	Electrostatic Discharge	4	
6.	Vapor-Phase Soldering	5	
7.	Automated Surface Mounting	4	1 (United Kingdom)
8.	Contamination Control	4	
9.	Metal Recovery and Waste Water Treatment	3	
10.	Surface Mount Applications	4	1 (West Germany)
11.	Printed Circuit Board Processing	6	
12.	Multilayer Printed Wire Boards	6	
13.	Multilayer Board Processing Materials	4	
14.	Soldering Techniques	5	
15.	Printed Circuit Board Processing 2	6	
16.	Computerized Wave Soldering	3	1 (Belgium)
17.	Solder Processing	5	
18.	Statistical Quality Control	3	
19.	Thermal Control Designs and Reliability Tests	4	
20.	Bareboard Testing	3	
	Total	85	3

Source: DATAQUEST
March 1984

Table 3

SURFACE MOUNT TECHNOLOGY
PAPERS PRESENTED

Title	United States	Europe
Surface Mount Components		
Benefits	1	
Myth of Cheap Wire	1	
PCB Size Comparison	1	
World Class Surface Mount Facilities	1	
Surface Mounting in Automated Factory		
Packaging Trends	1	
Leadless Component Placement	1	
Infrared Soldering of Surface Mounted Devices	1	
Test Problem Process Control Management	1	
Application of SMCS		
Infrared Soldering of Surface Mounted Components	1	
The Epoxy Alternative	1	
Evaluation for Surface Mounting	1	
The Pin Frame Alternative		1 (West Germany)
Solder Masking Techniques	1	-
Total	12	1

Source: DATAQUEST
March 1984

SIS Code: 1984-1985 Newsletters: March

INTERNATIONAL SOLID STATE CIRCUITS CONFERENCE 1984

SUMMARY

The thirty-first annual meeting of the International Solid State Circuits Conference (ISSCC) was held in San Francisco February 22-24. Over 375 authors and coauthors from the worldwide semiconductor industry and academic institutions presented 113 papers introducing new concepts and achievements in IC design. The three-day conference, 19 daytime sessions and 10 evening sessions, demonstrated that memories are holding on to their lead position in semiconductor technology. Among other notable developments presented were the rapid advances in custom and semicustom ICs, telecommunication chips, and GaAs technology. The conference also addressed such topics as image sensors, dedicated signal processors, microprocessors/microcontrollers, and high-speed analog ICs.

OVERVIEW

The number of technical papers at ISSCC from any one country often indicates the level of R&D within that country. Table 1 summarizes the country of origin of ISSCC technical papers for the years 1980 through 1984. Considerable research in semiconductor technology is performed worldwide by semiconductor manufacturers, universities, and government institutions. The United States accounted for 51 percent of the 113 technical papers presented this year. The United States focused strongly on custom and semicustom circuits, telecommunication chips, and, of course, memory products. Japan delivered 39 percent of the papers, with emphasis on memories, signal processing, and GaAs. Europe presented approximately 10 percent of the papers, with no key area of focus.

Table 2 summarizes the ISSCC paper count by application area for each of the years 1980 through 1984. Thirty of the 113 papers delivered (26 percent) and three of the informal sessions were devoted to memory technology. All these sessions were heavily attended. The number of analog papers decreased from 20 percent in 1983 to 16 percent in 1984. GaAs and custom and semicustom technology have made an impact during the past two years at ISSCC--19 percent of the papers presented in 1984 covered these areas. There were no papers presented at ISSCC on either topic before 1980. Moreover, trends toward wafer scale integration, VLSI testing methodologies, and CMOS processing were evident.

OVERVIEW OF TECHNICAL PAPERS

Session I covered custom and semicustom design techniques and emphasized a continuing trend toward the mixing of standard cell, gate array, memory, and linear/digital on the same chip. The presentations of Session I varied in scope from IBM's paper on a comparison of mixed gate array and handcrafted custom design to NTT's presentation on highly integrated modular and standard cell design. The University of California at Berkeley presented a 16-channel filter bank for speech recognition and a single filter generated by computer programs from filter descriptions. In the Friday session, Hitachi described a CMOS 12K-gate array with a flexible 10-Kbyte memory, and Stanford University described a 2-micron polygate CMOS analog/digital array.

During Session II, two major types of solid-state image sensors, CCD and MOS imaging devices, were discussed. Techniques to suppress the ongoing problem of noise and transfer inefficiency were presented by Hitachi. One of Fairchild's two papers presented in this session illustrated the development of a CCD imager using an antiblooming feature to control the exposure. Thompson-CSF, from France, described a 576 x 462-pixel color image sensor.

The gallium arsenide session featured three very high speed GaAs 1K and 4K static RAMs, which are not yet commercially available. These devices promise to rival the fastest ECL devices. Also featured were two GaAs gate array circuits, a 1K-gate and an uncommitted 1K-gate IC.

The nonvolatile memories session featured 512K and 1-Mbyte NMOS EPROMs, as well as two 256K CMOS EPROMs, two high-performance EEPROMs, and one 80ns 1-Mbyte ROM. As in the case of both the static and dynamic RAMs, much of the emphasis in the nonvolatile memory papers was on device performance.

Two of the papers in the nonvolatile memory session were delivered by Seeq, which described its CMOS 256K EPROM with 100ns access time, as well as a 64K EEPROM that extends the endurance limitation from 10,000 to more than a million cycles through the use of full error correction. Although this adds significantly to the die size, this new 64K CMOS EEPROM incorporates an improved cell structure and aggressive scaling that compensate for some of the die area penalty.

High-performance static RAMs were featured in one of the formal sessions and in one of the informal discussion sessions. In the formal session, seven papers were delivered, five of which described high-performance 64K CMOS static RAMs. These devices typically have access times in the 20- to 35-nanosecond range. Two of the 64Ks, from Toshiba and Hitachi, use a mixture of bipolar and MOS circuit techniques to enhance the speed. Most of the CMOS SRAMs described were 64Kx1, but Toshiba's 28ns device was 8Kx8, and IBM's NMOS device was 4Kx16. As evidence of the SRAM state-of-the-art part, Toshiba described a 256K full CMOS static RAM that incorporates over 1.4 million transistor elements and has an access time of 46ns.

Incidentally, Hitachi's CMOS 288K pseudostatic RAM, described in the second DRAM session, can probably be expected to achieve a strong competitive market position against dense static RAMs. This device uses much more liberal design rules (2 um vs. 1.2 um for Toshiba) and much lower levels of transistor integration.

An evening session focused on ultrahigh-speed SRAMs. Many of the panelists expect 5ns 64K static RAMs to be available by the end of the decade, with bipolar/CMOS and GaAs being promoted as the most likely candidates. The leading-edge GaAs parts currently being manufactured in the lab are sub-3ns 1K and 4K devices, which were described by Japan's NTT and Fujitsu in the gallium arsenide session on Wednesday.

Twelve papers and the Wednesday evening informal session dealt with dynamic RAMs or DRAM circuit or device structures. High-performance 256K RAMs with six of the devices having speeds faster than 100ns were featured along with four 1-Mbyte DRAMs described by NTT, NEC, Fujitsu, and Hitachi.

The session also addressed technology trends (NMOS or CMOS) in conjunction with market needs for a variety of device architectures (x1, x4, x8) or addressing schemes (page, nibble, ripple, or static column). Strong, and varying, opinions were expressed as to the ultimate makeup of the Mbyte DRAM market, both from a manufacturing feasibility/economic viewpoint, as well as from the viewpoint of market need. There was general agreement, however, that the Mbyte DRAM market would be able to support a wide variety of special-function DRAM submarkets.

In the telecommunications area, two sessions were held covering telecommunication systems ICs and modems. With emphasis moving to the data communication field, interest has focused on the data modular/demodulator or modem. The session on modems examined some monolithic solutions to the cost and performance problems of local area network interfaces, data-over-voice recovery, and, in particular, voice bandwidth modems for the home and office. The telecommunication systems ICs session provided insight regarding committed directions for telecommunications. A collective display of a dense 350V BORSCHT circuit, a 3,000MHz regenerator for optical links, a feature-packed Codec/filter, a sophisticated subscriber board controller, and two pioneering subscriber-line-baseband transceivers was presented.

Session II papers focused on 32-bit microprocessors. All of the papers described new devices that use NMOS technology. Eight of the 10 devices presented have a 32-bit word length and large die size. Digital Equipment Corporation dominated the session with three of the seven papers, describing MicroVAX and the Superminicomputer Chip Set. UC Berkeley and Stanford University delivered papers, respectively, on RISC II and pipelined 32-bit microprocessors. SGS-ATES, from Italy, presented a 5-volt microcontroller with nonvolatile RAM, and Texas Instruments described its communications processor, which has a dedicated architecture. It is interesting to note that there were no Japanese manufacturers presenting at this session.

Most of the major minicomputer makers have announced and shipped 32-bit microprocessor families, while the traditional semiconductor companies are still developing their components. National Semiconductor is the only semiconductor company that is presently sampling its 32-bit microprocessor. Many of the present generation of 32-bit microprocessors are multiple-chip sets. This is true of the Intel iAPX-432, the NCR/32, and Digital's new chip set.

Jan Rey

Table 1

ISSCC TECHNICAL PAPERS BY COUNTRY OF ORIGIN
(Percent)

Country	1980	1981	1982	1983	1984
United States	68%	61%	66%	50%	51%
Japan	25	25	29	42	39
Western Europe	7	14	5	8	10
Total	100%	100%	100%	100%	100%
Total Papers (Excluding Panel Sessions)	90	89	101	98	113

Table 2

ISSCC PAPER COUNT BY APPLICATION AREA

Topical Area	1980	1981	1982	1983	1984
Analog	21	25	16	20	16
Custom and Semicustom	0	1	7	7	12
Memory	27	17	19	26	26
Microprocessor/Microcontroller	3	14	5	6	7
Telecommunications	8	7	13	11	14
Signal Processing	8	4	18	6	17
CCDs and Imaging	6	4	6	7	6
GaAs	5	6	-	6	7
Design Processing	11	10	16	8	7
Keynote Address	1	1	1	1	1
Total	90	89	101	98	113

Source: IEEE Solid State Circuits Council
February 1984

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: March

EDIF--SEARCHING FOR A STANDARD INTERFACE FORMAT

OVERVIEW

With more than 105 semiconductor companies, 10 CAD/CAM companies and a host of OEM companies all participating in the application-specific integrated circuit (ASIC) marketplace, it almost goes without saying that some form of standard design interface is needed. Most of the equipment currently used to design custom and semicustom integrated circuits is based on incompatible formats. As a result, a designer who wishes to use a combination of CAD tools from different vendors must first convert various software formats before completing the design.

ENTER EDIF--ELECTRONIC DESIGN INTERCHANGE FORMAT

Bound together by this common problem, seven organizations have formed a committee to seek out a standard interface. The members of this committee are Daisy Systems, Mentor Graphics, Motorola, National Semiconductor, Tektronix, Texas Instruments, and the University of California at Berkeley. Each of the participants has committed to adopt the EDIF once it has been defined. The new standard is intended to provide an interface between the many types of hardware and software used to design, test, and manufacture such ASICs as gate arrays, standard-cell ICs, and custom chips.

The committee wishes to solicit extensive industry comment prior to release of the first EDIF version. A summary of the proposed interface formats will be available at the next meeting of the committee, scheduled for March 30, in Santa Clara, California. The committee would like to receive all comments on the standard and publish a preliminary version of the EDIF by the end of the second quarter of 1984. Publication of documentation is targeted for the third quarter 1984 and will reside in the public domain.

DATAQUEST believes several existing languages are being proposed as the starting point for the new standard, including the following:

- TIDAL (Design-Automation Language) from Texas Instruments

- TDF (Technology Definition File) from Motorola and Mentor Graphics

- GAIL (Gate Array Interface Language) from Daisy Systems

- CIDF (Common Interchange Data Format) from National, Tektronix, and UC Berkeley

It should also be noted that once a format has been defined and implemented, the EDIF committee hopes to transfer responsibility for further enhancement and general administration to a recognized standards organization.

DATAQUEST believes that the proposed EDIF standard warrants careful review--particularly since the members of the committee represent an influential group that could establish important standards.

Andrew Prophet

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

ANOTHER STRONG YEAR FOR CONSUMER ELECTRONICS

The 1984 Winter Consumer Electronics Show (CES), which concluded its four-day convention in Las Vegas on January 10, is much more than a trade show. It is a marketplace that focuses on consumer electronics. It is a place where more than 91,000 manufacturers, retailers, distributors, engineers, and financial analysts meet to introduce, buy, sell, and promote consumer electronic products. It is a place where more than 1,300 exhibitors focus on consumer needs.

Consumer electronics is expected to be a $19 to $25 billion industry worldwide in 1984. Total factory sales of consumer electronic products have grown at a compound growth rate of approximately 27 percent over the last several years. This industry is alive and profitable because of strong home computer, telephone equipment, and audio and video sales. The home computer, software, and telephone products represent a significant portion of this overall volume.

A few of the highlights of CES are as follows:

- Smart corded and cordless telephones are fast-growing product categories in the industry today due to the differences in phone systems around the country. The smart phones are controlled by 8-bit microprocessors and have memory dialing, automatic redialing, and coded security systems. Consumers are stressing the need for features and convenience in phones, and the microprocessor-controlled phones are the answer. Total unit sales of corded and cordless telephones in 1982 were 5.7 million. Unit sales are expected to be 31 million in 1984.

- Compact discs (CDs) are the trend of consumer microelectronics in the stereo industry. The digital discs, only 4-3/4 inches in diameter, contain musical information that is encoded in binary form beneath the transparent surface of the disc. The code is ready by a low-power diode laser in the player and translated back to an audio signal. Two to three microcontrollers are used in the controlling device in compact disc players. Lower noise, longer playing time (one side = 75 minutes), and no distortion are some of the impressive capabilities of the new compact discs. Using the compact disc player is like using a cassette deck, but with random access capability thrown in.

- VCRs had penetrated approximately 10 percent of all U.S. households as of year-end 1983. With increasing consumer awareness and continued healthy economic conditions, VCR sales could increase substantially in 1984. Emphasis will be on high-tech features such as the microcontrollers used to control the ease of operation and the scope of recording capabilities. Each VCR has three microcontrollers.

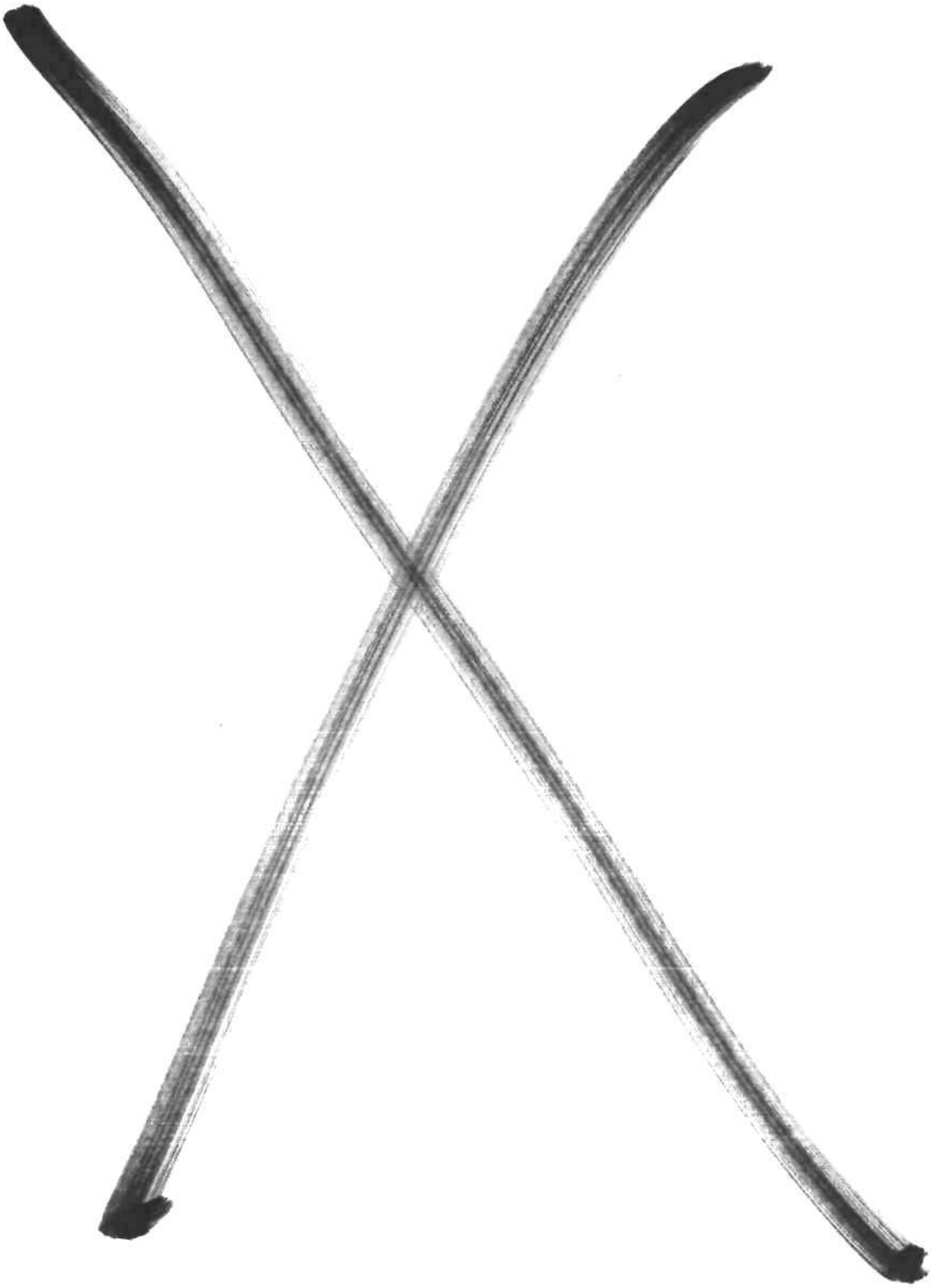
- Home computers have a high semiconductor content. All home computers use some type of 8-bit or 16-bit microprocessor such as the 6502, Z80, or 8086. Some systems utilize multiple microprocessors, with microperipherals assigned specific tasks such as display control or communication interface.

  Among some of the home computer competitors at the Consumer Electronics Show were Apple, Atari, Coleco, and Commodore. Commodore introduced its 264 series home computer during the show. The Commodore 264 is based on a microprocessor from the 6500 family; it has built-in applications software in ROM and built-in speech synthesis but is not software compatible with the Commodore 64 home computer.

Consumer product manufacturers can economically incorporate integrated circuits into many consumer applications because of the power and low cost of the chips. The largest application area for microcontrollers is consumer products and many of the new applications opening up are in the home. Wherever there is an electrical motor, there is a possible application for a microcontroller. A few typical applications for a microcontroller are video tape recorders, clock radios, microwave ovens, washers and dryers, food processors, electric ranges, security systems, and air conditioners. Current and new applications have stimulated the demand for 4-bit and 8-bit microcontrollers.

The future of microcontrollers appears strong in both computer-related and consumer product applications. The continued growth of the consumer electronics market will be influenced by product development attuned to the needs of the consumer, by technology improvements stimulated by designers' imaginations, and, most important, by reasonable prices for the consumer.

Jan Rey



April Newsletters

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

- Worldwide ASIC Design Centers
  Reaching Out to the User

- MOS Microprocessor/Microcontroller Shipments Surge in Fourth
  Quarter 1983

- Dry Etching: The Emergence of New Technologies

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: April

WORLDWIDE ASIC DESIGN CENTERS REACHING OUT TO THE USER

SUMMARY

In summary of the recently published April 1984 Application-Specific Integrated Circuit (ASIC) Design Center (DC) notebook section, this newsletter discusses worldwide ASIC design center segmentation, the criteria needed for successful centers, and geographical considerations in the Japanese and European marketplaces.

In the past, most ASIC designs have been done at the supplier's main plant; but recently, with the proliferation of low-cost EDA equipment, the design function has moved out into the user's backyard. In effect, the marketplace has become a battleground where suppliers compete to capture new designs. The new wave of remote DCs offers a wide array of services and design tools. A typical DC may act as a regional training center; it may lease EDA equipment and time to an experienced designer; or, for those users who do not wish to do their own design, the DC's technical staff is capable of doing the design. DATAQUEST believes that the success of a DC, in large measure, is determined by its ability to service the engineering community and by its ability to establish close working relationships with a diverse user community.

ASIC DESIGN CENTERS

Universal Segmentation

Depending on the structure of ASIC suppliers within the ASIC international marketplace, four types of DCs exist: vendor, user, distributor, and third-party. Vendor DCs are universally the most common type and are funded and staffed by ASIC manufacturers offering in-depth expertise with their own gate arrays and custom and semicustom circuits.

User DCs are located in the users' facilities and are limited to firms requiring a large number of designs per year. Because of the vertically integrated infrastructure of Japan's ASIC community, user and vendor DCs may be one and the same. User DCs are captive in the sense that the firm will market its own design to different departments within the same company. Vendor DCs market their designs to outside users. In Europe, fewer firms are able to immediately justify user DCs because of the substantial investment required. The position of the user DCs will probably grow stronger as the ASIC marketplace matures.

Distributor DCs focus on firms with a low design-per-year count (1 to 3 designs) and generally link the supplier and engineer via the engineer's workstation. In the European marketplace, distributor DCs are more technically aware, as opposed to being a supply house for differing product lines. Distributor DCs may see increased growth by utilizing their technical abilities in the design function and taking advantage of market opportunities.

Third-party DCs specialize in semicustom services and are a cost-effective way for the small ASIC firm to capture designs without investing time and capital into many centers.

Within the Japanese, U.S., and European communities, the distributor, third-party, and vendor DCs may see increased demand because of the market need for a variety of products and suppliers.

Criteria for DC Selection

Criteria for evaluating DC selection vary for each user and are complicated by geographical and cultural influences. Major factors include:

- Number of designs per year required by user
- Depth of technological expertise
- Thoroughness of training
- Development cost
- Design cycle time
- Proximity to user

Standardization

The proliferation of firms actively marketing semicustom products will lead to more alternate source agreements, installation of supplier cell libraries, and the establishment of an industry-wide software standard. A prime example of alternate sourcing is the agreement between Fujitsu and Texas Instruments in which the user, because of compatible software, can take advantage of either company's systems.

The Electronic Design Interchange Format (EDIF) is a committee formed to confront the lack of standardization. EDIF's main function is to develop a standard electronic design interchange format that will allow different products to communicate with each other. The format will provide an interface between software used to design, test, and manufacture electronic circuits. Adoption of a standard format will alleviate the problem faced by designers who wish to use a combination of CAD tools and software from different manufacturers. DATAQUEST believes that standardization will accelerate the growth of design centers worldwide by reducing the amount of hardware and software redundancy and by adding a dimension of flexibility that users need.

CRITERIA FOR SUCCESS

The primary factor affecting the overall success of a design center is service, complemented by technology, product offerings, and cost effectiveness. Other factors include location, user-friendly CAD tools, technical support, and error minimization.

Most successful DCs are located near major concentrations of system designers. The United States, with over 50 existing centers, is a viable location consideration for many firms planning future facilities. As shown in Table 1, Japanese firms are expanding their DC networks on a worldwide basis. The top 13 Japanese gate array vendors have 25 centers in Japan and 29 centers outside of Japan, with plans for 21 more to be located in either Japan or the United States.

There are 94 European DC locations specializing in custom circuits, standard cells, and gate arrays. Because of the complexity of the European marketplace with its diverse languages and cultures, larger numbers of centers can be supported, focusing on a wider user community as shown in Table 2.

On a worldwide basis, centers that incorporate a competent technical staff, supply user-friendly CAD tools, and offer a wide variety of products will win more designs. However, these centers will have to reduce error rates and move the user through the design process quickly in order to compete for repeat design projects.

Arden DeVincenzi
Andy Prophet

Table 1

JAPANESE DESIGN CENTER LOCATIONS

Company	Japan	U.S.	Europe	Asia	Planned
Asahi Microsystems	1	3	2	-	1-U.S.
Fujitsu	3	3	2	-	4-U.S. (12)*
Hitachi	2	2	2	1	-
Matsushita	1	2	-	-	-
Mitsubishi	1	-	-	-	1
NEC	7	2	1	1	8-U.S./EUR.
Nihon LSI Logic Corp.	1	-	-	-	-
Oki	4	3	-	-	3-U.S.
Ricoh	1	1	-	-	-
Sanyo	1	1	-	-	-
Sharp	1	-	-	-	-
Suwa Seikosha	1	1	-	-	3-JAP./U.S.
Toshiba	1	2	-	-	1-U.S.
Total	25	20	7	2	21 (12)*

*Fujitsu-Texas Instruments' alternate sourcing agreement in which the user can take advantage of either company's systems.

Source: DATAQUEST
April 1984

Table 2

EUROPEAN ASIC DESIGN CENTER LOCATIONS
AND DESIGN TECHNIQUES USED

Company	Number of Locations	Custom Circuits	Standard Cells	Gate Arrays
ASEA-HAFO	1	X		
American Microsystems	1	X	X	
Austrian Microsystems	1	X	X	X
British Telecom	1	X		
CTT-Alcatel	1	X		
California Devices	1			X
Denyer Walmsley Microelectronics	1	X	X	X
Eurosil	1	X		X
Exar Integrated Systems	1	X	X	X
Fairchild	1			X
Faselec	1	X		
Faveg	1	X		
Ferranti	2			X
Fujitsu	1			X
General Instrument	1	X		
Giltspur Microsystems	1			X
Harris-MHS	1	X		
Hitachi	1			X
Hughes	2	X	X	
I.M.I.	1		X	
IBM	1		X	
IMP	1		X	
ITT	8	X		
Intel	2	x		
Lattice Logic	1		X	X
Linear Technology	1	X		
LSI Logic	1			X
LTC	1	X		
Lucas	1	X		
MEDL	1	X	X	X
Matra-Harris	1			X
Microcircuit Engineering	1			X
Microelectronics-Marin	1	X		
Micronas	1		X	X
Mietec	1	X	X	
Mitel	1	X		
Motorola	1		X	
Mullard	2	X	X	
NEC	1			X
National Semiconductor	4		X	X

(Continued)

Table 2 (Continued)

EUROPEAN ASIC DESIGN CENTER LOCATIONS
AND DESIGN TECHNIQUES USED

Company	Number of Locations	Custom Circuits	Standard Cells	Gate Arrays
Olivetti	1	X		
Philips	1	X	X	X
Plessey	1	X		X
RCA	1		X	X
RIFA	1	X		
RTC	1		X	X
Racal	1			X
Robert Bosch	1	X		
SGS-ATES	4	X		X
STC (STL)	1	X		X
Siemens	2	X		X
Silicon Arrays Ltd.	1			X
Silicon Microsystems	1	X	X	X
Swindon Silicon Systems	1	X	X	X
Synertek	1		X	
Telefunken Electronic	1	X		
Telmos	1			X
Texas Instruments	5	X	X	X
The Cad Centre	1	X	X	X
Thomson-CSF	2	X		
UMIST	1			X
VDF Zentrum	1	X	X	X
VTI	3		X	
Valvo	1	X	X	X
Wolfson Microelectric Instruments	1		X	X
Zeltron	1	X	X	X
ZyMos	3		X	
Total Locations	94			

Source: DATAQUEST
April 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: April

MOS MICROPROCESSOR/MICROCONTROLLER SHIPMENTS SURGE IN FOURTH QUARTER 1983

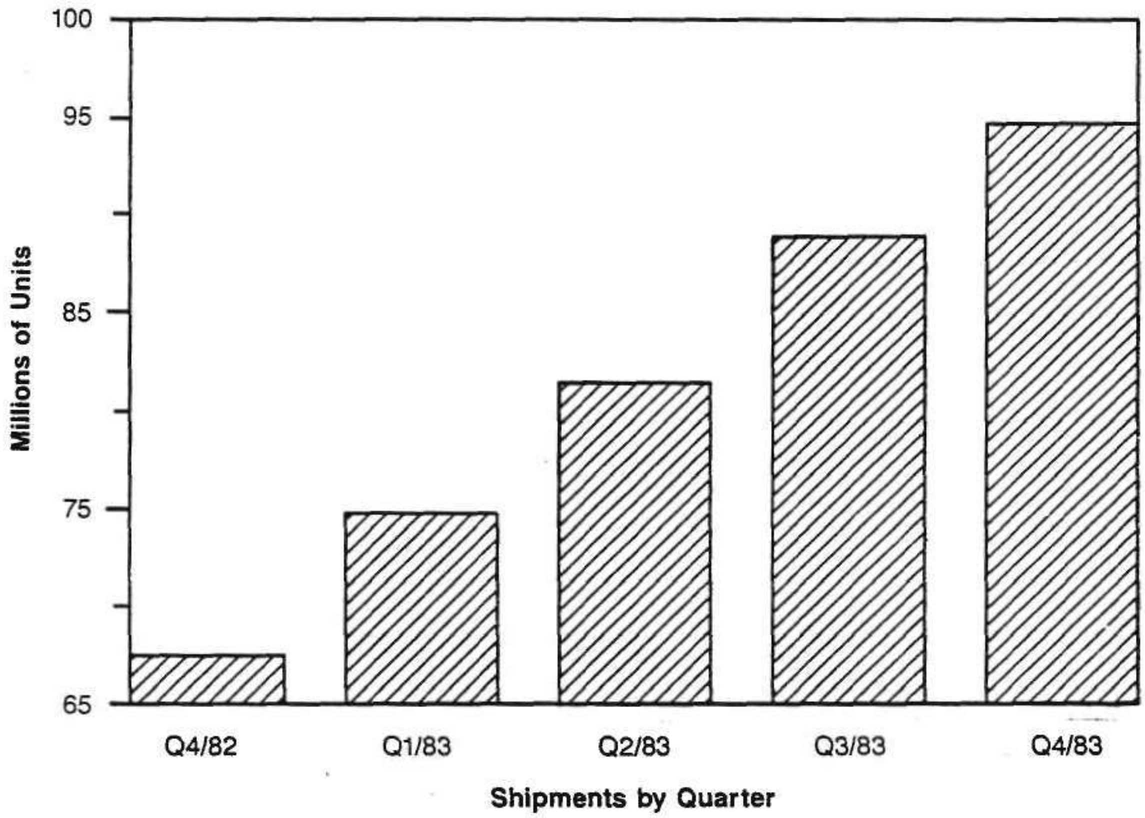
SUMMARY

Total shipments of microprocessors and microcontrollers increased an estimated 28.5 percent from 1982 to 1983; totals shipped were 264.5 million units and 339.8 million units, respectively. Microcontroller shipments experienced a 24.6 percent growth rate in 1983 from 1982; to 264.7 million units from 212.4 million units. Microprocessor shipments grew approximately 44 percent; up to 75.1 million units in 1983 from 52.1 million units in 1982. DATAQUEST expects the growth of 1984 microprocessor and microcontroller shipments to be even more robust than 1983's growth, by approximately 50 percent.

During the fourth quarter of 1983, worldwide shipments of microcontrollers and microprocessors totaled an estimated 94.6 million units, up 6.4 percent from the estimated 88.9 million units shipped in the third quarter. Microcontroller shipments grew approximately 8.2 percent in the fourth quarter, while microprocessor shipments remained relatively unchanged. It is interesting to note that 4-bit microcontroller shipments remained relatively constant in the fourth quarter at an estimated 45.8 million units, from an estimated 45.4 million units in third quarter. Microprocessor shipments also stayed constant in the fourth quarter, remaining at an estimated 19.0 million units--the same as in the third quarter. Hence, 8-bit microcontroller shipments increased substantially, up to a estimated 29.9 million units in the fourth quarter from an estimated 24.5 million units in third quarter. This was the sole contribution to the 8 percent growth rate of microprocessor and microcontroller shipments in the fourth quarter. Figure 1 shows DATAQUEST estimates of worldwide shipments of microprocessors and microcontrollers.

Figure 1

MICROPROCESSORS AND MICROCONTROLLERS
ESTIMATED WORLDWIDE SHIPMENTS
(Millions of Units)



Source: DATAQUEST

INDUSTRY TRENDS

Demand

DATAQUEST believes that manufacturers of microprocessors and microcontrollers are on the road to catching up with demand in the second half of 1984. This is due to capacity expansion directed toward die shrinks, six-inch wafer conversion, second sourcing (internal and external), and multiple fab production. Book-to-bill ratio was declining by the end of fourth quarter, by approximately 1.66. Supply and demand are expected to be more balanced by the summer of 1984.

Lead Times and Pricing

Lead times and pricing are closely correlated. During 1983, both lead times and prices surged. But by the fourth quarter, lead times and prices stabilized, and appear to be established for the robust market expected in 1984. Lead times presently range from 20 to 40 weeks for most microcontroller and microprocessor components.

CMOS and VLSI

Interest in microprocessor and microcontroller areas is increasing as a result of CMOS and VLSI technologies; demand began to accelerate in 1983. The transition to CMOS technology was realized during the past year in both microprocessor and microcontroller shipments. The approximate growth rate of 8-bit CMOS microcontroller shipments from 1982 to 1983 was more than 300 percent, and CMOS 8-bit microprocessor shipments increased by approximately 63 percent.

Japanese manufacturers of 4-bit microcontrollers have made significant progress developing their CMOS processes. Their progress is demonstrated in fourth quarter 1983 unit shipments: approximately 67 percent of CMOS 8-bit microcontrollers and 33 percent of CMOS 8-bit microprocessors were shipped by Japanese manufacturers. DATAQUEST believes that the percent of CMOS usage in microprocessors and microcontrollers will increase, due to the energy conservation and portability attributes of CMOS technology.

We also believe that the use of VLSI micro devices will be prevalent in PCs, factory automation, local area networks, and high-end consumer products. Currently, the 8086 family architecture dominates the 16-bit microprocessor market, and accounted for approximately 58.5 percent of the leading 16-bit microprocessor total market in the fourth quarter. The 68000 family has been gaining market share quarter-by-quarter, and accounted for 23 percent of the total leading 16-bit microprocessor market in the fourth quarter. Estimated shipments for leading 16-bit microprocessors are shown in Table 1.

Table 1

ESTIMATED SHIPMENTS FOR LEADING 16-BIT MICROPROCESSORS
(Thousands of Units)

Product	Q3/1983 Units	Q3/1983 Percent of Shipments	Q4/1983 Units	Q4/1983 Percent of Shipments	Percent of Growth from Q3-Q4
8086	575	59.6%	752	58.5%	30.8%
80186	42	4.5	70	5.4	66.7%
80286	1	-	12	0.9	1,100.0%
68000	200	20.7	296	23.0	48.0%
Z-8000	117	12.1	122	9.5	4.3%
16032	30	3.1	35	2.7	16.6%
Total	965	100.0%	1,287	100.0%	33.4%

Source: DATAQUEST

Mature Products

Although overall 8-bit microprocessor shipments decreased approximately 1.7 percent in the fourth quarter, which was the second consecutive quarter they decreased, they still captured approximately 90 percent of the microprocessor market.

The 8085 and 8088 families increased 7.9 percent and 19.2 percent, respectively, from third quarter shipments. Z-80 and 650X shipments families declined 0.5 percent and 21.3 percent, respectively. In the third quarter, 650X shipments declined approximately 36 percent. Estimated shipments for leading 8-bit microprocessors are shown in Table 2.

Jan Rey
Mel Thomsen

Table 2

ESTIMATED SHIPMENTS FOR LEADING 8-BIT MICROPROCESSORS
(Thousands of Units)

Product	Q3/1983 Units	Q3/1983 Percent of Shipments	Q4/1983 Units	Q4/1983 Percent of Shipments	Percent of Growth from Q3-Q4
Z-80	6,640	38.5%	6,610	39.0%	(0.5%)
650X	2,714	15.7	2,135	12.6	(21.3%)
8085	2,610	15.1	2,815	16.6	7.9%
6802	1,369	7.9	1,350	8.0	(1.4%)
8088	1,205	7.0	1,436	8.4	19.2%
Other	2,721	15.8	2,623	15.4	(3.6%)
Total	17,259	100.0%	16,969	100.0%	(1.7%)

Source: DATAQUEST

Nielsen Dataquest
RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: April

DRY ETCHING: THE EMERGENCE OF NEW TECHNOLOGIES

SUMMARY

DATAQUEST recently published the March 1984 update of the dry etch equipment section in the Semiconductor Industry Service notebook Industry and Technology. This newsletter summarizes that publication.

As the semiconductor industry approaches production of two-micron line geometries, demand for anisotropic dry etching is accelerating. Dry etching is rapidly replacing wet etching as the percentage of total steps etched with dry processing grows from 30 percent in 1983 to approximately 55 percent in 1988.

Worldwide consumption of dry etch equipment (which includes barrel, parallel plate, and ion milling systems) was $232 million in 1983, up 40 percent from $167 million in 1982. Consumption of barrels increased 8 percent from $28 million to $26 million. Parallel plate systems (including hexodes) grew 43 percent from $133 million to $190 million. Ion milling systems grew 75 percent from $8 million to $14 million.

Dry etching is replacing wet etching because it has the following advantages:

- Dry etching provides better anisotropy (vertical etch profiles) which is necessary for small line dimensions.
- Dry etching eliminates the handling and disposal of corrosive liquids.
- Dry etching allows better etch process control.
- Dry etching can do several steps in situ with one pump-down, which reduces contamination that could result from handling in several steps.

Barrel etching is a mature technology that will not grow faster than semiconductor device unit sales. The corresponding growth rate in dollars is expected to be less than 21 percent compound annual growth rate (CAGR) from 1983 to 1988. Barrel etchers will continue to be used for resist stripping and noncritical silicon nitride layers. There are additional opportunities for barrels outside of wafer processing.

Parallel plate plasma systems that operate at low vacuum have shown great success in polysilicon applications. They will continue to find niches in silicon nitride and silicon dioxide processing. However, for smaller geometries in silicon dioxide and aluminum alloy layers, high-vacuum reactive ion etching (RIE) systems will be used. These will include batch and single-wafer systems.

Of the batch approaches, the hexode approach is the most successful and will continue to be used because of its throughput advantages over other approaches. Of the single-wafer approaches, the magnetically enhanced systems and triode systems will provide the throughput that competes with batch approaches. The parallel plate market will grow at a CAGR of 39 percent from $190 million in 1983 to $979 million in 1988.

Ion milling systems will continue to be used for etching substrates that are chemically inert. This market will grow slightly faster than device unit sales as new applications are found. Worldwide consumption will increase at 25 percent CAGR from $14 million in 1983 to $45 million in 1988.

DATAQUEST believes that dry etch technology will take several years to mature. Equipment suppliers will have to stay technologically current by sharing process-solving experiences with their customers. Each technology, plasma and RIE, will find a niche in which it will dominate.

THE TECHNOLOGY

Wet Chemical Etching

DATAQUEST estimates that the process of etching a wafer patterned with photoresist by submerging it into a liquid chemical solution is used to produce 70 percent of all mask layers. The positive characteristics of wet etching include the high selectivity (difference between etched material and underlying layer) and inexpensive pricing of the equipment. Negative characteristics include the use of hazardous chemicals, waste disposal problems, and a lack of control in the etch process.

Dry Etching

The dry etch process uses an electrical discharge to partially ionize a gas in a vacuum chamber. Depending on the type of gas used (reactive or inert) and the electrode configuration, the ions chemically etch or sputter the unmasked material from the wafer surface.

The production advantages of dry etching include a higher safety level because of a lack of hazardous chemicals, no waste disposal problem, and a reduction in the etching inconsistencies associated with batch wet etching. Dry etch technological advantages include greater control over slope and the ability to etch several different materials. There are three categories of dry etching: barrels, parallel plate, and ion beam milling.

Barrels

Barrels were first used to strip resist and have since evolved to silicon nitride removal or patterning where there are no anisotropy requirements. The etch mechanism results from chemically activating species in the gas, forming volatile gas by-products with the substrate, which are pumped out of the system. To date, two Japanese firms have developed automatic loaders for the barrel system.

Parallel Plate

There are two basic approaches to parallel plate plasma etching: planar plasma and RIE. Planar plasma usually operates at pressures from 1 to 10 Torr and relies on gas chemistry to achieve etching. At these pressures, single-wafer systems can achieve high etch rates and high wafer throughputs. Because of the short mean free path of the gas molecules, however, perfect anisotropy is difficult to attain.

RIE consists of four approaches: planar batch, hexode, triode, and magnetically enhanced. These RIE configurations rely on ion acceleration to achieve etching and operate at low pressures such as 10 to 100 mTorr. Better anisotropy results at these low pressures because the gas molecule mean free path is longer. To obtain adequate throughput, these low-pressure systems usually run in a batch mode.

In the hexode approach, the wafers are held vertically on a hexagonally shaped cathode. This approach helps achieve uniformity within a batch of wafers to produce adequate yields. Because of the optimum loading of the wafers, very high throughputs are attained.

For a single-wafer system to operate in the RIE mode, the etch rates must be increased to maintain throughput. This can be done by increasing the ratio of ions to neutral gas molecules in the plasma. To increase this ratio, the plasma can be magnetically enhanced, which results in the etch rates needed for adequate throughput. Another method, the triode etcher, increases the power level to the electrodes, thus increasing the ionization ratio and achieving better throughput.

Ion Milling

Ion milling evolved from the process of manufacturing bubble memories to become the dominant process for bubble memory devices and magnetic head applications. These applications use chemically inert materials such as gold, chrome, and nickel-iron. Ion milling uses ablation (sputtering) of the substrate as the etch mechanism. The inert gas plasma is produced remotely and the ions are extracted and accelerated toward the substrate by an electric field. There is little selectivity over the photoresist, as the ions sputter each material equally. Because no chemical action occurs in ion milling, the etch rates are low, but can be improved with use of reactive ion beam etching (RIBE) which utilizes a reactive gas as opposed to an inert gas. Although RIBE improves etch rates, little success in solving the selectivity problem has occurred as the combination of chemical action and sputtering affects all surface materials.

Because of its low pressure and the use of a collimated beam, ion milling can etch lines below one micrometer. The disadvantages of ion milling include lack of selectivity and low throughput. Thus, for production processing of mainstream devices, ion milling is not cost effective.

ANALYSIS

Wet Versus Dry

Wet etching is still more cost effective to perform than dry etching and produces higher yields for devices above 4 microns. The total number of layers currently done wet versus dry is about 2.3 to 1. For newer devices, line geometries are more critical. DATAQUEST predicts that over the years 1983 to 1988, the CAGR for wet etching will be 10.57 percent.

The market for dry etching breaks down as shown in Table 1. Applications for silicon nitride and polysilicon have the lion's share of the levels etched, and the cost of the equipment for these processes is generally much lower. Since high-priced equipment is needed to etch oxides, metals, and silicides, and since there will be more growth into those process steps, the highest dollar growth is expected for silicon nitride and polysilicon applications. As stated earlier, the most competitive technology is the RIE mode for those applications. However, the higher-pressure plasma systems will continue to find healthy sales into less critical layers.

One of the processes in the "other" category in Table 1 is trilevel resist. There are fundamental barriers with respect to shrinking line geometries below one micron in production. One of these barriers is the severe topography that is created as the devices are built up. Trilevel resist will be used to improve yields at these small geometries. The RIE technology is more capable of etching the deep organic layers and will profit from this technology.

Table 1

MARKET SHARE FOR PROCESS APPLICATIONS
(Percent)

	1983	1988
Silicon Nitride	10%	5%
Polysilicon	49	30
Silicon Dioxide	17	25
Aluminum	14	20
Other	10	20
Total	100%	100%

Source: DATAQUEST
April 1984

Single-Wafer Versus Batch

There has been controversy in the past over whether batch or single-wafer etching is more advantageous. The market for single-wafer systems has grown faster than for batch systems because of polysilicon and silicon nitride etching. DATAQUEST believes that both technologies will continue to grow. Batch will develop very high throughputs. Single wafer systems will become highly automated with respect to end-point detection. Table 2 lists single-wafer and batch system manufacturers. For both single-wafer and batch system manufacturers, total dollar amounts are approximately equal.

Of the batch system approaches, the RIE hexode has been the most successful. This success is mostly dependent on the productivity advantage of large wafer loading. This throughput advantage comes without compromising process quality.

As described earlier, triode and magnetically enhanced etching allow low pressure in a single-wafer system with throughputs approaching or exceeding those of plasma reactors and batch systems. However, prices for triode systems will be higher than for plasma type systems, and for production, low-cost systems will be better for less critical processes. Magnetically enhanced systems operate at a lower pressure than any technique except ion beam milling. As with triode, there is no real differentiation between magnetically enhanced and plasma systems for less critical processes. The competitive advantage of these emerging new technologies will be seen when low pressure becomes necessary for high-growth processes in very fine lines.

DATAQUEST believes that the production advantages of the hexode type system will help maintain its dominance in the near future for the high-growth markets. As the new RIE single-wafer systems gain experience, they will gradually replace the batch type systems.

Table 2

MAKERS OF SINGLE-WAFER AND BATCH SYSTEMS

Single-Wafer Systems	Batch Systems
Tegal	Applied Materials
Lam Research	Anelva
Tokyo Ohka (Airco)	Plasma-Therm
Perkin-Elmer	Branson/IPC
CIT-Alcatel	Ulvac
Zylin	Technics
MRC	LFE
GCA	Tokuda (Tylan)
E.T. Electrotech	E.T. Electrotech
Plasma-Therm	Kokusai (Veeco)

Source: DATAQUEST
April 1984

DATA

As presented in Table 3, DATAQUEST estimates that worldwide dry etch wafer processing equipment consumption was $232 million in 1983, an increase of 40 percent over the $167 million of consumption in 1982. It is interesting to note that the market grew at a rate of 34 percent in 1981 from $125 million to $167 million during an industry recession. Worldwide consumption should reach $365 million in 1984 and $1,094 million in 1988, representing a 36 percent CAGR between 1983 and 1988.

By geographical area, North American consumption of dry etch systems should increase at 34 percent CAGR between 1983 and 1988. Japanese consumption should grow at 38 percent CAGR during that same period. Western European consumption should grow at 40 percent CAGR and Rest of World (ROW) sales will increase 48 percent CAGR.

Parallel plate will grow fastest in North America with a 36 percent CAGR, reaching $480 million in 1988. Barrel systems will grow at 21 percent CAGR, reaching $36 million in 1988, and ion milling will grow at 25 percent CAGR, attaining a 1988 level of $21 million.

In the Japanese market, parallel plate will reach $401 million in 1988 with a 41 percent CAGR. Barrels will reach $24 million in 1988 at 19 percent CAGR, and ion milling will reach $15 million in 1988 at a 25 percent CAGR.

Table 3

ESTIMATED WORLDWIDE DRY ETCH WAFER PROCESSING EQUIPMENT CONSUMPTION BY GEOGRAPHICAL AREA

	1980	1981	1982	1983	1984	1988
North America	$60	$ 77	$ 94	$124	$192	$ 537
Japan	25	40	61	87	144	440
Western Europe	5	8	12	18	25	97
ROW	N/A	N/A	N/A	3	4	21
Total	$90	$125	$167	$232	$365	$1,094

N/A = Not Available

Source: DATAQUEST
April 1984

The European market figures for parallel plate are 45 percent CAGR to $83 million in 1988. Barrels will grow 21 percent CAGR to $8 million, and ion milling will grow 25 percent to $6 million.

In the ROW market, parallel plate will grow to $15 million in 1988 for a 5-year CAGR of 45 percent. Barrels will grow at a 29 percent CAGR to $4 million, and ion milling systems will grow at a 25 percent CAGR to $2 million.

Robert McGeary
Arden DeVincenzi

May Newsletters

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

- General Industry Update
- MOS Static and Dynamic RAM Shipments Second Half 1983--Year-End Review
- Integrated Circuit Packaging: Major Technologies

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: MAY

GENERAL INDUSTRY UPDATE

SUMMARY

Semiconductor consumption continues to increase, although the rapid growth of the last three quarters of 1983 is beginning to moderate. The industry book-to-bill ratio has declined from an all-time high of 1.66 in December 1983 to 1.41 in March 1984. U.S. semiconductor consumption reached an estimated $2,702 million in the first quarter of 1984, an increase of 6.6 percent over the fourth quarter of 1983. This represents a staggering 59.9 percent increase over the first quarter of 1983.

Since demand has increased by almost 60 percent in the course of a year, we expect capacity to be strained. The easy increases in capacity have all been used, and we anticipate slower quarter-to-quarter growth in 1984 than we saw in 1983. Consumption in 1984 is expected to grow by 39.5 percent over 1983 (as shown in Figure 1), and to continue strong growth into 1985. Semiconductor consumption in the United States is expected to reach almost $12 billion in 1984.

RECENT ECONOMIC TRENDS

The U.S. economy appears to be well positioned to continue expanding throughout 1984. The GNP increased at an annualized rate of 8.3 percent in the first quarter of 1984 over the fourth quarter of 1983, the fourth consecutive quarter of strong growth. Other indicators of a strong economy include the continued rise in the industrial production index to 160.7 in March, a moderate 4.1 percent inflation rate, and declining unemployment--the figure for both February and March was 7.8 percent. Some of the moderation in inflation can be attributed to the modest recovery in the rest of the world. Japanese industrial production grew more slowly than that of the United States in 1983, and the European countries have shown only limited growth. The strong dollar has helped bring prices of imports down in the United States.

Developments over the past few weeks suggest that the rapid pace of economic growth is beginning to slow. Such a situation is viewed in a positive light by many economists, since there was some concern that the economy would overheat and cause rapid inflation. Retail sales in March were 2.2 percent lower than in February (seasonally adjusted). Housing starts fell abruptly, and the Index of Leading Economic Indicators declined. Poor weather was only partly a factor. The rate of increase in the industrial production index was slower than it has been for several months.

THE ECONOMIC FUTURE

All the major indicators point to continued expansion of the economy. The current economic situation will be buoyed by the fact that 1984 is an election year and by the financial impact of the Olympic Games in Los Angeles. Every postwar downturn experienced by the U.S. economy has been preceded about 9 to 12 months earlier by a sharp rise in interest rates and a decline in the money supply. Over the past few months, the money supply has grown and interest rates have remained reasonably stable. Considering the strength of the economy in the last year, the modest increase in interest rates has been very encouraging.

DATAQUEST anticipates slower growth for the next two quarters, with the increase in the GNP moderating to an annualized rate of 2 to 3 percent, compared with 8.3 percent in the first quarter. This change is a very positive long-term factor. The more modest growth rate anticipated for the rest of 1984 will increase the duration of the economic cycle.

The major concerns about the U.S. economy center around the federal budget deficit and the trade deficit. The magnitude and intractability of these deficits suggest that the United States may pay for today's economic strength at a later date. It is critical that these problems be moderated.

SEMICONDUCTOR INDUSTRY OUTLOOK

The strong growth in semiconductor consumption is a function of the underlying strength of the economy. Economic growth in recent years has been heavily skewed toward the electronics and high-technology segments, while the more traditional smokestack industries have not fared so well. In the five years from the first quarter of 1979 to the first quarter of 1984, U.S. industrial production grew 4 percent, while U.S. semiconductor consumption grew 149 percent. The pervasiveness of semiconductor devices, which we have frequently noted, has assumed a new aspect. Increasingly complex devices are being used in even the simplest products. Many microwave ovens, for example, are now controlled by 8-bit microcontrollers rather than 4-bit devices.

Table 1 shows our estimates of U.S. semiconductor consumption for the years 1982 through 1984. Consumption is expected to grow 39.5 percent in 1984 over 1983. Growth of integrated circuit consumption will continue to exceed that of discrete devices, with IC consumption growing at 42.2 percent and discrete consumption growing at 25.6 percent.

Table 2 shows our estimates of U.S. semiconductor consumption for 1983 through the first quarter of 1985. In 1984, we expect to see a return to the typical pattern of consumption growth in which the second and fourth quarters show stronger growth than the first and third quarters. This pattern is clearly shown in Figure 2.

The true magnitude of the upturn in semiconductor consumption is shown most clearly by comparing each quarter with the same period a year earlier (see Figure 3). Consumption in the first quarter of 1984 is estimated to be 59.9 percent higher than in the same quarter of 1983. The increase in demand for semiconductors has resulted in a higher book-to-bill ratio, increased backlogs, spot shortages of some products, and improved profits for semiconductor manufacturers.

Such phenomenal growth has obvious implications for the coming months. All the easy semiconductor capacity has been used up. Future growth must come from new facilities, creating stress on the infrastructure of the industry. Semiconductor consumption will be supply limited throughout 1984. Prices are expected to remain relatively firm, although we do expect to see some softening of DRAM prices as new capacity comes on-stream at the end of the year.

The cost of building a wafer fabrication facility increased by a factor of 8 in the last 10 years, a problem compounded by the need to move to the next generation of devices with geometries of less than 2 microns. DATAQUEST anticipates a 62 percent increase in capital spending by U.S. semiconductor manufacturers in 1984 over 1983.

The industry has shown a distinct secular change in its rate of growth. Before 1978, industry growth averaged 13 to 15 percent; but since 1978, growth has averaged more than 20 percent. Even in a slow-growing economy, we believe that the semiconductor industry can continue relatively strong growth. The positive aspects of such a substantial rise in semiconductor consumption are the opportunities for economies of scale and the increased possibilities of niche markets. DATAQUEST expects to see strong growth in many of the new semiconductor companies.

However, in spite of the increase in the growth rate, the semiconductor industry is still a cyclical industry. Shortly after the beginning of the next economic downturn, we expect to see a halt to semiconductor industry growth, caused mainly by price pressure. The last semiconductor industry slowdown was essentially a price recession while unit volume continued to grow. This could be the predominant pattern of future semiconductor industry slowdowns.

Frederick L. Zieber
Jean Page

Figure 1

ESTIMATED INCREASES IN U.S. SEMICONDUCTOR CONSUMPTION
(Percent)

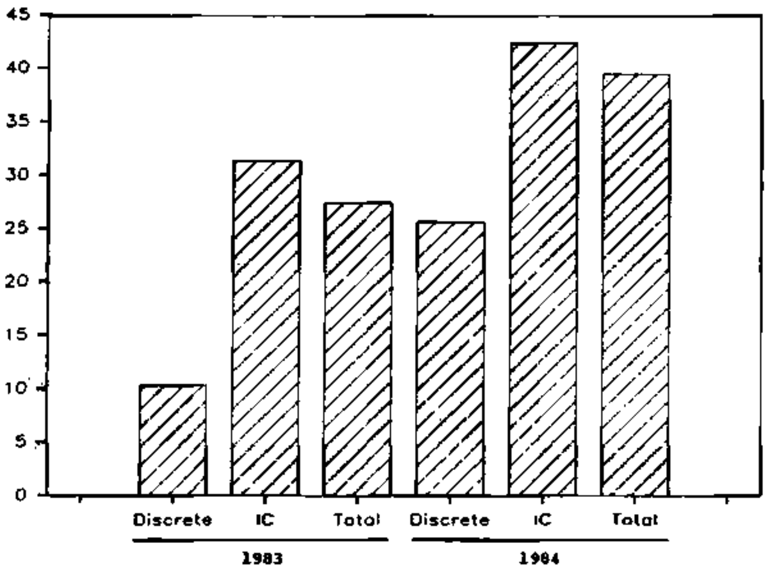


Table 1

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

	1982	Percent Change 1982-83	1983	Percent Change 1983-84	1984
Discrete Devices	$1,248	10.3%	$1,377	25.6%	$ 1,730
Integrated Circuits	5,364	31.3%	7,044	42.2%	10,017
Total	$6,612	27.4%	$8,421	39.5%	$11,747

Source: DATAQUEST
May 1984

Table 2

ESTIMATED QUARTERLY U.S. SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1983				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 290	$ 331	$ 354	$ 402	$1,377
Integrated Circuits	1,400	1,652	1,858	2,134	7,044
Total	$1,690	$1,983	$2,212	$2,536	$8,421
Percent Change from Previous Quarter	2.2%	17.3%	11.6%	14.7%	
Percent Change from Previous Year	8.0%	15.7%	31.6%	53.0%	27.4%

	1984				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 404	$ 425	$ 439	$ 462	$ 1,730
Integrated Circuits	2,298	2,480	2,526	2,713	10,017
Total	$2,702	$2,905	$2,965	$3,175	$11,747
Percent Change from Previous Quarter	6.6%	7.5%	2.1%	7.1%	
Percent Change from Previous Year	59.9%	46.9%	34.0%	25.2%	39.5%

	1985				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 468				
Integrated Circuits	2,802				
Total	$3,270				
Percent Change from Previous Quarter	3.0%				
Percent Change from Previous Year	21.0%				

Source: DATAQUEST
May 1984

Figure 2

ESTIMATED QUARTERLY INCREASES IN U.S. SEMICONDUCTOR CONSUMPTION (Percent)

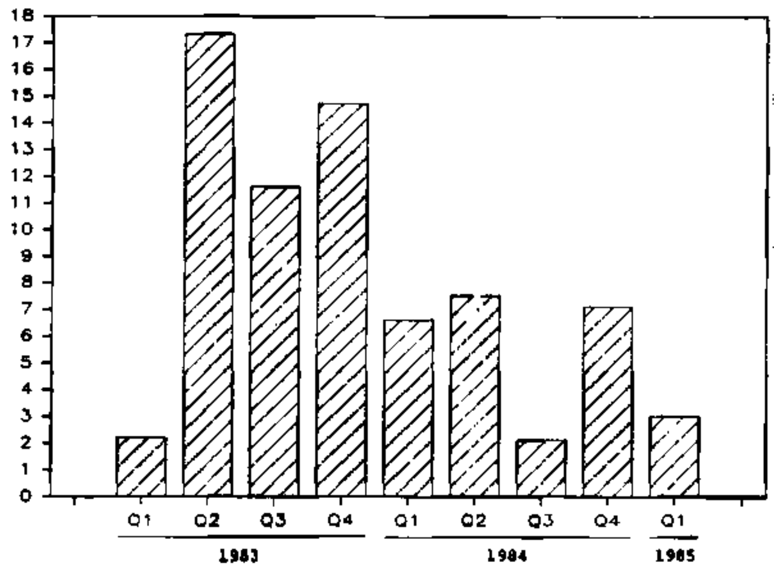
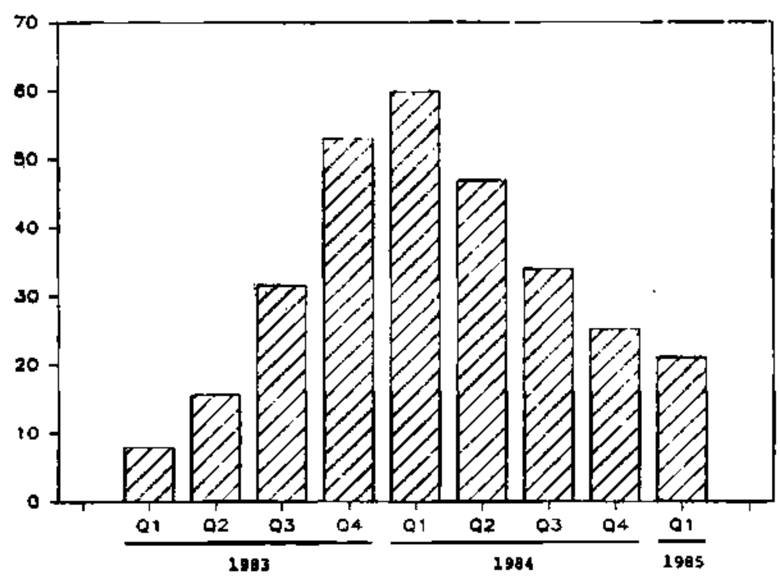


Figure 3

ESTIMATED INCREASE IN U.S. SEMICONDUCTOR CONSUMPTION OVER THE SAME QUARTER OF THE PRECEDING YEAR (Percent)



Source: DATAQUEST
May 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

MOS STATIC AND DYNAMIC RAM SHIPMENTS SECOND HALF 1983--YEAR-END REVIEW

DATAQUEST recently published the service section "MOS Static and Dynamic RAM Shipments Second Half 1983--Year End Review." This newsletter summarizes the highlights of that service section. Please contact the binderholder in your company for complete shipment numbers.

SUMMARY

The MOS RAM market grew nearly 70 percent in 1983 over 1982 due to stable prices and strong unit growth. The MOS static RAM market grew 32 percent in 1983 from an estimated $540 million to $713 million, while the MOS dynamic RAM market grew 97 percent, from $950 million to $1,878 million. Quarterly aggregate production figures and market share data are summarized in Table 1.

Table 1

ESTIMATED QUARTERLY MOS RAM REVENUES--1983
(Millions of Dollars)

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
Static RAMs	$130	$153	$188	$242	$ 713
Fast (≤100ns)	30	32	38	46	146
Slow (≥120ns)	100	121	150	196	567
Dynamic RAMs	320	403	512	643	1,878
Total	$450	$556	$700	$885	$2,591
U.S. Mfrs. SOM	38%	38%	39%	39%	39%
Japanese Mfrs. SOM	58	58	57	57	57
European Mfrs. SOM	4	4	4	4	4
Total	100%	100%	100%	100%	100%

Source: DATAQUEST
May 1984

The development of production capacity was the important issue in 1983 and will remain important throughout 1984. Several manufacturers were able to gain market share during the supply shortage because of their ability to bring production on-line sooner than their competitors.

DYNAMIC RAMS

The 1983 revenue run rate for dynamic RAM suppliers more than doubled in less than nine months from $320 million in the first quarter to an estimated $643 million in the fourth quarter. This is what happens when prices that have historically dropped more than 30 percent per year firm up while unit shipments continue to grow.

Shipments of 16K dynamic RAMs picked up beginning in the spring of 1983 and continued to be quite strong through the end of the year. The market is becoming more and more concentrated as the few remaining vendors increase their market shares as other manufacturers move on to producing higher-density devices. Shipments of 16K dynamic RAMs in 1983 were 296.6 million units, up 4 percent over 1982 shipments of 286.3 million units. Total unit shipments by density are shown in Table 2.

64K Dynamic RAMs

Shipments of 64K dynamic RAMs in 1983 were an estimated 371.2 million units, more than triple the 104.0 million units shipped in 1982. Strong growth and stable market prices (coupled with improving manufacturing costs) have provided strong incentive for manufacturers to bring their 64K DRAMs up as fast as possible. Some significant blocks of production capacity have been brought on-line since the end of 1983. Manufacturers who added capacity include Mitsubishi and NEC in Japan, and in early 1984, NEC in Roseville. Additionally, in the fourth quarter of 1983, Texas Instruments brought on a significant block of front-end capacity in Miho, Japan.

Table 2

ESTIMATED WORLDWIDE DYNAMIC RAM SHIPMENTS
(Thousands of Units)

	1982	1983				
Device	Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
4K	4,635	750	650	650	350	2,400
16K						
3-PS	263,060	56,920	64,890	61,700	55,700	239,210
5-Volt	23,240	11,950	13,650	15,900	15,900	57,400
64K	103,965	56,345	78,585	104,010	132,300	371,240
256K	10	25	80	480	1,115	1,700

Source: DATAQUEST
May 1984

256K Dynamic RAMs

Production of 256K dynamic RAMs grew rapidly in the second half of 1983. Total production for the year was an estimated 1.7 million units. Hitachi and Fujitsu led the production ramp-up, shipping 650,000 units and 480,000 units, respectively, giving the Japanese about 93 percent initial market share. Western Electric was the leading U.S. supplier, shipping 120,000 units in 1983.

STATIC RAMS

The static RAM market appears to be more capacity bound than the dynamic RAM market. The rapid growth in demand and the production allocations at major static RAM suppliers promise to leave the market strong. The market is no longer characterized by transistion from 4K to 16K; we are now seeing new design-ins of the 64K part concurrent with strong demand for the older 16K parts.

4K Static RAMs

There continued to be a strong market for 4K NMOS static RAMs as a few major manufacturers continued to pick up market share at the expense of other producers. Several manufacturers who had more interesting production options at higher densities retreated from the 4K market, causing some problem in getting certain parts, particularly the 2114-type part.

The 4K CMOS static RAM market had problems similar to those in the 4K NMOS market. While abandonment and no-bid contracts caused problems for users, they created opportunities for committed vendors. Estimated static RAM unit shipment totals are shown in Table 3.

Table 3

ESTIMATED WORLDWIDE STATIC RAM SHIPMENTS
(Thousands of Units)

	1982	1983				
Device	Year	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Year
4K NMOS						
Fast	10,995	3,230	3,510	3,905	4,195	14,840
Slow	67,795	15,945	14,870	14,760	15,465	61,040
4K CMOS	31,780	6,620	6,280	6,630	6,330	25,860
16K						
Fast	4,138	1,795	2,150	3,050	4,320	11,315
Byte-wide	36,260	16,190	22,815	29,095	34,485	102,585
64K	155	190	715	1,275	1,970	4,150

Source: DATAQUEST
May 1984

16K Static RAMs

Shipments of 16K fast static RAMs showed steady growth in the second half of 1983, with 11.3 million units shipped for the year. CMOS devices equaled about 23 percent of the total 16K fast static RAMs shipped during 1983.

The byte-wide 16K static RAM market showed extraordinary growth in the third and fourth quarters. An estimated 29.1 million units were shipped in the third quarter, up 28 percent over the second quarter. Shipments in the fourth quarter were 34.5 million units, up 19 percent over the third quarter.

CMOS 16Ks equaled about 70 percent of the total units shipped. Although CMOS continued to command a price premium throughout the year, prices of CMOS, N/CMOS, and NMOS devices all increased in the second half of 1983.

64K Static RAMs

Shipments of 64K static RAMs in the fourth quarter of 1983 were an estimated 2.0 million units, up 55 percent over third quarter shipments of 1.3 million. The 64K static RAM market was strictly CMOS and all Japanese at year-end. Intel's iRAMs (2186/87) were the only U.S.-manufactured devices penetrating 64K SRAM sockets.

CONCLUSIONS

Stable prices and remarkable growth in demand and production resulted in extraordinary growth for static and dynamic RAM suppliers in the second half of 1983. This strong market promises to continue through the first half of 1984 and into the second half of the year. As additional capacity comes on-line, we may begin to see some weakening in dynamic RAMs in the second half of 1984.

The major points of the service section can be summarized as follows:

- The development of production capacity has been the important issue for the last nine months and promises to remain so throughout 1984. Additionally, more concern about the long-term state of the economy is being voiced.

- Phenomenal unit growth built on stable prices caused the MOS RAM market to grow nearly 70 percent in 1983.

- The second half of 1983 saw some significant production introductions of 256K dynamic RAMs and 64K static RAMs; Japanese manufacturers dominated these markets with more than 95 percent market share.

- DATAQUEST believes that in spite of the strong unit growth in all memory products, the bigger part of the revenue growth predicted for 1984 will be attributable to stable prices.

Katy Guill
Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

INTEGRATED CIRCUIT PACKAGING: MAJOR TECHNOLOGIES

SUMMARY

The Semiconductor Industry Service recently updated the integrated circuit packaging section in the Industry and Technology notebook. This newsletter summarizes that section, discussing package technologies, mounting methods, and packaging trends.

DATAQUEST believes that total North American package consumption grew 35.1 percent from 8.2 billion units in 1982 to a 1983 level of 11.1 billion units. Unit consumption will grow to 15.0 billion units in 1984, a 35.2 percent increase over 1983, and will reach a 1988 level of 31.8 billion units, representing a 23.4 percent compound annual growth rate from 1983 through 1988.

As the use of plastic dual-in-line packages (DIPs) declines during the 1980s, DATAQUEST believes that they will be gradually replaced by small outline and plastic chip carrier packages. Similarly, ceramic chip carriers will replace a portion of the flatpak, CERDIP, and ceramic DIP packages. Because of its importance in high-pin-count VLSI, the pin grid array will see an increase in unit growth. As surface mount technology matures and increases in popularity, packages such as high-density chip carriers, quad and small outline packages, plastic chip carriers, and pin grid array packages will also see increased unit consumption. We believe that the use of surface-mounted packages will grow from a combined 1.5 percent of total packages in 1983 to 14.1 percent in 1988.

The variety of packages available are suited to the high densities and pin counts required by LSI and VLSI technologies. Selection of these packages is a function of such factors as circuit density, heat dissipation, reliability, and cost.

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

PACKAGE TECHNOLOGIES

DIPs have dominated integrated circuit packaging. They derive their name from their two rows of in-line leads. They are manufactured using ceramic, CERDIP, and plastic technologies. In ceramic DIPs, leads are metallized onto the ceramic body and the lead pins are brazed to the sides. CERDIP packages, consisting of a lead frame and two ceramic body parts, are fused with a glass frit seal. Plastic DIP packages, after the IC has been wirebonded to the lead frame, are sealed and encapsulated with injection-molded epoxy. Single-in-line packages (SIPs) vary from DIPs in that they employ a single row of pins for higher board density applications.

Flatpaks mount close to the printed circuit board (PCB), giving them a low profile. They have leads on two sides, but are half the length of DIPs. Flatpaks are used where packing density is important (such as in space and military applications). Flatpaks are available in two forms, the CERPAK (which is similar to the CERDIP in structure) or the solder seal. As the lead count increases beyond 20, the size and weight advantages of flatpaks increase.

Chip carriers, which were developed for high-density packaging, have leads on all four sides and are available in four basic versions: leaded, leadless, plastic, and ceramic. The leadless ceramic chip carrier (LCCC) is either surface mounted or mounted in a socket. This requires that consideration be given to inspection and cleaning requirements and to thermal expansion coefficients. The leads extend from the die attach cavity out to the sides and down under the carrier. The leaded ceramic chip carrier, because of its compliant leads, can be used with epoxy PCBs without using sockets. Clips are attached to the metallized edges and, depending upon the bend of the clips, the carrier can be either surface or through-board mounted. Depending on whether encapsulation is performed before or after die attach and lead bonding, plastic chip carriers (PCCs) are available in pre- and postmolded versions. In postmolded PCCs, the die is attached and bonded to a lead frame before it is encapsulated with epoxy in an injection mold. Premolded packages are constructed by molding plastic to a lead frame. When the die is attached, the cavity is sealed with an adhesive and a lid. Similar in construction to the PCC, the plastic quad package leads either extend downward for through-board mounting or are bent outward for surface mounting.

Small outline (SO) packages have leads bent down and out from the package body for surface mounting. SOs are miniature DIPs, occupying approximately one-fourth of the conventional DIP board space.

The pin grid array (PGA), which can be through-board or socket mounted, is used for circuits with more than 64 pins; PGAs have been used for circuits with as many as 256 pins. The pins are arranged in a rectangular array and the package is constructed from a ceramic material. The pad grid array, similar to the pin grid array, is surface mounted and uses soldering pads instead of mounting pins.

Tape Automated Bonding (TAB) is not separated as a packaging technology, since in its current form, devices on a TAB frame are enclosed in plastic packages. The lead frames, which are designed to match the IC bonding pad locations, are formed on reels of thin copper that is sprocketed on the edges. All bonds are made simultaneously.

Chip-on-board, the attachment of ICs directly on the PCB, is the process of bonding and encapsulating the chip in a plastic compound. Wirebonding is from the die directly to the PCB tracing, rather than to a lead frame. This packaging technology is popular in consumer electronics.

MOUNTING METHODS

Through-the-board mounting is the process in which the package leads are inserted in holes on one side of the PCB. The holes are gold plated for reliable contacts. Wave soldering is the most common solder method for through-the-board mounting. Table 1 presents the mounting and solder methods for each package type.

Surface mounting, the mounting of the IC packages directly onto the PCB, reduces the space utilization compared to through-the-board mounting. Both sides of the PCB can be used. Solder reflow, which is effected by vapor phase, infrared, and wave soldering methods, is the method of attachment.

Sockets are used primarily for high-lead-count packages to allow the IC to be easily removed or isolated. These ICs are often removed after the board has been debugged and the chip is then mounted directly on the board.

Mounting by the flip chip process incorporates solder bumps built directly on the chip while in wafer form. Contact areas on a ceramic substrate are matched to those on the chip. The die is placed in flip (upside down) position and the assembly is heated to melt the solder. Because the contact area is small and fragile, these unpackaged ICs are difficult to test.

MARKET DATA

DATAQUEST's estimates of North American integrated circuit consumption by package type are presented in Table 2. DATAQUEST expects total package consumption to grow at a 23.4 percent compound annual growth rate (CAGR) from approximately 11.1 billion units in 1983 to 31.8 billion units in 1988. The plastic DIP, as the dominant package throughout the forecast period, will probably grow at 20 percent CAGR. As plastic DIP growth slows in the late 1980s, plastic chip carrier and small outline growth will increase. For the forecast period, we expect plastic chip carriers and quads to grow at 133 percent CAGR from

29.0 million units in 1983 to 2.0 billion units in 1988. At a CAGR of 109 percent, small outline units will increase from a 1983 level of 34.0 million units to 1.4 billion units in 1988.

With ceramic chip carriers taking some of the share of flatpaks, CERDIPs, and ceramic DIPs, we expect ceramic chip carriers to grow at a CAGR of 90 percent from 40 million units in 1983 to 983 million units in 1988.

The pin grid array, which will probably be an important package in the more-than-84-pin VLSI segment, is forecast to grow at a CAGR of 87 percent from 6 million units in 1983 to 131 million units in 1988. Because of the current trend toward surface mounting, TAB, flip chip, and high-density chip carriers will see increased growth.

Table 3 shows package use as a percent of total package consumption. As can be seen from the table, plastic DIPs are expected to slowly lose market share, dropping from 81 percent of total units in 1983 to 70 percent in 1988. A similar decline is expected for CERDIPs and ceramic DIPs. The surface-mountable packages such as ceramic chip carriers, plastic chip carriers, quads, small outline packages, and pin grid arrays are all expected to see increased use, consistent with the trend toward increasing use of surface mount technology.

Arden DeVincenzi
Robert McGeary

Table 1*

MOUNTING/SOLDER METHODS
BY PACKAGE TYPE

Package	Through-the-Board	Surface Mount	Solder Methods
Ceramic DIP	X		Wave
Plastic DIP	X		Wave
CERDIP	X		Wave
Flatpak		X	Weld
Leadless Ceramic Chip Carrier		X	Reflow
Leaded Ceramic Chip Carrier	X	X	Wave/Reflow
Plastic Chip Carrier		X	Reflow
Quad Package	X	X	Wave/Reflow
SO		X	Reflow
PGA	X	X	Wave/Reflow
Chip-on-Board		X	Epoxy Adhesive
Tape Automated Bonding	X	X	Weld

*This table was not included in the integrated circuit packaging section of the Industry and Technology notebook.

Source: DATAQUEST
May 1984

Table 2

ESTIMATED NORTH AMERICAN SHIPMENTS
(Millions of Units)

Package	1983	1984	1985	1986	1987	1988	CAGR
Plastic DIP	9,002	12,058	15,487	17,604	19,202	22,445	20.05%
CERDIP	1,307	1,619	1,933	2,078	2,150	2,340	12.35%
Ceramic DIP	92	112	131	137	137	146	9.78%
Flatpak	41	43	44	39	34	32	-5.12%
Ceramic Chip Carrier	40	105	189	325	514	983	89.60%
Plastic Chip Carrier and Quad	29	99	254	498	822	1,963	132.85%
SO	34	105	218	361	562	1,364	108.75%
PGA	6	13	29	51	68	131	87.00%
Header	75	92	109	115	110	116	9.23%
Other	499	796	1,156	1,479	1,712	2,363	36.49%
Total Packages	11,125	15,043	19,550	22,686	25,311	31,883	23.44%

Table 3

ESTIMATED NORTH AMERICAN SHIPMENTS
(Percent)

Package	1983	1984	1985	1986	1987	1988
Plastic DIP	80.9%	80.2%	79.2%	77.6%	75.9%	70.4%
CERDIP	11.8	10.8	9.9	9.2	8.5	7.3
Ceramic DIP	0.8	0.7	0.7	0.6	0.5	0.5
Flatpak	0.4	0.3	0.2	0.2	0.1	0.1
Ceramic Chip Carrier	0.4	0.7	1.0	1.4	2.0	3.1
Plastic Chip Carrier and Quad	0.3	0.7	1.3	2.2	3.2	6.2
SO	0.3	0.7	1.1	1.6	2.2	4.3
PGA	0.1	0.1	0.1	0.2	0.3	0.4
Header	0.7	0.6	0.6	0.5	0.4	0.4
Other	4.5	5.3	5.9	6.5	6.8	7.4
Total	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%

Source: DATAQUEST
May 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

AT&T INTRODUCES 32-BIT MICROPROCESSOR FAMILY TO THE MERCHANT MARKET

The long-awaited battle between traditional semiconductor makers and large captive minicomputer makers in the microprocessor arena has begun in earnest. Since the first microprocessor was introduced over a decade ago, semiconductor manufacturers have been offering successive generations of higher-performance microprocessors. Migration from 8-bit to 16-bit microprocessors led to object code compatibility problems that semiconductor manufacturers learned to overcome but which initially hindered the growth of 16-bit MPUs. Migration from 16-bit to 32-bit MPUs is expected to be less painless for microprocessor manufacturers due to the installed software base. A mainframe on a chip has been envisioned by semiconductor manufacturers since the first microprocessor was created, and it is closer to reality with the emergence of the 32-bit microprocessor.

The 32-bit architecture on a single chip offers many opportunities due to its hardware and software enhancements. CAE, certain CAD applications, and high-accuracy robotics were not possible without a full 32-bit microprocessor. Needs met only with a 32-bit MPU are now a reality, and many so far unknown high-performance applications will become realities. While semiconductor manufacturers have been offering upward migration paths for microprocessors, minicomputer manufacturers have turned to manufacturing proprietary circuits to maintain economic and technological advantages within their industry. The upward migration of 8- and 16-bit microprocessors and the downward migration from system level architecture have collided in the 32-bit market arena.

AT&T has announced commercial availability of its 32-bit microprocessor family, and has announced sampling of its 16-bit microprocessor in fourth quarter 1985. Its 16-bit MPU is fully upward object code compatible with its 32-bit MPU. AT&T's strategy is a combination of upward and downward migration to enter the 32-bit market. AT&T believes that both approaches are essential to capture market share. The 16-bit microprocessor market only has 12 percent of the market today but is expected to take off in 1985, according to DATAQUEST. We believe that AT&T's introduction of its 16-bit microprocessor has not missed the market. However, AT&T's marketing must be strong to capture designs at this time. The 16-bit microprocessor, WE32116, will sample late in 1985 and will make upgrading easier for users not quite ready for 32-bit cost or performance. The complete family is part of an integrated UNIX microsystem that includes the microprocessor, support chips, and software. Other available products are a development system that supports in-circuit-emulation for the memory management unit as well as the microprocessor, development software, and an evaluation board.

The following components make up the AT&T family:

- WE32100, 32-bit Microprocessor
- WE32101, Memory Management Unit
- WE32102, System Clock Chip
- WE32103, Dynamic RAM Controller
- WE32104, Direct Memory Access Controller
- WE32105, System Interface Unit
- WE32106, Math Acceleration Unit
- WE32116, 16-bit Microprocessor

The microprocessor, memory management unit, and system clock chip are in full production now; the other units are presently available for sampling, and will be in full production by the end of 1985.

The UNIX operating system, which was originally developed by AT&T, is a strong feature and AT&T plans to capitalize on it. The UNIX System V has been licensed to all of the major semiconductor manufacturers and has become a de facto standard in the industry. Because of AT&T's experience with UNIX, the WE32100 microprocessor family has been optimized to achieve outstanding performance with this software. DATAQUEST believes that although AT&T is a newcomer to the microprocessor market, its relationship with UNIX will provide it with the distinctive competency necessary to penetrate the market.

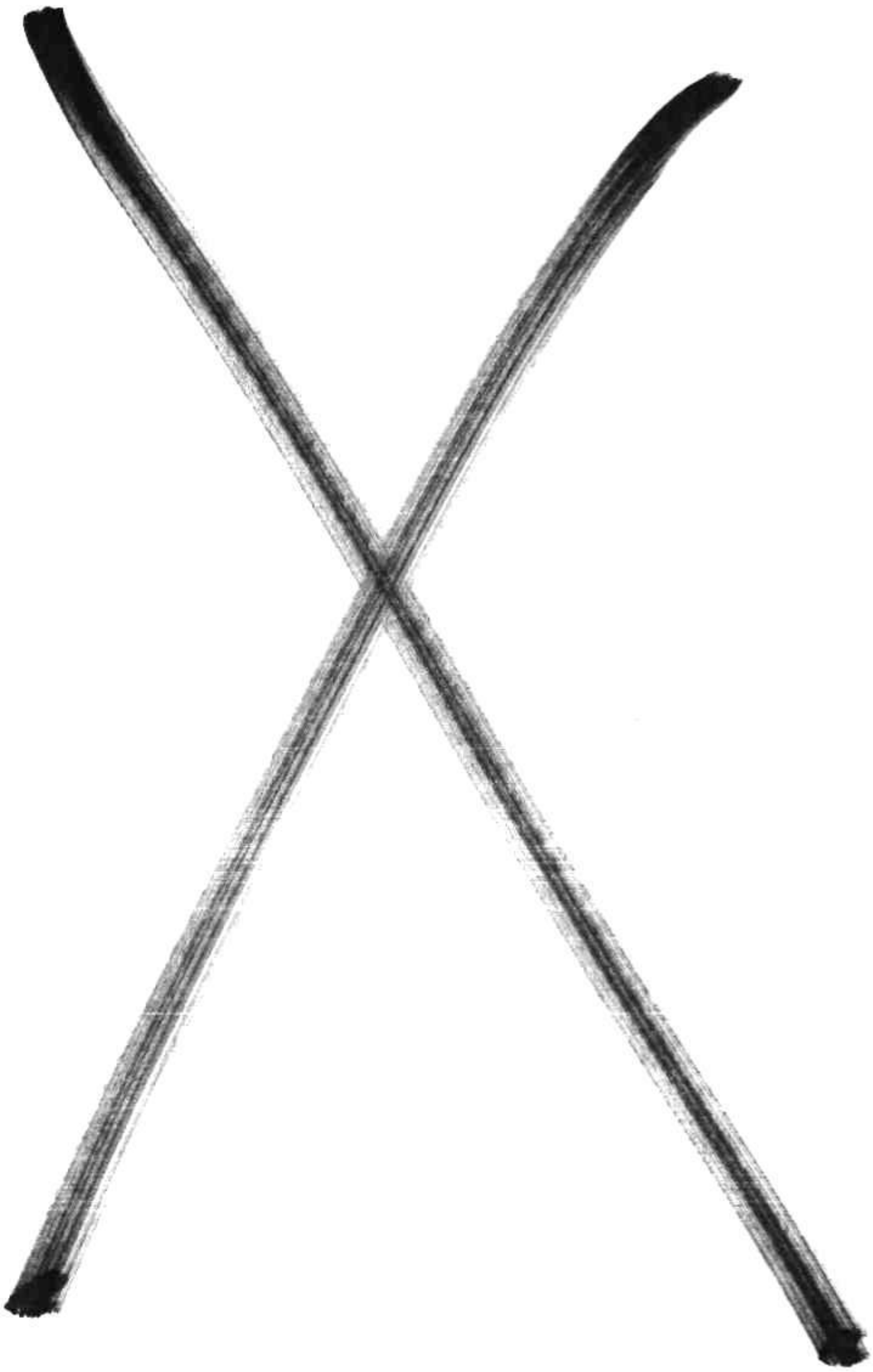
ANALYSIS

AT&T is the second captive manufacturer to announce commercial availability of its microprocessor family. (The first was NCR with the NCR/32 family.) We expect other minicomputer manufacturers to follow this trend. Other major minicomputer makers (Hewlett-Packard, Digital Equipment Corporation, and Data General), also are generally ahead of the semiconductor manufacturers in the development of the 32-bit microprocessor families. AT&T has been in production with the WE32100 since last year and prior to that with its predecessor, the WE32000. In fact, AT&T has manufactured several tens of thousands of the 32-bit microprocessor for use in its own terminals, workstations, and telecommunications equipment. Minicomputer manufacturers have the advantages of generally superior architecture for high-performance systems, more extensive software for both development and application, and a large installed base of development systems. They also have an advantage because their internal consumption helps to increase the production volume.

AT&T's WE32100 family fits the 32-bit market well, but can AT&T market the product effectively without previous experience in the merchant market? The company's strategy is a good one combining upward and downward migration paths for its users. The strength of UNIX and the fact that the product should run smoother than any other product on UNIX is key to its success. The development of an effective sales and marketing force for this new market area is the most important factor in launching a product designed and manufactured by a captive manufacturer.

Two major semiconductor manufacturers National Semiconductor and Motorola) with experience in effective sales and marketing throughout the semiconductor industry are already in the 32-bit microprocessor market. These companies have an advantage over other merchant manufacturers in the 32-bit arena due to their early entry into the market. DATAQUEST believes that AT&T's entry into this dynamic and challenging marketplace adds merit to the 32-bit market and offers great opportunities for industry.

Mel Thomsen
Jan Rey



June Newsletters

The following is a list of material in this section:

- Military Semiconductor End-Use Outlook
- The Smart Card: A U.S. Market Outlook
- 1984 Custom Integrated Circuit Conference--A World Class Event

Nielsen Dataquest RESEARCH NEWSLETTER

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MILITARY SEMICONDUCTOR END-USE OUTLOOK

INTRODUCTION

This newsletter gives a general overview of the defense electronics market, followed by a discussion of military semiconductor consumption. It covers consumption through 1985 forecasted by major semiconductor products. The section ends with a discussion of market trends.

The semiconductor market for military electronics appears extremely strong for the next two years (1984-1985). A 5 percent real growth in defense appropriations is expected for fiscal 1985, as pressure continues from both government and industry for improved military capabilities.

MILITARY SEMICONDUCTOR CONSUMPTION

Military semiconductor consumption, as shown in Table 1, grew almost 10 percent from 1982 to 1983, from $908 million to $1 billion. Continuous strong demand from the military community for complex integrated circuits represents a significant increase in the use and application of LSI and VLSI devices such as microprocessors, peripheral support chips, and MOS memory and logic devices in military electronic equipment. DATAQUEST believes that consumption will continue to increase by approximately 15 percent annually through 1985.

Table 1

ESTIMATED U.S. MILITARY SEMICONDUCTOR
CONSUMPTION BY TECHNOLOGY
(Millions of Dollars)

	1980	1981	1982	1983	1984	1985
Discrete Devices	$150	$160	$179	$ 190	$ 218	$ 245
Integrated Circuits	583	628	729	810	926	1,080
Total	$733	$788	$908	$1,000	$1,144	$1,325

Source: DATAQUEST
June 1984

IMPACT OF DEVICE SPECIFICATIONS

The Department of Defense (DOD) is continuing to stress, develop, and process electronic device standards and specifications for military semiconductor manufacturers, in an effort to reduce life cycle costs and improve product quality.

Until recently, the military market has not been attractive to semiconductor manufacturers because of the expense incurred in meeting the stringent device specifications and requirements of MIL-M-38510, which qualifies devices for the military community's JAN-preferred (Joint Army-Navy) program status. The limited number of available suppliers of JAN-type devices, coupled with depleted inventories resulting from the 1982 recession, has resulted in shortages of complex ICs that are qualified under MIL-M-38510. Due to insufficient availability of JAN-type devices in 1982 and 1983, the military community has been purchasing more MIL-STD-883B devices to meet the needs of its systems applications. MIL-STD-883B is accepted as the minimum JAN specification for military devices and offers the following advantages to both military user and manufacturer:

- MIL-STD-883B devices are more cost effective, i.e., MIL-M-38510 devices cost two to three times more than equivalent commercial devices, while 883B devices average 1.4 times the cost of equivalent commercial devices.

- An increase in the available number of military semiconductor suppliers offers increased alternate source availability.

The problem of limited availability of JAN-type devices is expected to be short term. Over the past few years, quality and reliability programs have received increased emphasis from both manufacturers and users of military standard products. Many semiconductor manufacturers are producing more ICs screened to military specifications for both commercial and military consumption, for the following reasons:

- As the number of defective devices decreases, delivery schedules improve.
- Production costs are reduced.

We estimate that MIL-M-38510 Joint Army-Navy (JAN) ICs will represent 25 percent of the $1.1 billion U.S. military semiconductor market in 1984. MIL-STD-883 Class B products will represent 70 percent of the 1984 market. Hi-rel and other standard ICs used in commercial and standard military applications will represent the remaining 5 percent of this market.

MILITARY END-USE FORECAST

DATAQUEST has compiled a market forecast for selected groups of devices shipped by defense equipment manufacturers from 1980 through 1985. As shown in Table 2, across the board, military market product demand will show steady growth. We expect a compound annual growth rate of 12.5 percent through 1985. Research and development expenditures are expected to continue, indicating an increase in demand for improved electronic technologies. The military community is expected to increase its use of IC memory products for application in the Defense Advanced Research Project Agency's (DARPA) Super Computer and the National Security Agency's (NSA) TEMPEST, advanced computer and electronic warfare (EW) programs.

The DOD's Command Control and Communication of Intelligence (C^3I) program is another major military project, with 1984 budget estimates of $31.4 billion. The DARPA Super Computer is budgeted for $50 million in 1984, and the unclassified Air Force reconnaissance and EW portion of TEMPEST is budgeted at $53 million. (Most of the TEMPEST program is classified information.)

Military semiconductor manufacturers expect to see decreasing use of TTL and LS TTL discrete logic devices as CMOS becomes the preferred product family.

PMOS and NMOS products are expected to diminish in military market share while HMOS and linear bipolar products will maintain a stable hold. MOS memory consumption is expected to exceed bipolar memory consumption, as military memory users are demanding increased system density. Although MOS memories, MOS logic, and MOS microprocessors are presently a small portion of the total market, a significant increase to $461 million is expected by 1985.

Table 2

ESTIMATED U.S. SHIPMENTS OF SEMICONDUCTORS TO THE MILITARY MARKET BY TECHNOLOGY
(Millions of Dollars)

	1980	1981	1982	1983	1984	1985
Bipolar Logic	$165	$180	$224	$ 240	$ 249	$ 275
Bipolar Memory	85	90	95	110	139	154
MOS Logic	89	91	93	116	137	158
MOS Memory	87	100	115	126	140	168
MOS MPU	37	44	55	73	101	135
Linear	120	125	147	145	160	190
Discrete	150	160	179	190	218	245
Total	$733	$790	$908	$1,000	$1,144	$1,325

Source: DATAQUEST
June 1984

Due to the lack of inventory at the majority of the semiconductor facilities that manufacture military ICs, MIL-STD semiconductor users experienced higher prices and longer lead times through the first quarter of 1984. Industry wide, DATAQUEST estimates that there will be a 30 to 50 percent increase in MIL-STD semiconductor device demand, which would be easy to adjust to in a normal market. Although the MIL-STD semiconductor is usually only a small percentage of a company's total unit volume, the estimated increase in demand in 1983 tweaked an already overburdened capacity. DATAQUEST believes that military semiconductor manufacturers experienced day-to-day capacity problems through the first quarter of 1984. We believe that 1984 fourth quarter lead-time estimates of 26 to 40 weeks will extend through the fourth quarter of 1985, due to capacity shortages and burn-in specifications, which increase assembly time by 10 percent.

Average selling prices for military semiconductor devices in the United States rose in fourth quarter 1983 by 5 to 10 percent over third quarter prices. DATAQUEST expects overall prices of military standard ICs to increase 10 to 15 percent through 1985, due to the implementation of Revision C to MIL-STD-883. We expect the 1985 average selling price for bipolar logic devices to be $2.99; MOS memory devices, $15.00 to $18.00; and linear devices, $4.25 to $15.00.

MILITARY SEMICONDUCTOR MANUFACTURERS

DATAQUEST surveyed the relative size and growth rates of selected product lines from major military manufacturers in the United States. Today, we believe that the following semiconductor manufacturers supply more than 60 percent of the U.S. military semiconductor market:

- Fairchild Camera & Instrument Corp.
- Harris Corporation
- Intel Corporation
- Motorola, Inc.
- National Semiconductor Corporation
- Texas Instruments, Inc.

Other military semiconductor manufacturers include:

- Advanced Micro Devices, Inc.
- Analog Device
- Monolithic Memories, Inc.
- Mostek Corporation
- RCA Corporation
- Raytheon Company
- Signetics Corporation
- Zilog, Inc.

Texas Instruments was the leading military semiconductor manufacturer in bipolar logic in 1982, with strong competition coming from Motorola, National Semiconductor, and Fairchild. Intel is expected to dominate the MOS market in 1983 and 1984 with 45 percent of the total market. Motorola expects to maintain a strong second place.

SUMMARY OF TRENDS

Government and industry officials are forecasting a steady demand for electronic equipment for computer applications. The increased demand for microprocessor and peripheral devices is expected to boost the annual sales of electronic equipment to military users by $350 million.

Custom and semicustom ICs are seen as significant areas of opportunity for military semiconductor manufacturers. Custom and semicustom products offer numerous advantages to military end users and manufacturers, including the following:

- Custom ICs meet the military community's needs for system density.

- As part of an all-out thrust to prevent security leaks of military intelligence data and export of technology, custom and semicustom devices are of a more sophisticated design and are more difficult to analyze than standard ICs.

- Custom ICs typically consume less power than standard ICs, and thus require smaller power supplies and have reduced cooling requirements.

Another trend indicates that Gallium Arsenide (GaAs) semiconductors may increasingly be used in military electronic applications. DATAQUEST believes that a steady amount of funds are flowing into R&D efforts for development of GaAs products and end equipment. For example, it is estimated that $100 million will be spent in development of GaAs memories and gate arrays for the DARPA project.

Benefits of GaAs technology for military use include the high speed and high performance found in both digital and linear applications, and the fact that GaAs chips are more easily radiation hardened. DATAQUEST believes specific applications of GaAs chips may include:

- Expendable decoys

- Satellite signal processors

- Advanced phased-array radar

- Space-based radar

- Communications, navigation, and identification systems

- Military computers

Active players pursuing GaAs technology for the military include:

- Gigabit Logic

- Honeywell

- Hughes

- Rockwell

- Texas Instruments

- TRW

FOREIGN COMPETITION IN THE U.S. MILITARY MARKET

U.S. manufacturers and users are expecting to see more foreign competition in the military market as foreign companies continue to establish factories in the United States. Competition in the 883B and JAN QPL products is expected in memories, with emphasis on NMOS DRAMs. Japanese technology has already appeared in sensitive U.S. defense applications, which could result in erosion of the average selling price of certain military products. Only devices produced in the United States can be used in JAN-qualified products. Table 3 lists foreign design and manufacturing facilities being constructed in the United States.

Fujitsu and NEC have also revealed plans to locate fiber-optics systems production plants in the United States by 1985.

It should also be noted that foreign companies have started to supply foundry capacity, dice, and finished products to U.S. semiconductor manufacturers. For instance, ASEA-Hafo presently supplies CMOS-SOS designs to Rockwell for aerospace applications, Ricoh provides foundry services for VLSI Technology's ROMs, Mitsubishi sells 64K EPROMs to Texas Instruments (who then resells them), and Seiko supplies 16K CMOS static RAMs for resale by RCA.

CONCLUSION

DATAQUEST believes that a strong demand for semiconductors in military applications will continue. We expect the political and economic climate for defense spending to remain favorable through 1986; the 1985 Department of Defense budget exceeds $280 billion. A five-year plan indicates that the budget may reach more than $350 billion. DATAQUEST estimates that U.S. government defense electronic equipment consumption will reach approximately $34 billion in 1984 and $40 billion in 1987. The pervasive nature of semiconductors in this equipment indicates a positive market in upcoming years.

Anthea C. Stratigos
Mary Olsson

Table 3

FOREIGN MOS MEMORY MANUFACTURING CAPABILITY IN THE UNITED STATES

Company	U.S. Company/Location	Function	Products
ASEA-Hafo	ASEA-Hafo San Diego, CA	Design and fab	Gate Arrays
Fujitsu	Fujitsu, Ltd. San Diego, CA	Assembly	16K, 64K DRAM 16K SRAM 32K, 64K EPROM
Hitachi	Hitachi America, Ltd. Irvine, TX	Assembly	16K, 64K DRAM 16K SRAM 32K, 64K EPROM
NEC	NEC Electronics USA* Mt. View, CA	Assembly	128K, 256K ROM 64K DRAM 32K, 64K EPROM
NEC	NEC Electronics USA* Mt. View, CA	Fab	8K, 16K EPROM 8K-64K ROM
NEC	NEC Electronics USA Roseville, CA	Fab and assembly	ROM, Custom Gate Arrays
Toshiba	Toshiba Semiconductor USA** Sunnyvale, CA	Assembly	16K SRAM, ROM
Toshiba	Toshiba Semiconductor USA Sunnyvale, CA	Fab	4K SRAM, ROM 16K DRAM

*Formerly Electronic Arrays, these operations were purchased by NEC in 1978 for an estimated $8.9 million.
**Toshiba purchased Maruman in 1980 for an estimated $2.7 million and subsequently renamed it Toshiba Semiconductor USA (TSUSA).

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THE SMART CARD: A U.S. MARKET OUTLOOK

INTRODUCTION

In an age when chips are found in thousands of applications, it is not too surprising that plastic cards are next on the list of innovative uses. Smart cards--plastic cards with chips in them--are presenting a tremendous opportunity; this evolving technology has the potential to:

- Handle virtually all of a typical credit card's functions
- Act as a portable computational device to maintain on- or off-line security without complete dependence on a host system
- Reduce the more than $800 million lost annually in credit card fraud and misuse in the United States
- Be used in new applications that cannot otherwise be cost-effectively achieved with on-line systems
- Provide a personal, self-contained method by which transactions of all kinds can be made and recorded
- Become the largest single market for integrated circuits

Work on the smart card is just beginning in the United States. U.S. players in the smart card arena are keeping a watchful eye on their French counterparts, who launched the technology; in fact, many U.S. companies are actively involved in the French smart card effort. These same companies will approach the U.S. market differently. This newsletter discusses smart card technology and its potential from a U.S. market perspective.

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THE SMART CARD VS. THE MAGNETIC STRIPE

A smart card is typically 85.7 x 54 x 0.76 millimeters--the size of a standard credit card. One or two integrated circuits with processing abilities and nonvolatile memory are incorporated into the card. During transactions, computations and the storage of their results are handled on the card, thus relieving a host computer of those duties. Estimated costs of a smart card range between two and ten dollars; magnetic-stripe cards cost between ten cents and a dollar. But an IC has several advantages over the traditional magnetic stripe, the most important being its processing abilities. This processing power provides security--a most important smart card feature because it:

- Allows the application of smart cards in many new markets
- Provides more effective card use in already established markets (for example, by reducing credit card misuse and fraud)

These advantages quickly justify the cost of a more expensive card, especially when the current annual fraud losses of over $800 million are taken into account.

Cards with magnetic stripes do not have the power to execute programming instructions internally, and the cost of putting all card readers on-line is prohibitive. Thus, it is difficult to couple magnetic-stripe storage with computational capability. The smart card combines computing and storage and thus provides security that only a computing device can. The card's memory can be segmented to hold a personal identification number, security protocols, and codes. Such data can only be used by the MPU inside the card. The smart card has the ability to interact with a card reader that also has security protocols. Together, they can simultaneously perform complex encryption algorithms. This is the smart card's greatest asset. This combination provides sophisticated and virtually impenetrable security.

The magnetic stripe also does not have the memory capacity to hold user identification, security, and transaction information. DATAQUEST believes that other smart card user ID tests under consideration include matching digital images of signatures, fingerprints, eyeprints, or voiceprints. A magnetic stripe, holding under 1,000 bits, is inadequate for such uses.

Other smart card benefits include:

- Application adaptability
- Increased operational complexity
- Processing at lower cost per transaction

SMART CARD TECHNOLOGY

The One- vs. Two-Chip Solution

There are three chip arrangements currently used on smart cards:

- A single custom IC incorporating 4.6K bits of EPROM and dedicated logic
- A single chip with a dedicated 8-bit NMOS MCU and 8K to 12K bits of EPROM
- Two chips using a standard 8-bit NMOS MPU and a 16K-bit EPROM

Wired logic is adequate for some applications (e.g., password comparison), but it is the ability to perform operations (especially complex security algorithms) and the flexibility for use in different applications that makes the MPU-based smart card the solution for the future.

Although memory is not as limited in a two-chip configuration, it is possible to tamper with the connections between the MPU and memory chips. But one chip may be less cost-effective because of the need to produce chips with the same MPU but different variations of memory. Meeting various memory demands for different applications would result in smaller production runs, each with different MPU and memory combinations. This, combined with lower yields, could inhibit the economies of scale and the relationship between volume and cost that accompany semiconductor production. DATAQUEST believes, however, that memory capacity for applications can be standardized, and that the total available markets (TAMs) for the smart card in the United States indicate large-volume production; the smart card used domestically will likely contain one chip.

One-Chip MCUs with EPROM vs. EEPROM

DATAQUEST believes that EEPROM for a smart card is under development, although there is some debate about the need for this technology on a smart card. EPROM appears to ensure better security (a must for the financial community), and even though the memory is not reusable, proponents argue that having to dispose of the card when memory has reached capacity is not a problem. The estimated average life of a financial card is 1.5 years, with an average of 100 transactions taking place during that time. The ratio of transactions to card life indicates that an EPROM can easily accommodate records of these exchanges.

DATAQUEST believes, however, that the argument for EEPROM is more compelling. There are a myriad of applications for the smart card that reach beyond financial uses; and it is not at all clear that the financial community will lead the smart card effort in the United States.

Although care would be needed to avoid accidental erasure of an EEPROM, there are significant benefits in this technology:

- Erasing and reusing the card is requisite for many smart card applications.

- A disposable card is not desirable given the possible $10.00 cost of each smart card.

- Tampering by erasing or reprogramming the memory of an EEPROM is not as easy as EPROM advocates would contend:

  - An EEPROM can be made so that its easier to make programming difficult. For example, software in ROM can examine the serial or parallel port and accept or reject programming based on the layer of security protocols built into it. In actuality, an EPROM may be more susceptible to tampering because of the need for externally programming the device.

- EEPROM is impossible to analyze without destroying its contents.

Other technological issues surrounding the smart card include the choice of processing power and semiconductor technology. First, given the choice between a 4-bit or 8-bit MCU, the MCU with an 8-bit processor is more effective because of the advanced hardware it can interface with. In addition, a certain amount of overhead is involved in I/O operations, which can be handled with either hardware or software. Since I/O operations are more cost-effectively handled via software, and since a 4-bit MCU is software limited, the 8-bit MCU is an optimum solution. Second, because of the low power source likely to be used with smart cards, there will be a distinct advantage to having a card that is low on power consumption. The low power benefits of CMOS technology appear very appropriate. DATAQUEST believes that predominant smart card technology will utilize a single-chip, 8-bit, CMOS microcontroller with up to 16K bits of EEPROM.

THE U.S. SMART CARD MARKET

Most discussion about the smart card revolves around activities in France, where the smart card was pioneered as part of a national campaign to modernize the nation's economic and information infrastructure. A consortium consisting of major banks and the French government's telecommunications administration spearheaded projects involving point-of-sale experiments, home banking via videotex, record cards for university students, and pay telephones. Today, the smart card is a commercial product in France.

The smart card gained momentum in France because of the need to build and improve the country's financial and communication infrastructure. That need is the single most important factor to consider when examining the U.S. market. The financial community-government link that is pushing the smart card in France is nonexistent in the United States.

The use of credit cards and the mechanisms for making credit transactions are firmly entrenched in the United States. Financial institutions are also fully committed to the use of automatic teller machines. While the smart card may ease a tremendous amount of credit card fraud, the financial community is not eager to reorganize its infrastructure. There is still concern in this community about security, cost, and losing the ability to float as much capital as when using the traditional credit card.

Another factor inhibiting the smart card's use as a mass market credit card is the problem of packaging. The area for a chip is limited to about 25 square millimeters to prevent breaking when a card is flexed. And the International Standards Organization (ISO) has established 0.76 millimeters as the thickness standard for a credit card. Meeting these size limitations and technical requirements, and insuring survival over a wide range of temperatures, exposure to contamination and normal human handling poses quite a challenge.

The smart card as a credit card has tremendous potential, but DATAQUEST believes that it will not be the first major smart card application. Use as a credit card will most likely be preceded by two events. First, if the financial community initiates smart card use, DATAQUEST believes that it will be marketed as an innovative service item specifically targeted toward a select group of customers.

Second, there are many applications where overall card size (especially thickness) and high-level security are not issues. DATAQUEST believes that the smart card will initially be used for these nonfinancial applications. Once smart card technology is successfully applied, DATAQUEST believes that the financial community will play a more active (mass market-oriented) role.

Smart Card Applications

Many smart card applications are under consideration in the United States, with many pilot projects already underway. In Reading, Pennsylvania, the U.S. Department of Agriculture is testing the smart card as a means of replacing food stamps. The U.S. Department of Defense is considering the smart card as a method for keeping military and servicemen's records. And a trial home banking project (now headed by J.C. Penney) has been started in North Dakota. DATAQUEST believes that the smart card is being explored by leaders in the telecommunications industry for handling pay telephone transactions. (This could very well be one of the first commercial uses in the United States.) Other smart card applications include their use for:

- Gasoline purchases
- New automobile warranty and service records

- Hospital, medical, or pharmaceutical care

- Insurance policy records, claims, and transactions

- Government programs such as welfare, Social Security, and Medicare

- Film in the next generation of cameras

- Academic records

- Program cartridges for portable microcomputers

- Production information in manufacturing environments

Potential U.S. markets for many smart card applications are quite large. To name just a few:

- The American Bankers Association reports that there are approximately 70 million individual domestic Visa cardholders and approximately 55 million Mastercard holders. There are also an estimated 15 million American Express Card users.

- Credit card manufacturers estimate that there are approximately 600 million credit cards held in the United States.

- In April 1984, the U.S. Department of Agriculture monitored 21.5 million individual food stamp recipients living in 7.7 million U.S. households.

- The U.S. National Center for Education Statistics projects that public and private high school and college enrollment will be approximately 25 million in 1989.

- At year-end 1983, the U.S. Department of Defense maintained 2.1 million military personnel on active duty.

- The U.S. auto industry recorded sales of 6.8 million cars in 1983.

U.S. Smart Card Participants

Many companies are interested in smart cards, from either a supplier, manufacturer, or end-user perspective. DATAQUEST believes that the following organizations are actively pursuing the smart card:

Suppliers
- Intel Corporation
- Motorola, Inc.
- SEEQ Technology, Inc.
- Texas Instruments, Inc.
- Xicor, Inc.

Manufacturers
- Corpra Research
- Data Card Corporation
- Datakey Inc.
- IBM Corporation
- Smart Card International, Inc.
- Smart Card Systems, Inc.

End Users
- AT&T
- American Express Co.
- Bank of America
- Chase Manhattan Bank
- Citicorp
- Eastman Kodak
- J.C. Penney
- MCI
- New York Stock Exchange
- Polaroid
- Sears
- U.S. Department of Defense
- U.S. Department of Agriculture

The three Paris-based companies leading the manufacturing effort in France are negotiating with potential U.S. smart card users. These French companies are Cii Honeywell Bull, Flonic-Schlumberger, and Philips SA. They produce smart cards and the systems the cards utilize. In addition, the ISO and its national affiliate, the American National Standards Institute (ANSI), are currently working on standards for the IC-based card.

CONCLUSIONS

DATAQUEST believes that the smart card will soon be at work in the United States; technical and market barriers will be overcome. We expect to see the smart card in commercial use by 1986 and believe that by 1990, given the players, their activities, and the total available market, there may be at least 25 million smart cards in the United States. We expect the smart card to first enter niche markets and then gain momentum over the next five years. We believe that the predominant technology will incorporate an 8-bit CMOS MCU with up to 16K bits of EEPROM.

The most exciting aspect of the smart card is its potential for widespread use and the fact that its success will incorporate the talents of a broad spectrum of industry participants--from the legal, financial, telecommunications, and information processing communities to the manufacturers of semiconductors, cards, and equipment.

Anthea C. Stratigos

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1984 CUSTOM INTEGRATED CIRCUIT CONFERENCE-- A WORLD-CLASS EVENT

OVERVIEW

This year's Custom Integrated Circuit Conference (CICC) broke all attendance records. More than 1,100 attendees, 400 more than in 1983, gathered to share the latest ideas in application-specific integrated circuits (ASICs). The 1984 CICC proceedings comprise a hefty tome of 618 pages filled with a diverse array of technology ranging from advanced fabrication techniques to unique new applications. In six years, the CICC has grown from a small regional conference to a world-class event with attendees from the United States, Western Europe, Japan, the Asia-Pacific area, and Canada.

This year's conference included tutorial sessions, educational sessions, and technical papers on Electronic Design Automation (EDA) tools, IC processes, and new applications. The CICC lasted from May 21 through 24, with two concurrent educational sessions on the fourth day.

DATAQUEST observed the following recurring themes:

- CMOS Everywhere--CMOS is emerging as the mainstream technology and will continue to grow for the balance of the decade.
- Need for Advanced EDA Tools--At CICC one was constantly reminded of the impact of third-party workstation manufacturers. They continue to garner a larger portion of the design process.
- Information Overload--The most frequent comment heard in the hallways was "How will I ever keep up with all of the new innovations?" This is substantiated by the fact that cell libraries are nearly outdated before the design cycle is completed.

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- A Widening Gap--The new process technologies continue to rush ahead, while the tools needed by the system designer advance more slowly. It appears that the user community must run hard to stay abreast of the advances in technology. For example, most major universities are just beginning to teach courses in the fundamentals of gate arrays, let alone other design techniques.

- Standardization--All semiconductor manufacturers, EDA makers, software firms, and ASIC users agree that the industry needs a set of standards, especially at the software level.

SUMMARY OF PAPERS

Following are our comments on some of the papers. The total number of papers presented is shown in Table 1.

Fabrication Technologies

Perhaps the most interesting paper presented in the process session related to the use of electron beam technology on wafer scaled integration. D.C. Shaver of MIT Lincoln Laboratory presented a tutorial paper on the use of E-beam equipment to test, customize, and repair ASICs.

It has been known for some time that in order to apply the concepts of wafer scaled integration, defect densities will have to come down, or some other technique will have to be developed to repair faulty sections of the wafer. Mr. Shaver's paper discussed how an electron beam system could be used as a powerful tool, not only for repairing wafers but also for testing and customizing. Rather than rely on defect-free processing, the author suggests that chips be designed with redundant sections that can be substituted for defective ones. Mr. Shaver's paper discussed three possible approaches:

- Using the electron beam to probe the wafer

- Using the electron beam to break or fuse an entire section of a wafer

- Electrically programming the storage elements to a prescribed state to achieve better testability

Table 2 summarizes the current status of ROM design and suggests that much larger ROMs could be built.

The implication is that this technology would have a much wider appeal than just for ROMs. It is quite likely that an electron-based system could be designed to program up to a million storage elements on a single wafer, thus greatly simplifying the testing problem for a complex "system-on-wafer."

Also of interest was W.S. Graber's paper entitled "Reconfiguring Semi-Custom ICs Using Laser Microchemical Techniques." By using a tightly focused laser beam along with localized chemical etching, a small section of aluminum could be removed or polysilicon could be deposited. This means that a circuit could be modified for design corrections and thus optimized for performance, or redundant sections could be added or deleted to improve yield after fabrication has been completed.

While both the electron and laser beam approaches are far from viable production techniques, they do suggest a way in which wafer scaled technology could become a reality.

Faster and Bigger Gate Arrays

Applied Micro Circuits Corporation announced a high-speed 3,500-gate array using an advanced 3-micron oxide-isolated dual layer metal process. This innovative design achieves a propagation delay as low as 275 picoseconds with power consumption between 3 and 4 watts.

In the advanced gate array session, three papers discussed CMOS arrays with more than 10,000 gates. They are summarized in Table 3.

Silicon Compilers

In the last few years there has been a great deal of rhetoric about developing a top-down family of design tools that in their ultimate form could automatically synthesize an ASIC. Ideally, a designer could describe an IC in a high-level language that could be compiled into a completed set of photo tooling for fabrication. This process would be used like a high-level programming language such as FORTRAN is compiled and used to drive a computer. Unfortunately, the ideal is far from the reality. While most engineers believe that some day silicon compilers will indeed exist, no one is willing to estimate when. This, however, has not discouraged some very innovative and interesting work presented at the CICC.

The session on design synthesis had two papers on silicon compilers. IBM's paper described a control logic macro for a 32-bit microprocessor. The complexity of logic was equivalent to a 500-gate, 4-way network using CMOS cascode voltage-switched logic. It was compiled in less than 10 minutes and was 26 percent smaller than the same function implemented in an NMOS-programmable logic array.

The second paper of interest on this subject was by Jeffery Fox of GTE Laboratories. The paper reported about a performance prediction package that he has added to a compiler called MacPitts. This performance predictor can provide important information on critical timing paths within a circuit.

Both papers and the work that preceded them suggest that silicon compilation is in its infancy and that further refinements will require a long evolutionary process.

Automatic IC Layouts

In the area of automated placement and routing, two papers stood out. The first paper described a layout system called CIPAR, from American Microsystems. CIPAR does layout and routing of standard cells without requiring a great deal of editing, thus eliminating tedious electrical continuity and design rule checks. With this family of programs, a user can partition a large VLSI logic into a number of smaller, more manageable blocks that can be treated in a somewhat hierarchical fashion.

The second paper was presented by Carl Sechen and A. Sangiovanni-Vincentelli of the University of California. The paper described a unique set of placement and routing programs called TimberWolf. These programs are capable of optimizing gate arrays, standard cells, and micro cells with some remarkable results. As shown in Table 4, substantial reductions in wire lengths and chip area were achieved over other commercially available programs.

Analog ASIC

The sessions on analog techniques were well attended despite the long-predicted demise of analog circuitry. Based on the content of these sessions and discussions with the engineering community, DATAQUEST believes that analog ASIC will continue to grow. We noted the following important long-range trends:

- Improved resolution, linearity, and sample rates for A/D and D/A converters
- Elimination of thin-film resistors with laser trimming
- Improvement in the dynamic range and sample rate for codecs--especially as they apply to voice applications
- Switched capacitor filters with improved frequency ranges, possibly in 100 MHz range as 1 micron technology emerges

NEXT YEAR--PORTLAND, OREGON

The CICC planning committee is planning to hold the 1985 conference in Portland, Oregon. After that, the site will probably alternate between the east and west coasts.

Andy Prophet

Table 1

1984 CICC PRESENTATIONS

Source Region	Count
United States	91
Canada	6
Japan	14
Asia-Pacific	3
Western Europe	7
Total	121

Source Category	Count
Company	101
Academic	19
Government	1
Total	121

Table 2

ELECTRON BEAM TECHNOLOGY APPLIED TO WAFER INTEGRATION

Wafer Sizes	Minimum Size	ROM Size	Comments
2 inches	6 microns	128K	Completed to demonstrate feasibility
3 inches	3 microns	2 Megabytes	Could be reasonably achieved
3 inches	1 micron	20 Megabytes	Possible in the future

Source: DATAQUEST
June 1984

Table 3

ADVANCED CMOS GATE ARRAYS

Company	Gate Count	Gate Length	Comments
Hewlett-Packard	10,000	1.5 microns	100% automatic routing 95% gate utilization
General Electric	13,500	2.0 microns	11.2-ns gate delay, with analog cells on the chip
NEC	11,000	2.0 microns	2-ns gate delay, 90% utilization, 100% automatic routing

Table 4

TIMBERWOLF OPTIMIZATION RESULTS

ASIC Layout Medium	Wire Length Reductions	Chip Area Reduction
Standard Cell	5.5 - 6.1%	34 - 35%
Gate Array	17 - 21%	-

Source: DATAQUEST
June 1984

July Newsletters

The following is a list of material in this section:

- Growing ASIC Market Redefined
- 1983 Worldwide Semiconductor Consumption Forecast
- 1984 Merchant Capital Expenditures--United States and Japan
- Automatic Photoresist Processing Equipment: Bellwether of Capacity

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

GROWING ASIC MARKET REDEFINED

SUMMARY

The Semiconductor Industry Service's recently published ASIC overview section of the Products and Markets notebook revises DATAQUEST's ASIC market definition and discusses market growth and shifts in gate arrays and standard cells. This newsletter summarizes that section.

The application-specific integrated circuit (ASIC) market is experiencing substantial growth. We believe that this growth will have a major impact on the entire IC industry. The following changes will take place over the next five to ten years:

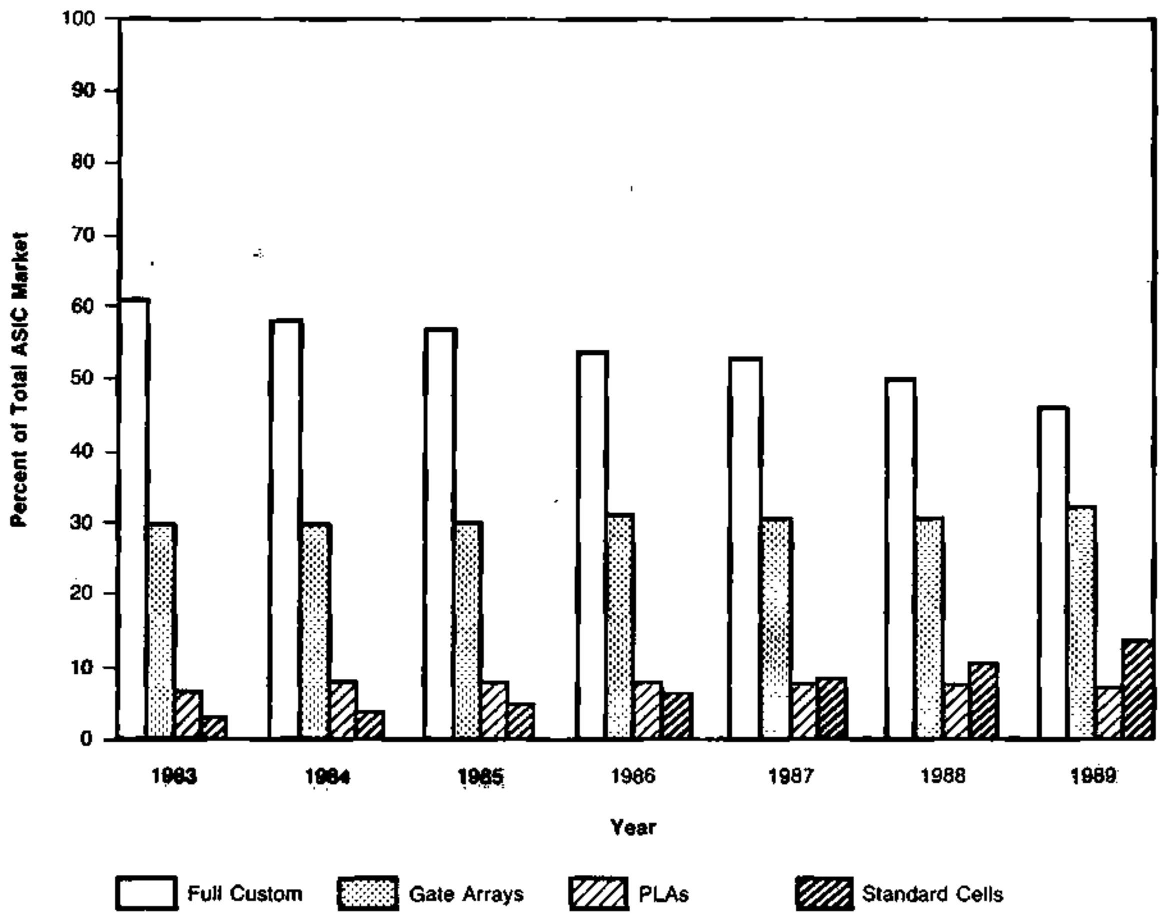
- ASICs will significantly increase their market share.
- The dividing line between gate arrays and standard cells will blur.
- Electronic design automation (EDA) will drive ASIC growth.

The total merchant ASIC market was worth $1.7 billion in 1983. This figure is expected to be close to $2.5 billion in 1984 and will probably reach a 1989 level of $9.0 billion, representing a 32 percent compound annual growth rate (CAGR) from 1983 through 1989.

There are four ASIC market segments: full custom, gate arrays, standard cells, and programmable logic arrays (PLAs). Figure 1 shows the estimated market shares of each segment as a percentage of total ASICs for 1983 through 1989. In 1983, full custom represented 60.9 percent of the total ASIC market. At 29.8 percent, gate arrays were second. PLAs and standard cells followed with 6.4 percent and 2.8 percent, respectively. As the market matures, the 1989 picture will change somewhat as full custom loses market share and standard cells, gate arrays, and PLAs enjoy an increase in share. Full custom will drop to 46.5 percent, a loss of 14.4 percent. The loss will be divided among the remaining sectors. Gate arrays will add 2.6 percent for a total of 32.4, PLAs will gain approximately 1 percent for a total of 7.4 percent, and standard cells will gain 11 percent to attain a market share of 13.8 percent.

Figure 1

ASIC MARKET SEGMENTATION



Source: DATAQUEST
July 1984

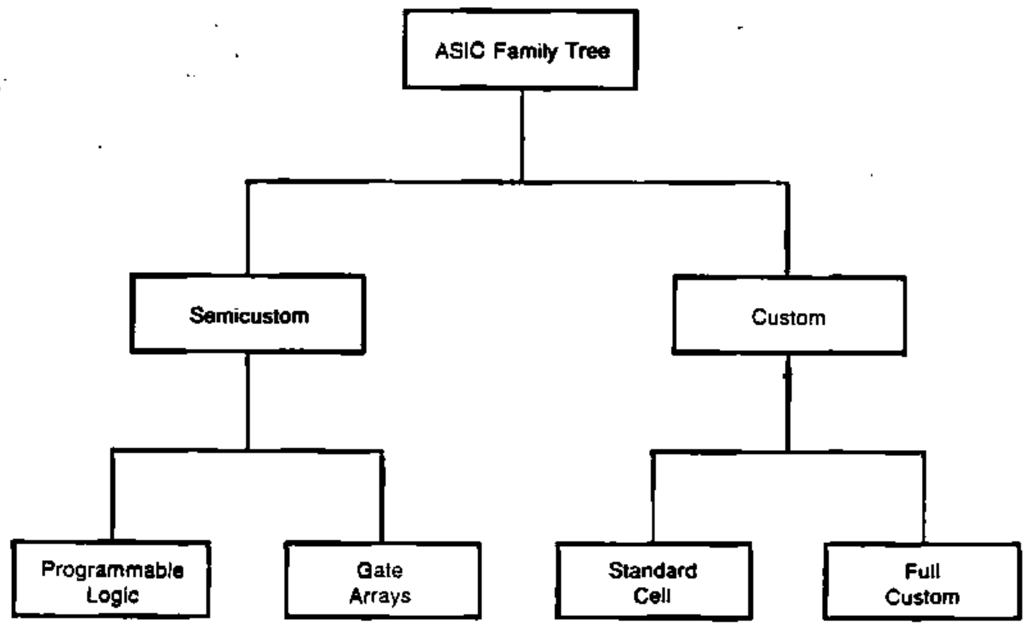
ASICS REDEFINED

As the semiconductor industry struggles with rapid growth, DATAQUEST must stay current with the markets. In the past, we have defined the ASIC to include ROMs and their close relatives, EPROMs and EEPROMs. But recently, it has become apparent that additional segmentation is necessary to refine our forecasting methods and provide more focus. Figure 2 illustrates our new definition of the products currently tabulated under ASIC.

Note that ROMs, EPROMs, and EEPROMs no longer appear under the ASIC family tree but will now be classified in the memory section. We believe that this division will help our clients, who generally focus on two major groups: memory and logic. The memory group is most interested in all memory products: standard products as well as customer-specific products like ROMs. Also, many of the strategic issues that center around RAMs also carry over to ROMs and related products.

Figure 2

ASIC FAMILY TREE



Source: DATAQUEST
July 1984

What Changed?

To help preserve continuity with our earlier reports, and especially with respect to those IC shipments that are defined as ASIC under the old definition, we have prepared Figure 3, which illustrates how much of the total IC market is ASIC with respect to the earlier definition that includes ROMs. This should give a much clearer picture of the issues that have changed our forecast.

In particular, we have noted several factors that have changed the ASIC share of ICs:

- Slower ROM growth rates--While the EPROM and EEPROM markets continue to look very strong, the mask-programmable ROMs have grown more slowly, due largely to the sharp reduction in demand in the consumer segments.

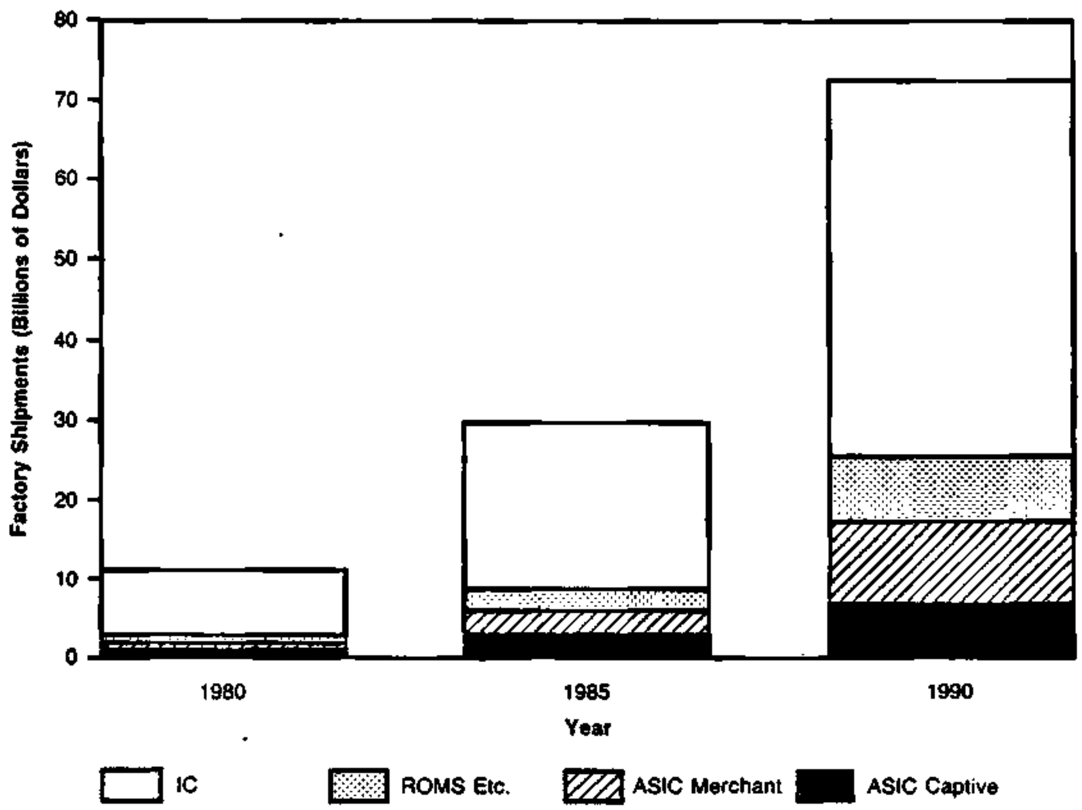
- Slower growth for captive ASICs--Although we have recently seen a slowing in the shift from captive to merchant, largely due to sharp increases in internal demand, in the long run we expect this problem to be corrected as more production capacity becomes operational. This, in turn, will result in a return to slower growth of captive ASICs relative to the ASIC market as a whole.

- Less volatility in the ASIC forecast--DATAQUEST has noted that, in general, when demand surges ahead of supply for all ICs, standard products such as memories, microprocessors, and standard logic experience sharper increases in demand than ASICs. In other words, demand is not as elastic for ASICs as for standard products. Thus, as the economy moves into a strong upturn, as occurred recently, the standard product segment of the IC market gains rapidly, and when a recession emerges, the reverse is true. Demand for standard products drops quicker than for ASICs.

Overall, ASICs, that is full custom, gate arrays, standard cells, and programmable logic arrays, will grow at a 32 percent CAGR between 1983 and 1990 while the IC market as a whole will grow at a 25 percent CAGR. DATAQUEST expects this to continue to do so for the balance of the decade. By 1990, these four categories alone will represent 23 percent of the total world merchant and captive IC market.

Figure 3

ESTIMATED ASIC SHARE OF WORLDWIDE IC SHIPMENTS



Source: DATAQUEST
July 1984

DESIGN APPROACHES

The choices available to an ASIC user when implementing a system are full custom, standard cells, gate arrays, field-programmable logic, and small-scale integration/medium-scale integration (SSI/MSI). The design costs of each method relative to the cost of full custom are shown in Table 1.

The factors affecting the choice of design include the availability of the design center, the design objectives to be met, costs compared to those of other competitive methods, time and budget restraints, and flexibility in changing the design.

Table 1

RELATIVE DESIGN COSTS FOR ASICS

Method	Relative Design Cost
Full Custom	100%
Standard Cells	40%
Gate Arrays	15%
Field-Programmable Logic	1%
SSI/MSI	0%

Source: DATAQUEST
July 1984

Gate Arrays

The gate array market experienced relatively slow growth until 1978, when it was learned that some major computer companies like IBM, Amdahl, and Digital Equipment were using arrays. Since then, the gate array market has grown to $512 million in 1983 and will continue to grow at a 33.8 percent CAGR to reach approximately $2.9 billion in 1989. The gate array business has gained momentum from changes in systems constraints and circuit density, resulting in a perceived value that encompasses system design security, simplified logistics, and lower systems costs due to package size reduction. Also, gate array lead times are lower, at 8 to 13 weeks, compared to 12 to 18 months for full custom circuits and 14 to 20 weeks for standard cells.

Gate arrays are available in both CMOS and ECL, which is approximately 10 times faster than CMOS. Industry trends suggest that many firms are moving toward two-layer metal interconnects and sub-2-micron gates.

Table 2 lists the major gate array and standard cell suppliers. Note that many suppliers offer both; this suggests that the dividing line between gate arrays and standard cells become less distinct. DATAQUEST believes that ASIC manufacturers will eventually incorporate both gate array and standard cell capabilities onto one chip.

Table 2

GATE ARRAY AND STANDARD CELL SUPPLIERS

Companies	Gate Arrays	Standard Cells
AT&T Technologies		X
Alphatron Inc.	X	X
Alta Semiconductors	X	X
Applied Micro Circuits Corp.	X	
Array Technology	X	X
Asahi Microsystems Inc.	X	X
ASEA HAFO	X	X
AWA Microelectronics	X	X
Barvon Research, Inc.	X	X
California Device Inc.	X	X
Calmos Systems Inc.	X	
Cherry Semiconductor	X	
Circuit Technology		X
CIT Alcatel	X	
Citel	X	X
CMOS Technology Inc.	X	X
Custom Integrated Circuits	X	X
Custom Silicon Inc.		X
Electronic Technology Corp.	X	X
Exar Integrated Systems	X	
Fairchild Semiconductor	X	X
Ferranti Electric	X	
Fujitsu Microelectronics	X	X
General Instrument Corp.	X	X
Gould AMI Semiconductors	X	X
GTE Microcircuits	X	X
Harris Corp.	X	X
Hitachi, Ltd.	X	
HMT Microelectronics Ltd.	X	
Holt	X	X
Honeywell Inc.	X	
Hughes Solid State	X	X
Insouth Microsystems Inc.	X	X
Integrated Logic Systems Inc.	X	
Integrated Microcircuits	X	
Intel		X
Interdesign	X	
International Microcircuits	X	
International Microelectronic Products		X
Intersil	X	

(Continued)

Table 2 (Continued)

GATE ARRAY AND STANDARD CELL SUPPLIERS

Companies	Gate Arrays	Standard Cells
Kontron Electronics	X	
LSI Logic Corp.	X	
Marconi Electronic Devices, Ltd.		X
Master Logic Corp.	X	X
Matra-Harris Semiconductors	X	
Matsushita Electronics	X	
Micro Circuit Engineering	X	X
Microcircuits Technology Inc.	X	X
Mitel Corporation	X	X
Mitsubishi Electronics	X	
Mostek	X	
Motorola	X	X
National Semiconductor	X	X
NCM Corporation		X
NCR		X
NEC Electronics USA	X	X
Nitron	X	
Oki Semiconductor	X	X
Plessey	X	X
R.T.C. La Radiotechnique-Compelec	X	
Racal Electronics, Ltd.	X	
Raytheon Co.	X	
RCA Corporation	X	X
Ricoh Co. Ltd.	X	
Semi-Processes Inc.	X	
SGS-ATES Componenti Elettronici-SpA	X	X
Sharp Corp.	X	
Siemens, AG	X	X
Sierra Semiconductor		X
Signetics Corp.	X	X
Silicon Compiler Inc.		X
Silicon Microsystems Ltd.	X	X
Silicon Systems		X
Siliconix	X	
Solid State Scientific		X
Suwa Seikosha	X	
Synertek		X
Telmos	X	
Texas Instruments	X	X
Thomson-CSF	X	X
Toshiba Semiconductor	X	X
Universal Semiconductor Inc.	X	
VLSI Technology	X	X
Western Digital Corp.	X	X
Zymos	_	X
Total	67	51

Source: DATAQUEST
July 1984

Standard Cells

The CAD tools for designing gate arrays have become widely available in recent years. However, for standard cells to become more prevalent, more electronic design automation (EDA) tools are needed. Emerging forces driving standard cell design are the use of structured logic, the rise in the development of extensive standard cell libraries, and the establishment of vendor interface standards.

The standard cell market was at a level of $48 million in 1983. This level should reach $94 million in 1984 and, with a CAGR of 72 percent, $1.2 billion in 1989.

There are specific advantages in using standard cells:

- Adaptability to logic, memory, and analog functions
- Flexibility of supercells, i.e., cells that were once standard products
- Efficient utilization of space over gate arrays
- Reduced development time compared to full custom

FORCES

One of the main driving forces in the ASIC market is electronic design automation (EDA). In the early 1980s, there were only about 3,000 competent IC designers. Currently, with the aid of EDA, there is a pool of 300,000 to 400,000 systems engineers who can design ICs.

Today, the EDA workstation offers features for all aspects of the design cycle, not just for physical layout. Future EDA tools will be able to do logic and circuit design as well as functional and architectural design. Perhaps the most difficult problem in the design process is system simulation. There are three problems inherent in system simulation:

- Delay and distractions--Most logic simulation is done using a batch method. The system engineer submits a set of test vectors to the computer center and hours later receives a report on the simulation. During the interval, the engineer must turn to other pressing matters and may forget his or her previous line of thought.
- Information overload--When the information comes back from the computer, the designer gets all the information in one large report and must then tediously sift through the information to extract the pertinent details.

- Complexity of the design--Many large systems are so complex that a division of labor is required--one engineer cannot do the entire design.

To help solve these design problems, some EDA firms offer hardware that simulates logic at very fast speeds. Most of the emerging simulators are using parallel processor architecture, achieving throughput ten times faster than previous systems.

A major objective of this newsletter is to look at the ASIC market growth in its entirety in order to formulate a new framework within which the growth of the various segments can be judged. Since it is entirely possible that one approach may eventually displace another, it is important in making a strategic analysis to be able to relate one market segment to another.

Arden DeVincenzi
Andy Prophet

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

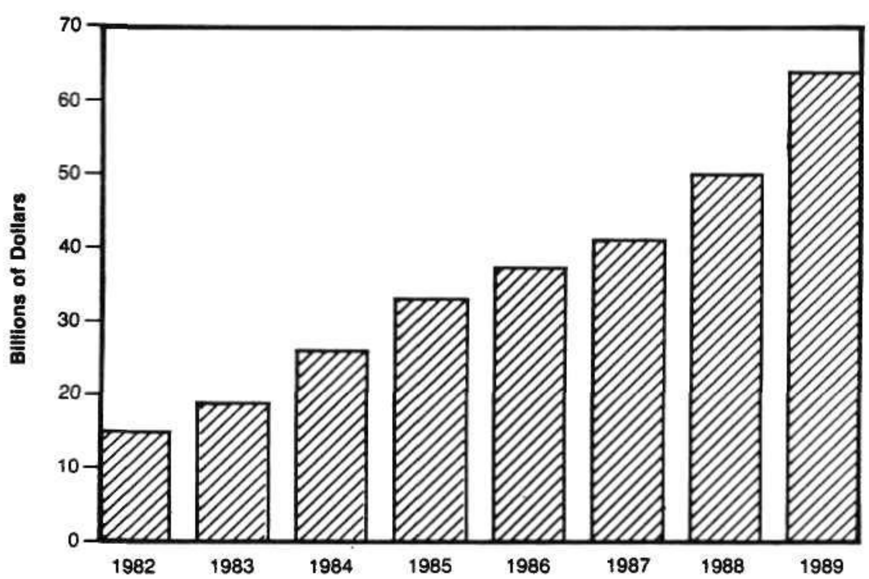
1983 WORLDWIDE SEMICONDUCTOR CONSUMPTION FORECAST

SUMMARY

DATAQUEST estimates that total worldwide semiconductor consumption in 1983 was $18,685 million. This represents an increase of 26 percent over the 1982 figure of $14,832 million. Most of this growth occurred during the second half of 1983, and heightened demand along with increased production is creating a tremendous sales surge. DATAQUEST projects that 1984 sales will grow by 38 percent. Compound annual growth covering the period from 1983 to 1989 is estimated at 23 percent. While we believe that there may be a downturn in the future, we do not expect the industry to experience any slackening in sales before late 1985. An economic slowdown by 1986 is reflected in weakening semiconductor demand in that year. Nevertheless, the market is expected to experience some growth, as shown in Figure 1.

Figure 1

ESTIMATED WORLDWIDE SEMICONDUCTOR CONSUMPTION 1982-1989
(Billions of Dollars)



Source: DATAQUEST

SEMICONDUCTOR PRODUCT AREAS

Most of the semiconductor product areas enjoyed good growth in 1983, though there was some weakness in the discrete area. (See Table 1.) The strongest growth came from the IC area, with MOS circuits contributing a hefty 39 percent. In 1984, we expect even stronger growth from these traditionally dynamic areas. We believe that ICs will grow by 44 percent and MOS technology will grow by 56 percent this year. Looking farther out to 1989, we expect healthy growth rates for all the major product categories; although discretes may experience weaker growth.

REGIONAL SEMICONDUCTOR CONSUMPTION--1983 vs. 1982

Regionally, the U.S. market dominates in semiconductor consumption, with 44 percent of total consumption. The Japanese are becoming a larger user, however, increasing their total usage from 28 percent in 1982 to 30 percent in 1983. (Refer to Tables 2 and 3.) They will, undoubtedly, continue to use large quantities of electronic components in their high-volume consumer-oriented markets. Consumption of semiconductors actually declined in the European market. As a percentage of total worldwide consumption, European consumption dropped from 21 percent in 1982 to 18 percent in 1983. The consumption in the Rest of World is increasing slowly. In 1983, consumption rose to 8 percent of the total market, up 1 percent from the previous year.

Some interesting shifts took place in the IC area, mainly between Japan and the United States. MOS consumption declined slightly in the United States and increased slightly in Japan. (See Tables 2 and 3.) In the bipolar area, there were slight increases in both the United States and Japan. It is also interesting to note the increased consumption of linear products for these regions. Domestic Japanese activity in the high-volume consumer markets also spurred a significant increase in the discrete and optoelectronics areas.

Note: This newsletter is a summary of the SIS Consumption and Factory Shipments Service Section that was issued June 25. For details on any of the statistics mentioned, please refer to the Products and Markets binder of your Semiconductor Industry Service Notebooks.

Barbara A. Van

Table 1

WORLDWIDE SEMICONDUCTOR CONSUMPTION FORECAST
(Millions of Dollars)

	1982	1983	1984	1989	CAGR 1983-89
Total Semiconductor	$14,832	$18,685	$25,767	$63,971	23%
Total IC	$10,711	$14,133	$20,294	$55,437	26%
Bipolar	$ 2,425	$ 3,043	$ 4,147	$ 7,808	17%
MOS	$ 5,546	$ 7,694	$11,984	$39,201	31%
Linear	$ 2,740	$ 3,396	$ 4,163	$ 8,428	16%
Total Discrete	$ 3,315	$ 3,549	$ 4,216	$ 5,770	8%
Total Opto	$ 806	$ 1,003	$ 1,257	$ 2,764	18%

Table 2

1982 REGIONAL SEMICONDUCTOR CONSUMPTION
(In Percent/Millions of Dollars)

	US %	Japan %	Europe %	ROW %	Total $
Total Semiconductor	44	28	21	7	$14,832
Total IC	49	27	19	5	$10,711
Bipolar	55	22	18	5	$ 2,425
MOS	55	23	17	5	$ 5,546
Linear	31	39	22	8	$ 2,740
Total Discrete	30	29	31	10	$ 3,315
Total Opto	35	30	21	14	$ 806

Source: DATAQUEST
July 1984

Table 3

1983 REGIONAL SEMICONDUCTOR CONSUMPTION
(In Percent/Millions of Dollars)

	US %	Japan %	Europe %	ROW %	Total $
Total Semiconductor	44	30	18	8	$18,685
Total IC	49	28	16	7	$14,133
Bipolar	56	23	16	5	$ 3,043
MOS	53	25	16	6	$ 7,694
Linear	33	40	18	9	$ 3,396
Total Discrete	30	35	24	11	$ 3,549
Total Opto	33	36	18	13	$ 1,003

Source: DATAQUEST
July 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

AUTOMATIC PHOTORESIST PROCESSING EQUIPMENT: BELLWETHER OF CAPACITY

SUMMARY

DATAQUEST recently completed research on automatic photoresist processing (APP) equipment. The results will be published in the Semiconductor Industry Service (SIS) notebook Industry and Technology. This newsletter summarizes the findings of that research.

Photoresist processing is one of the most important and fundamental technologies in wafer fabrication. The automation of that process has allowed productivity and yield improvements to keep pace with reductions in the design geometries of integrated circuits (ICs). It is estimated that 75 percent of the yield loss at wafer sort (die probe) is a result of the defect level associated with the photoresist patterning. The driving forces behind changes in APP equipment are for improvements in:

- Maintainability and reliability to increase equipment utilization
- Flexibility and modularity to adapt to process changes
- Capacity per square foot to allow maximum output from a given clean room space
- Contamination level and particulate generation to increase yields of VLSI production
- Ability to produce and control finer lines in photoresist

APP systems, sometimes referred to as tracks, typically are purchased in units of two, three, and four tracks per system, representing large incremental capacity additions. Because of this tendency toward overcapacity, APP equipment sales are sensitive to fluctuations in the semiconductor business environment. During downturns, semiconductor manufacturers do not need to add additional capacity; therefore, purchases consist of replacement equipment and advanced product capacity additions. Purchases of APP equipment begin their upward acceleration when excess capacity is at a minimum.

In the last recession (1980 to 1982), the emergence of application-specific integrated circuit (ASIC) manufacturers, who purchased equipment with investors' money rather than from revenues, helped to augment APP equipment sales. In addition, U.S. captive and Japanese manufacturers continued to add capacity during this period. Silicon Valley Group and Machine Technology both increased their market shares during this period, growing from 4.5 percent each in 1980 to 19 percent and 9 percent, respectively, in 1983.

Table 1 shows DATAQUEST's estimates of worldwide APP equipment sales from 1974 through 1983 and forecast sales from 1984 through 1988. We estimate that worldwide APP equipment sales rose 34.3 percent from $67 million in 1982 to $90 million in 1984. U.S. consumption grew 22.5 percent to $49 million during this period, and European consumption grew 14.3 percent to $8 million. Japanese markets grew 65 percent to $33 million as Japanese manufacturers continued aggressive capital spending plans made during the recession.

Table 1

ESTIMATED WORLDWIDE APP EQUIPMENT SALES
(Millions of Dollars)

Year	Sales	Growth
1974	$ 4.2	
1975	$ 2.5	(40%)
1976	$ 11.4	365%
1977	$ 18.9	66%
1978	$ 28.9	53%
1979	$ 48.1	66%
1980	$ 88.0	83%
1981	$ 72.0	(18%)
1982	$ 67.0	(7%)
1983	$ 90.0	34%
1984	$137.1	41%
1985	$189.2	11%
1986	$221.6	17%
1987	$230.9	17%
1988	$294.5	29%

Source: DATAQUEST

DATAQUEST estimates that the APP equipment market will grow 52.8 percent to $137.1 million in 1984. Most of this increase will come from U.S. manufacturers who must add capacity to keep up with burgeoning semiconductor demand. We estimate that worldwide sales of APP equipment will grow to $294.5 million in 1988, representing a 26.8 percent compound annual growth rate (CAGR) from 1983 through 1988.

TECHNOLOGY

Photoresist processing takes place after wafers leave thin-film deposition or oxidation, prior to align-expose, and again prior to wet or dry etching. The photoresist processing steps universally used are: coating on a spinner, baking in a belt oven or on a hot plate, and developing. Additional steps that can be added to the processing as needed are scrubbing and dehydration processing prior to coating, a postexposure bake prior to developing, a hard bake after developing, and deep ultraviolet (UV) resist hardening after developing. Photoresist processing is done in an area separate from the rest of the wafer fabrication, since illuminating the photoresist-coated wafers in the green or blue portions of the light spectrum would expose the resist. This section of the fab area is frequently called the "yellow room" because of the yellow lights used to illuminate it.

The average number of mask layers per semiconductor device is steadily increasing as devices become more complex. The number of times a wafer goes through a typical photoresist processing stream is 5 to 7 times for discretes, 7 to 10 times for ICs, and 10 to 15 times for LSI devices.

The various semiconductor manufacturing segments have slightly different needs with respect to automatic photoresist processing equipment, depending upon the needs of their markets. U.S. merchant and large captive suppliers are putting heavy emphasis on capacity per square foot, process control, and contamination control. U.S. ASIC and small captive suppliers are interested in process flexibility and maintainability. Japanese manufacturers, who possess both merchant and captive characteristics, emphasize process and contamination control. European manufacturers consume only a small portion of the equipment and seem to follow the lead of worldwide markets.

Technology Trends

Bake

The development of the hot plate as an alternative to belt ovens has been a significant improvement. The hot plate has fewer moving parts, and thus generates less particulate contamination and requires less maintenance. Recently, some vendors have integrated this module with an HMDS (hexamethyldisilazane) vapor prime process to improve resist adhesion. The hot plate's single-wafer configuration increases the feasibility of integrating photoresist processing and photolithography into an in-line, cassette-to-cassette system.

Single-Track Systems

For small semiconductor manufacturers, the single-track APP system has made it possible to distribute risk over several systems. Since tracks were historically purchased in multitrack packages, the malfunction of one track often affected the other tracks, rendering the system nonoperational. With an inexpensive, single-track system, small manufacturers with lower capacity needs can buy two or three separate systems that will maintain some capacity in the event of a malfunction.

Resist Types

The use of positive resist is growing with respect to the use of negative resist. Negative resist is subject to swelling, higher levels of defects, and reduced adhesion, making it less attractive for use at less than 3 micrometers. Although positive resist represents one-third of the volume of photoresist consumed, it represents about the same number of dollars in sales because of its higher price.

ANALYSIS

Because of the high productivity of APP equipment, the market is extremely susceptible to slow growth during periods of overcapacity. Other steps of the fabrication process can be done in a variety of ways and have changed with the increasing level of integration (e.g., implanting has largely replaced predisposition, and thin-film deposition has largely replaced grown oxide films). But photoresist processing has stayed fundamentally the same. Thus, during business downturns, manufacturers can produce their newer products on the older APP equipment, in which case, new equipment sales consist of replacement equipment and new capacity additions.

During the last recession (1980 to 1982), the emergence of the ASIC markets and the continued strength of the Japanese equipment market buffered the effects of the recession on APP equipment sales. Even with that buffer, sales fell 24 percent during that period. DATAQUEST estimates that semiconductor sales will increase more than 30 percent per year in 1984 and 1985, followed by two years of slower growth, after which, higher growth will ensue. We can expect the slow-growth period to affect APP equipment sales as it has historically.

However, the exaggerated effect of reduced sales may be ameliorated by technological factors that increase demand. For instance, if newer products cannot be manufactured on older equipment, then newer equipment will be in demand. Technological factors that increase demand are:

- The need for lower defect levels is generating a need for more automation and less operator involvement, which will result in the integration of the photoresist and lithography processes in a single-cassette-to-cassette operation.

- VLSI devices will require sophisticated processing techniques, such as photoresist thickness monitors, end-point detection on developers, and developer temperature control.

- To maintain competitive yields, manufacturers will require local controller environments to control defect levels during processing.

The development of technological innovation will divide equipment into market segments according to user. Two major markets will emerge: the standard product market, populated by large merchant manufacturers, and the ASIC market, populated by small captive and merchant manufacturers. Large captive manufacturers will fall into either category. The standard product market will demand better productivity, better process control, and extremely low particulate levels. The ASIC market will demand redundancy, process flexibility, and maintainability. Both segments will demand reliability.

ASIC manufacturers purchased approximately $20 million worth of the $90 million of APP equipment sold in 1983. However, with the exception of one manufacturer, Machine Technology, APP equipment is not positioned to target this segment exclusively. Although ASIC sales make up about 20 percent of semiconductor sales, the quick-turn portion of semiconductor products will bring the ASIC-type market segment to approximately 50 percent by 1988. Therefore, the two market segments will have equal value.

DATA

Table 2 shows DATAQUEST's estimates of sales for APP systems by equipment vendor, and a summary of worldwide sales across all vendors. Sales declined during 1981 and 1982 by 24 percent. In 1983, sales increased strongly, even though bookings for new photoresist processing equipment did not start accelerating until the beginning of the third quarter.

Table 3 lists sales of APP equipment by regions of the world. Japan was the only area that had increasing sales during the recession period. Japanese sales do not include internal manufacturing of equipment by Hitachi, NEC, and Toshiba. Therefore, actual Japanese consumption is greater than the figures reported here.

DATAQUEST's estimates of the future worldwide sales of APP equipment are given in Table 4. Sales in 1984 are expected to be $137.1 million, up 52 percent from $90 million in 1983. We expect sales to grow again in 1985 to $189.2 million to meet the burgeoning demand for semiconductors. Sales in 1986 and 1987 will grow more slowly as demand for semiconductors flattens during this period. In 1988, sales will probably increase to $294.5 million as semiconductor sales start to accelerate again. This represents a 26.8 percent CAGR from 1983 through 1988.

Robert McGeary

Table 2

ESTIMATED WORLDWIDE AUTOMATIC PHOTORESIST PROCESSING EQUIPMENT FACTORY SHIPMENTS
(Millions of Dollars)

	1980	1981	1982	1983
U.S.				
Eaton	24	18	9	10
GCA	35	22	19	22
Machine Technology	4	6	8	8
Semiconductor Systems	-	-	-	1
Silicon Valley Group	4	8	11	17
Solitec	-	-	-	1
Veeco	9	4	3	4
Japanese				
Dianippon Screen	9	10	12	18
Tokyo Electron	2	3	4	7
European				
Convac	_1_	_1_	_1_	_2_
Total	88	72	67	90

Source: DATAQUEST
July 1984

Table 3

ESTIMATED WORLDWIDE AUTOMATIC PHOTORESIST PROCESSING EQUIPMENT CONSUMPTION BY GEOGRAPHIC AREA (Millions of Dollars)

	1980	1981	1982	1983
U.S.	$62	$42	$40	$49
Japan	16	16	20	33
Europe	10	14	7	8
Total	$88	$72	$67	$90

Table 4

ESTIMATED FUTURE WORLDWIDE SALES (Millions of Dollars)

1984	1985	1986	1987	1988
$137.1	$189.2	$221.6	$230.9	$294.5

Source: DATAQUEST
July 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

1984 MERCHANT CAPITAL EXPENDITURES-- UNITED STATES AND JAPAN

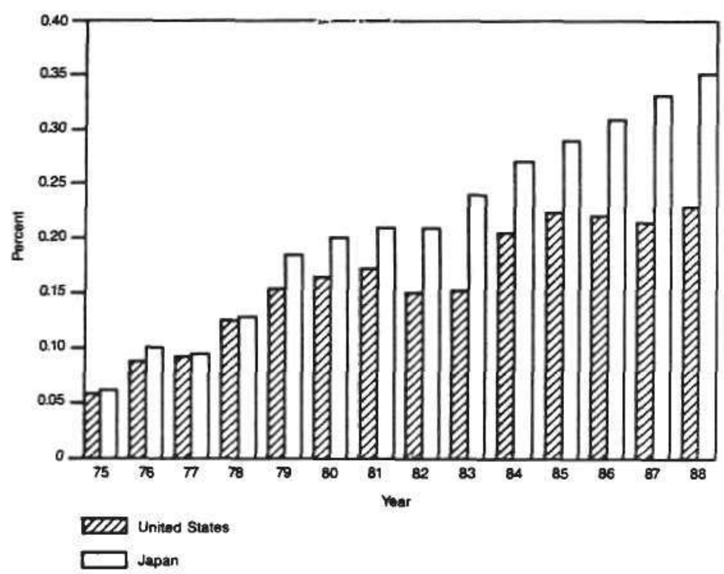
SUMMARY

DATAQUEST recently published the June 1984 update of the merchant capital spending section in the semiconductor Industry Service notebook Industry and Technology. This newsletter summarizes that section.

DATAQUEST estimates that U.S. merchant semiconductor manufacturers' 1984 capital spending will be $2.8 billion, up 85 percent over the 1983 level of $1.5 billion. Japanese merchant capital spending is forecast to be $2.5 billion in 1984, a 48.5 percent increase from 1983. These ambitious forecasts result in the capital-spending-to-revenue ratios shown in Figure 1.

Figure 1

ESTIMATED U.S. AND JAPANESE CAPITAL SPENDING AS A PERCENT OF REVENUE



Source: DATAQUEST July 1984

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

In 1984, approximately 20 to 30 percent of U.S. semiconductor capital spending will be for replacement equipment. In periods of high growth, expenditures for replacement equipment are at the lower end of this range as manufacturers spend more to outfit new facilities. In 1983, U.S. manufacturers spent approximately 60 percent of their capital spending budgets on new equipment or replacements. This is expected to rise slightly in 1984.

CAPITAL SPENDING FORECAST

As shown in Table 1, total U.S. manufacturers' budgeted capital spending projections of $2.6 billion are lower than DATAQUEST's forecast. DATAQUEST's econometric model is currently forecasting higher capital spending than the manufacturers themselves. This also occurred in 1983, and DATAQUEST's forecast was borne out as manufacturers increased their spending later in the year.

DATAQUEST's econometric model forecasts Japanese spending to be lower, at $2.5 billion in 1984 as opposed to the manufacturers' forecast of $2.8 billion. In this case, the model seems to anticipate Japanese manufacturers' not being able to take delivery of all the equipment they have ordered this year.

U.S. 1983 spending was up 23.4 percent from 1982's level of $1.2 billion. Manufacturers' early estimates were for a mere 4.4 percent increase, indicating that they were continuing a cautious outlook from the previous recessionary years.

CAPITAL SPENDING AS A PERCENT OF REVENUES

DATAQUEST's forecasts of U.S. and Japanese capital spending as a percent of revenue are shown in Tables 2 and 3. These forecasts are derived using an econometric model that is tied to semiconductor industry projections and historical spending and revenue patterns. Therefore, it is a valuable predictor of the increases and decreases that can be expected in capital spending.

U.S. spending plans lag sales by approximately seven months. Clearly, U.S. manufacturers follow a reactionary policy. Japanese spending leads sales by two months, implying that spending is based upon forecast sales, or that spending generates future sales. Both U.S. and Japanese capital spending-to-revenue ratios are increasing. In 1984, the U.S. ratio is estimated at 20.5 percent, and at 22.4 percent for 1985. Japan's 1984 and 1985 ratios are 27.1 percent and 28.8 percent, respectively.

CONCLUSIONS

It would appear from the data that the U.S. semiconductor manufacturers' financial infrastructures, which dictate that their operations be profitable for the shareholder, have locked U.S. companies into lower capital expenditure budgets that may result in continual market share losses to the Japanese. It seems that U.S manufacturers must maintain a conservative debt-to-equity financial strategy. The Japanese, on the other hand, seem to be able to command higher debt-to-equity ratios to finance their long-term strategies without adverse effect on their equity markets.

It appears that U.S. manufacturers are trying to forestall capital spending gains of Japanese manufacturers by increasing R&D budgets. This occurred during the last recession, and it could result in increased productivity, which, in turn, may increase the revenue per capital dollar spent. This would allow U.S. manufacturers to remain competitive even though capital spending levels are lower.

Arden DeVincenzi

Table 1

ESTIMATED U.S. AND JAPANESE MERCHANT CAPITAL EXPENDITURES (Millions of Dollars)

Company	1982	1983	U.S. Manufacturers' Forecast 1984	DATAQUEST Forecast 1984	Company	1982	1983	Japanese Manufacturers' Forecast 1984	DATAQUEST Forecast 1984
AMD	$ 67	$ 111	$ 219		Fujitsu	$ 173	$ 234	$ 397	
AMI	27	31	36		Hitachi	168	213	435	
Fairchild	156	125	158		Matsushita	40	128	317	
Intel	138	145	350		Mitsubishi	92	151	179	
Mostek	47	78	117		NEC	192	396	470	
Motorola	175	210	315		Oki	56	55	134	
National	82	120	200		Sanyo	36	51	80	
Signetics	55	58	115		Sharp	47	85	121	
Texas Instruments	130	232	420		Toshiba	128	255	411	
Others	339	391	649		Others	126	178	305	
Total	$1,216	$1,501	$2,579	$2,770	Total	$1,058	$1,656	$2,849	$2,459

Source: DATAQUEST
July 1984

Table 2

ESTIMATED U.S. CAPITAL SPENDING
AS A PERCENT OF REVENUE
(Millions of Dollars)

Year	U.S. Merchant Capital	Percent Change	U.S. Merchant Revenue	Percent Change	Capital as a Percent of Revenue
1973	$ 287	-	$ 2,830	-	10.1%
1974	$ 363	26.5%	$ 3,366	18.9%	10.8%
1975	$ 170	(53.2%)	$ 2,805	(16.7%)	6.1%
1976	$ 312	83.5%	$ 3,519	25.5%	8.9%
1977	$ 381	22.1%	$ 4,077	15.9%	9.3%
1978	$ 637	67.2%	$ 5,100	25.1%	12.5%
1979	$1,023	60.6%	$ 6,689	31.2%	15.3%
1980	$1,388	35.7%	$ 8,462	26.5%	16.4%
1981	$1,357	(2.2%)	$ 7,903	(6.6%)	17.2%
1982	$1,216	(10.4%)	$ 8,079	2.2%	15.1%
1983	$1,501	23.4%	$ 9,895	21.2%	15.2%
1984	$2,779	85.1%	$13,526	36.7%	20.5%
1985	$3,938	41.7%	$17,584	30.0%	22.4%
1986	$4,468	13.5%	$20,222	15.0%	22.1%
1987	$4,547	1.8%	$21,233	5.0%	21.4%
1988	$6,065	33.4%	$26,541	25.0%	22.9%

Table 3

ESTIMATED JAPANESE CAPITAL SPENDING
AS A PERCENT OF REVENUE
(Millions of Dollars)

Year	Japanese Merchant Capital	Percent Change	Japanese Merchant Revenue	Percent Change	Capital as a Percent of Revenue
1975	$ 52	-	$ 844	-	6.2%
1976	$ 143	172.5%	$ 1,428	69.2%	10.0%
1977	$ 163	13.8%	$ 1,738	21.7%	9.4%
1978	$ 318	95.6%	$ 2,484	42.9%	12.8%
1979	$ 521	63.8%	$ 2,819	13.5%	18.5%
1980	$ 753	44.5%	$ 3,777	34.0%	19.9%
1981	$1,009	33.9%	$ 4,835	28.0%	20.9%
1982	$1,058	4.9%	$ 5,069	4.8%	20.9%
1983	$1,656	56.6%	$ 6,915	36.4%	24.0%
1984	$2,459	48.4%	$ 9,086	31.4%	27.1%
1985	$3,309	34.6%	$11,358	25.0%	28.8%
1986	$3,910	18.2%	$12,551	10.5%	30.9%
1987	$5,045	29.0%	$15,048	19.9%	33.0%
1988	$6,677	32.3%	$18,690	24.2%	35.1%

Source: DATAQUEST
July 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

AUTOMATIC PHOTORESIST PROCESSING EQUIPMENT: BELLWETHER OF CAPACITY

SUMMARY

DATAQUEST recently completed research on automatic photoresist processing (APP) equipment. The results will be published in the Semiconductor Industry Service (SIS) notebook Industry and Technology. This newsletter summarizes the findings of that research.

Photoresist processing is one of the most important and fundamental technologies in wafer fabrication. The automation of that process has allowed productivity and yield improvements to keep pace with reductions in the design geometries of integrated circuits (ICs). It is estimated that 75 percent of the yield loss at wafer sort (die probe) is a result of the defect level associated with the photoresist patterning. The driving forces behind changes in APP equipment are for improvements in:

- Maintainability and reliability to increase equipment utilization
- Flexibility and modularity to adapt to process changes
- Capacity per square foot to allow maximum output from a given clean room space
- Contamination level and particulate generation to increase yields of VLSI production
- Ability to produce and control finer lines in photoresist

APP systems, sometimes referred to as tracks, typically are purchased in units of two, three, and four tracks per system, representing large incremental capacity additions. Because of this tendency toward overcapacity, APP equipment sales are sensitive to fluctuations in the semiconductor business environment. During downturns, semiconductor manufacturers do not need to add additional capacity; therefore, purchases consist of replacement equipment and advanced product capacity additions. Purchases of APP equipment begin their upward acceleration when excess capacity is at a minimum.

In the last recession (1980 to 1982), the emergence of application-specific integrated circuit (ASIC) manufacturers, who purchased equipment with investors' money rather than from revenues, helped to augment APP equipment sales. In addition, U.S. captive and Japanese manufacturers continued to add capacity during this period. Silicon Valley Group and Machine Technology both increased their market shares during this period, growing from 4.5 percent each in 1980 to 19 percent and 9 percent, respectively, in 1983.

Table 1 shows DATAQUEST's estimates of worldwide APP equipment sales from 1974 through 1983 and forecast sales from 1984 through 1988. We estimate that worldwide APP equipment sales rose 34.3 percent from $67 million in 1982 to $90 million in 1984. U.S. consumption grew 22.5 percent to $49 million during this period, and European consumption grew 14.3 percent to $8 million. Japanese markets grew 65 percent to $33 million as Japanese manufacturers continued aggressive capital spending plans made during the recession.

Table 1

ESTIMATED WORLDWIDE APP EQUIPMENT SALES
(Millions of Dollars)

Year	Sales	Growth
1974	$ 4.2	
1975	$ 2.5	(40%)
1976	$ 11.4	365%
1977	$ 18.9	66%
1978	$ 28.9	53%
1979	$ 48.1	66%
1980	$ 88.0	83%
1981	$ 72.0	(18%)
1982	$ 67.0	(7%)
1983	$ 90.0	34%
1984	$137.1	41%
1985	$189.2	11%
1986	$221.6	17%
1987	$230.9	17%
1988	$294.5	29%

Source: DATAQUEST

DATAQUEST estimates that the APP equipment market will grow 52.8 percent to $137.1 million in 1984. Most of this increase will come from U.S. manufacturers who must add capacity to keep up with burgeoning semiconductor demand. We estimate that worldwide sales of APP equipment will grow to $294.5 million in 1988, representing a 26.8 percent compound annual growth rate (CAGR) from 1983 through 1988.

TECHNOLOGY

Photoresist processing takes place after wafers leave thin-film deposition or oxidation, prior to align-expose, and again prior to wet or dry etching. The photoresist processing steps universally used are: coating on a spinner, baking in a belt oven or on a hot plate, and developing. Additional steps that can be added to the processing as needed are scrubbing and dehydration processing prior to coating, a postexposure bake prior to developing, a hard bake after developing, and deep ultraviolet (UV) resist hardening after developing. Photoresist processing is done in an area separate from the rest of the wafer fabrication, since illuminating the photoresist-coated wafers in the green or blue portions of the light spectrum would expose the resist. This section of the fab area is frequently called the "yellow room" because of the yellow lights used to illuminate it.

The average number of mask layers per semiconductor device is steadily increasing as devices become more complex. The number of times a wafer goes through a typical photoresist processing stream is 5 to 7 times for discretes, 7 to 10 times for ICs, and 10 to 15 times for LSI devices.

The various semiconductor manufacturing segments have slightly different needs with respect to automatic photoresist processing equipment, depending upon the needs of their markets. U.S. merchant and large captive suppliers are putting heavy emphasis on capacity per square foot, process control, and contamination control. U.S. ASIC and small captive suppliers are interested in process flexibility and maintainability. Japanese manufacturers, who possess both merchant and captive characteristics, emphasize process and contamination control. European manufacturers consume only a small portion of the equipment and seem to follow the lead of worldwide markets.

Technology Trends

Bake

The development of the hot plate as an alternative to belt ovens has been a significant improvement. The hot plate has fewer moving parts, and thus generates less particulate contamination and requires less maintenance. Recently, some vendors have integrated this module with an HMDS (hexamethyldisilazane) vapor prime process to improve resist adhesion. The hot plate's single-wafer configuration increases the feasibility of integrating photoresist processing and photolithography into an in-line, cassette-to-cassette system.

Single-Track Systems

For small semiconductor manufacturers, the single-track APP system has made it possible to distribute risk over several systems. Since tracks were historically purchased in multitrack packages, the malfunction of one track often affected the other tracks, rendering the system nonoperational. With an inexpensive, single-track system, small manufacturers with lower capacity needs can buy two or three separate systems that will maintain some capacity in the event of a malfunction.

Resist Types

The use of positive resist is growing with respect to the use of negative resist. Negative resist is subject to swelling, higher levels of defects, and reduced adhesion, making it less attractive for use at less than 3 micrometers. Although positive resist represents one-third of the volume of photoresist consumed, it represents about the same number of dollars in sales because of its higher price.

ANALYSIS

Because of the high productivity of APP equipment, the market is extremely susceptible to slow growth during periods of overcapacity. Other steps of the fabrication process can be done in a variety of ways and have changed with the increasing level of integration (e.g., implanting has largely replaced predisposition, and thin-film deposition has largely replaced grown oxide films). But photoresist processing has stayed fundamentally the same. Thus, during business downturns, manufacturers can produce their newer products on the older APP equipment, in which case, new equipment sales consist of replacement equipment and new capacity additions.

During the last recession (1980 to 1982), the emergence of the ASIC markets and the continued strength of the Japanese equipment market buffered the effects of the recession on APP equipment sales. Even with that buffer, sales fell 24 percent during that period. DATAQUEST estimates that semiconductor sales will increase more than 30 percent per year in 1984 and 1985, followed by two years of slower growth, after which, higher growth will ensue. We can expect the slow-growth period to affect APP equipment sales as it has historically.

However, the exaggerated effect of reduced sales may be ameliorated by technological factors that increase demand. For instance, if newer products cannot be manufactured on older equipment, then newer equipment will be in demand. Technological factors that increase demand are:

- The need for lower defect levels is generating a need for more automation and less operator involvement, which will result in the integration of the photoresist and lithography processes in a single-cassette-to-cassette operation.

- VLSI devices will require sophisticated processing techniques, such as photoresist thickness monitors, end-point detection on developers, and developer temperature control.

- To maintain competitive yields, manufacturers will require local controller environments to control defect levels during processing.

The development of technological innovation will divide equipment into market segments according to user. Two major markets will emerge: the standard product market, populated by large merchant manufacturers, and the ASIC market, populated by small captive and merchant manufacturers. Large captive manufacturers will fall into either category. The standard product market will demand better productivity, better process control, and extremely low particulate levels. The ASIC market will demand redundancy, process flexibility, and maintainability. Both segments will demand reliability.

ASIC manufacturers purchased approximately $20 million worth of the $90 million of APP equipment sold in 1983. However, with the exception of one manufacturer, Machine Technology, APP equipment is not positioned to target this segment exclusively. Although ASIC sales make up about 20 percent of semiconductor sales, the quick-turn portion of semiconductor products will bring the ASIC-type market segment to approximately 50 percent by 1988. Therefore, the two market segments will have equal value.

DATA

Table 2 shows DATAQUEST's estimates of sales for APP systems by equipment vendor, and a summary of worldwide sales across all vendors. Sales declined during 1981 and 1982 by 24 percent. In 1983, sales increased strongly, even though bookings for new photoresist processing equipment did not start accelerating until the beginning of the third quarter.

Table 3 lists sales of APP equipment by regions of the world. Japan was the only area that had increasing sales during the recession period. Japanese sales do not include internal manufacturing of equipment by Hitachi, NEC, and Toshiba. Therefore, actual Japanese consumption is greater than the figures reported here.

DATAQUEST's estimates of the future worldwide sales of APP equipment are given in Table 4. Sales in 1984 are expected to be $137.1 million, up 52 percent from $90 million in 1983. We expect sales to grow again in 1985 to $189.2 million to meet the burgeoning demand for semiconductors. Sales in 1986 and 1987 will grow more slowly as demand for semiconductors flattens during this period. In 1988, sales will probably increase to $294.5 million as semiconductor sales start to accelerate again. This represents a 26.8 percent CAGR from 1983 through 1988.

Robert McGeary

Table 2

ESTIMATED WORLDWIDE AUTOMATIC PHOTORESIST
PROCESSING EQUIPMENT FACTORY SHIPMENTS
(Millions of Dollars)

	1980	1981	1982	1983
U.S.				
Eaton	24	18	9	10
GCA	35	22	19	22
Machine Technology	4	6	8	8
Semiconductor Systems	-	-	-	1
Silicon Valley Group	4	8	11	17
Solitec	-	-	-	1
Veeco	9	4	3	4
Japanese				
Dianippon Screen	9	10	12	18
Tokyo Electron	2	3	4	7
European				
Convac	1	1	1	2
Total	88	72	67	90

Source: DATAQUEST
July 1984

Table 3

ESTIMATED WORLDWIDE AUTOMATIC PHOTORESIST
PROCESSING EQUIPMENT CONSUMPTION
BY GEOGRAPHIC AREA
(Millions of Dollars)

	1980	1981	1982	1983
U.S.	$62	$42	$40	$49
Japan	16	16	20	33
Europe	10	14	7	8
Total	$88	$72	$67	$90

Table 4

ESTIMATED FUTURE WORLDWIDE SALES
(Millions of Dollars)

1984	1985	1986	1987	1988
$137.1	$189.2	$221.6	$230.9	$294.5

Source: DATAQUEST
July 1984

August

August Newsletters

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

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: August

THE DESIGN AUTOMATION CONFERENCE: THE PREMIER EDA SHOW

INTRODUCTION

The 21st Design Automation Conference (DAC), held in Albuquerque, New Mexico, June 25 through June 27, outdid even the one held last year in Florida. It proved to be the best attended and most spectacular DAC yet. With more than 4,000 people attending the technical sessions and visiting the vendors' exhibits, this year's DAC clinched the status of being the premier conference and trade show for the electronic design automation (EDA) CAD/CAM market segment.

The conference was marked by 45 technical presentations in the form of papers, panel discussions, and workshops. Forty vendors demonstrated their EDA, CAE, IC, and PCB CAD/CAM products at the exhibition hall, while numerous private, invitation-only demonstrations took place in hotel suites located throughout Albuquerque.

The interest in, and the demand for, design automation products have spurred the DAC into joining the fast pace of the EDA CAD/CAM market segment. With attendance increasing 33 percent and the number of exhibitors increasing 67 percent from 1983 to 1984, the DAC reflects the need for products that increase productivity of electrical engineers.

The success of the show underscores how the surge of activity in the EDA market segment is positively affecting the semiconductor industry. From the standpoint of application-specific ICs (ASICs), EDA is clearly a driving force behind DATAQUEST's forecast for ASIC growth. In 1980, ASICs accounted for 16 percent of worldwide IC shipments. Similarly, we believe that ASICs will capture 19 percent in 1985 and 23 percent in 1990 of worldwide IC shipments (to both merchant and captive markets).

The EDA market is also affecting the semiconductor industry because it is part of a high-growth end-use market for semiconductor manufacturers. Although design automation tools represent a niche market, demands for superior processing capabilities and overall IC performance have expanded the potential market available to semiconductor suppliers.

TRENDS

Of all the products shown at the DAC, all illustrated one or more of several trends that are spurring the growth of the EDA market segment. These trends are described below.

Deliverable, Functional Personal Workstation

DATAQUEST believes that three major factors are restricting an even faster and more widespread acceptance of EDA systems: change from current design methodology, a relatively steep learning curve to become proficient with a system and realize real productivity increases, and cost. With the availability of both general-purpose and dedicated low-cost systems, the average system selling price is no longer such a large obstacle. We also believe that prices will continue to decrease, and conversely, that price/performance ratios will continue to increase. Because the majority of EDA systems will be used mostly for applications with low computational requirements and mid-range graphics requirements (such as logic design or schematics capture), the availability of systems priced in ranges less than $20,000 will open the market to all levels of engineers, not just to those working on key, high-priority projects.

Broadened Functionality

EDA systems have expanded from the originally introduced logic design and analysis products to include products that address the entire design cycle. Most notable is the inclusion of physical layout tools that can operate with or from the same data base used for logic design. The EDA companies are directly attacking turnkey companies with physical layout-only products. DATAQUEST believes that they will gain market share because users want integrated solutions.

Increased Analysis Emphasis

Second to schematics capture, EDA systems are used mostly for analysis. Schematic capture is a relatively rudimentary 2-D graphics application. Intractive, usable analysis of the design is the key to the successful logic design. Products range from logic and circuit simulation, to behavioral-level simulation, timing verification, physical modeling, fault simulation, and physical layout verification. DATAQUEST believes that as users become more confident with the functionality of the currently available analysis tools, the vendors will seek not only to add more analysis products to their lines, but to increase the performance of their existing ones.

Application-Specific Hardware

Specialized engines are being incorporated into product lines to implement software functionality onto hardware. Striving for ever-shortening product design throughput, not only does the application-specific hardware offered by EDA vendors decrease computational time, but the products offered also are distributed in nature, and can be accessed by many workstations within a network.

Niche Applications

Not all vendors participating in the EDA segment will be, or are, full-range turnkey vendors. Due to the high degree of sophistication and complexity of design automation products, many vendors can be successful with specialized, niche products, even though they may not reach hundreds of millions in sales. The high growth of the EDA segment and its infant stage create an umbrella for companies to participate with niche products and complement the turnkey vendors' product lines rather than compete directly with them.

The level of competition (i.e., the costly and glamorous booths, number of sales personnel and systems on the exhibit floor, new product introductions, and the sheer number of vendors) exemplifies the pressure to succeed and be one of the big winners in the still very young EDA market segment.

DESIGN AUTOMATION PRODUCTS

Many new and significant products were announced or shown at the DAC. The following paragraphs discuss the products that DATAQUEST believes will positively impact the growth and applications of the electronic CAD/CAM products and market.

Cadnetix Corporation, Boulder, Colorado

Cadnetix made its debut into the EDA market with the introduction of its Logic Design and Verification System (LDVS) based on a hierarchical schematic editor, document processor with word processing capabilities, HHB Inc.'s CADAT logic and optional fault simulators, and the SCALD-based timing verifier. The software packages run on the CDX-5000 and on the newly introduced desktop CDX-9000 Motorola 68010-based workstations.

Users of the Cadnetix CDX-5000 printed circuit board system can now incorporate comprehensive logic design capabilities with physical board layout in either one system or standalone and desktop units. DATAQUEST believes that Cadnetix's expanded product line enables the company to fulfill the end-to-end design needs of its customers and, possibly, to grow into other electronic CAD applications such as integrated circuit design.

CAE Systems Incorporated, Sunnyvale, California

CAE Systems demonstrated its front-end logic design and analysis functionality running on either an Apollo or a VAX computer. The company has developed interfaces for a variety of independently supplied software tools, including HiLo, Spice, and Zycad simulators; SCALD timing verifier; and SCI-MEDS, SCI-CARDS, GARDS, and CAL-MP physical layout products.

CAE announced that its products will run on Sun Microsystems' line of standalone workstations. CAE will not OEM the Sun system unless the sales volume is high enough to warrant such an arrangement.

CAE is pursuing its original software product strategy by interfacing its front-end design capabilities to already existing design automation tools. DATAQUEST believes that in this manner, the company can differentiate itself and its products, and offer users a choice of cost-effective integration solutions.

Calma Company, Santa Clara, California

Calma introduced T-ARRAYS and announced an agreement with ECAD. T-ARRAYS is a technology-independent gate array router that currently runs on the VAX, with plans to move it to an Apollo-based system in 1985. The ECAD agreement calls for Calma to modify ECAD's Dracula II software to provide a direct interface between the TEGAStation and GDSII for logic-to-layout (electrical rules) checking.

The company also demonstrated several of its other newly introduced or enhanced products, including: T-Boards, PCB software from Omnicad that runs on the Apollo and interfaces to Tegate's data base; FAST-MASK, a hardware accelerator for design rules checking manufactured by Silicon Solutions Corporation in Menlo Park; and testing communications options as an enhancement to TEGAStation.

A lot of activity, especially in the form of third-party agreements, is going on at Calma as they concentrated on becoming a major factor in the entire electronic CAD/CAM marketplace. With approximately 700 installed IC and PCB systems, DATAQUEST believes that Calma must continue this high level of activity to protect its installed base. We believe that the key to Calma's success lies in its ability to provide effective interfaces between its physical layout systems and its newly introduced front-end design automation tools.

Daisy Systems Corporation, Sunnyvale, California

Daisy announced that it is an IBM value-added remarketer (VAR) and introduced its Personal Logician, a schematic entry system based on the IBM PC/XT and Daisy's graphics display and controller. Through the proprietary graphics hardware and Daisy's operating system "shell," the Personal Logician provides the same user interface as Daisy's full product line. It is fully compatible with all Daisy products via an Ethernet communications interface. Daisy demonstrated Chipmaster, its recently introduced full-custom physical layout system, and the company's entire line of EDA products.

DATAQUEST believes that the Personal Logician is very significant because it provides a new level of price/performance on general-purpose hardware optimized for interactive, graphics applications. We believe that because of the Personal Logician, Daisy will be able to further penetrate the end-user market and protect its installed base.

Control Data Corporation, Minneapolis, Minnesota

CDC demonstrated its end-to-end electronic CAD solutions, which range from personal computers, workstations, minicomputers, mainframes, and supercomputers, to time-sharing and design center services. CDC incorporates both third-party and internally developed software into its products, which cover IC, PC, and systems level design.

CDC is one of the few computer vendors selling turnkey electronic CAD solutions. DATAQUEST believes that CDC offers unique design automation solutions through its design center and time-share network strategies matched with its turnkey products. The company provides not only the hardware and software tools, but also engineering services.

Data General Corporation, Westboro, Massachusetts

During the second show day, Data General announced its new DS/4000 distributed system standalone workstation. It is a single-user system, based on the MV/4000, that can operate in an office environment running office automation software. The DS/4000 supports all of the third-party software that is currently available from Data General.

DATAQUEST believes that the DS/4000 is significant, not only because it is Data General's initial entry into the engineering workstation market, but because it meets the diverse needs of engineers--namely, it is capable of running engineering and office automation software on one piece of hardware using one operating system.

Genrad Incorporated, Santa Clara, California

Genrad demonstrated its HiLo-2 logic design simulator, which it procured through the acquisition of Cirrus Computer, Ltd. Genrad is approaching design from a different perspective than that of the turnkey EDA vendors. It views design from the test world, and wants circuits to be built for testability. DATAQUEST believes that Genrad is in an excellent position to solve testing issues in the design phase, which is currently the largest gap in electronic design automation products.

The HiLo-2 logic design simulator includes functionality for functional modeling, logic simulation, timing analysis, fault simulation, and test pattern generation. Genrad is pursuing a third-party software strategy, and has formed several agreements for its HiLo-2 product with companies such as CAE Systems and Metheus-CV. DATAQUEST believes that by following this strategy, Genrad will be able to maximize sales of its simulators, while protecting the installed base of its testers by increasing integration with design products.

HHB Softron, Mahwah, New Jersey

HHB is the software company that developed the CADAT logic and fault simulator. The company has several major third-party software agreements with EDA vendors, most notably Mentor Graphics and Racal-Redac. DATAQUEST believes that because HHB offers one highly focused product, the company is in an excellent niche position to provide software to a wide range of EDA vendors.

Mentor Graphics Corporation, Beaverton, Oregon

Mentor announced its Hardware Verification System (HVS), which is used for both data acquisition and test pattern generation to stimulate electrical nodes for testing prototype circuits. The company also demonstrated the products it announced during February 1984 (refer to DATAQUEST Research Bulletin No. 49). Mentor also announced that it has repackaged its systems into the Idea Series, previously the Idea 1000 line. The newly packaged systems are bundled with the appropriate software to accomplish most electronic design tasks. They include the Capture, Design, Idea, Spice, Chip, Gate, Cell, Test, and DOC Stations.

Mentor also demonstrated its products on the Apollo DN550, Apollo's newly announced lower-cost color graphics product. Although Mentor has a schematics capture product priced in the high $20,000 range at large quantities (Apollo DN300-based), DATAQUEST believes that Mentor must aggressively pursue other low-cost hardware options so that it can provide systems with price/performance ratios competitive with new product introductions from Daisy and Valid.

Metheus-CV Incorporated, Hillsboro, Oregon

Because Metheus signed up for booth space as Metheus Corporation prior to the announcement of the joint venture with Computervision, the DAC committee would not allow the company to use the new name of Metheus-CV on its booth. Metheus demonstrated its 700-series workstations, which have a full range of logic design and analysis and physical layout functionality, as well as direct interfacing capabilities to Computervision's CADDS-2 VLSI design systems. (Refer to DATAQUEST Newsletter No. 55 for further details on the newly formed joint venture.)

NCA Corporation, Sunnyvale, California

NCA traditionally has been a software company specializing in the post-physical layout phases of the design cycle, with products for design and electrical rules checking and pattern generation. At the show, NCA demonstrated its newly announced Viewport and Graphic Logic Editor (GRALE) stations. The Viewport is an edit-only station intended to allow the layout designer to quickly correct layout errors found by NCA's design rules check programs. GRALE is a graphics station that allows the logic diagrams to be input directly to NCA's data base for use with its electrical rules checking program.

DATAQUEST believes that NCA has identified a specialized market niche for itself by developing programs that meet very specific needs within the design process.

Omnicad Corporation, Fishers, New York

Omnicad was at the DAC with its Omniboards and Omnigates PCB and gate array CAD/CAM products. Omnicad is the first CAD/CAM company to support AT&T's new microprocessor-based personal workstation. DATAQUEST believes that this is significant, because it takes AT&T into the CAD/CAM industry, competing with all the other computer and workstation companies. Companies now have a choice between a PC/DOS-based IBM personal computer and an AT&T UNIX-based personal computer.

Omnicad is a spinoff from nearby Scientific Calculations and has signed a major third-party agreement with Calma Company for Calma's newly announced T-Boards.

Phoenix Data Systems, Albany, New York

Phoenix Data Systems (PDS) is expanding its traditional line of logic simulation and layout verification products (LOGCAP and MASKCAP, respectively) into more comprehensive EDA products. At DAC, the company demonstrated its schematics capture, simulation, layout, verification, and pattern-generation products. PDS is largely dependent on Digital's host-dependent products, ranging from the VAX 11/725 to the VAX 11/780.

PDS is one of several software companies selling products for electronic design automation. DATAQUEST believes that for PDS to be successful in this market segment, it must differentiate its products from those offered by its competitors. In this way, it will be able to expand its end-user sales, as well as be able to interface its more well-established MASKCAP and LOGCAP products to other EDA systems.

Racal-Redac Incorporated, Westford, Massachusetts

DATAQUEST calls it EDA, and Racal calls it CIEE (Computer Integrated Electronic Engineering). Racal has long been one of the leaders in the PCB CAD/CAM market segment, and recently it has shown its intentions of becoming a dominant force in the entire electronic CAD/CAM market segment. Aside from its traditional PCB router, the company now offers logic design and analysis and full-custom VLSI design capabilities. In addition to Digital's PDP and VAX series, Racal's hardware lines have been expanded to include IBM PC/XT and Apollo processors.

Racal has signed agreements with HHB/Softron for its CADAT logic and test simulator, and with Inmos for its internally developed full-custom stick-like layout editor. Racal spokepersons say it has plans to announce a router for standard cell design methodology in the near future. DATAQUEST believes that Racal's new strategy will be especially successful in Europe, where the company dominates the PCB CAD/CAM market. We believe that the company will have to continue its corporate awareness campaign in the United States in order to effectively compete with the existing EDA vendors.

Silvar-Lisco, Menlo Park, California

Silvar-Lisco's booth stressed its software marketing strategies by demonstrating its full line of products on the newly announced Apollo DN550 and VAX computers. (The company's products are discussed in our Research Newsletter No. 56.) The company stressed that its software is compatible and integrated with a wide range of processors, including the two mentioned here and the IBM and Prime computers.

Teradyne Incorporated, Boston, Massachusetts

Teradyne, like Genrad, is approaching product design from a test perspective. Teradyne demonstrated Lasar, its logic and test simulator, at the show. The company is formulating a new strategy to market its software not only directly to end users, but also to turnkey CAD/CAM vendors. Teradyne already has formed several third-party agreements with major CAD/CAM vendors. DATAQUEST believes that by pursuing two distribution channels, Teradyne will be able to enter the CAD/CAM market quickly, and integrate testing with design via its Lasar products.

Valid Logic Systems Incorporated, Mountain View, California

Valid introduced its low-cost desktop workstation at the show. Unlike Daisy, Valid's product is proprietary, based on the Motorola 68010 and UNIX operating system. Called the SCALDsystem IV, the new system can perform schematic capture, timing vérification, logic simulation, and documentation. It interfaces to Valid's entire product line via Ethernet. The company also announced that it has added color capability to its SCALDsystem I and II. Valid was showing its entire line of EDA products at the show.

Via Systems Incorporated, North Billerica, Massachusetts

Via, until recently, has sold products solely for IC physical layout. At the DAC, the company was demonstrating its recently announced logic design system, which performs schematics capture and logic simulation. Via has chosen Sun Microsystems' product for its processor, and also sells systems based on Digital's PDP 11/23. DATAQUEST believes that Via's decision to expand its product lines to include front-end capabilities was wise, since logic design and simulation are more critical needs than products for physical layout only.

SUMMARY

The 22nd Design Automation Conference, to be held in Las Vegas during June 1985, promises to be just as spectacular as the 21st DAC. Although many of the vendors have mixed feelings about the structure of the conference (i.e., entry fee, floor selling, competing after-hour functions), most of the vendors agree that it attracts highly qualified sales prospects and is an extremely productive trade show.

(This newsletter is reprinted with the permission of DATAQUEST's CAD/CAM Industry Service.)

Anthea C. Stratigos
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Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: August

COMPUTER MANAGEMENT OF WAFER FABRICATION:
THE COMPETITIVE EDGE

SUMMARY

As the manufacturing technologies of different semiconductor firms become more comparable, the main difference in semiconductor vendors will be the service they provide to the customer. The semiconductor companies will all have the same available resources and will have to deliver products at market-driven prices. In this scenario, DATAQUEST believes that a significant part of a company's competitive advantage will come from efficient use of its manufacturing system. The CAM (computer-aided manufacturing) system is the glue that holds the manufacturing process together and allows the user to direct and control the manufacturing operation. The future leaders in the semiconductor industry are likely to be those companies that are most skilled in the use of CAM systems.

As of the beginning of 1984, merchant CAM system suppliers had installed approximately 100 CAM systems in U.S. and European semiconductor manufacturing facilities. This is in addition to the systems that were developed internally. These systems perform one or more of the following functions:

- Data collection and analysis
- Wafer start scheduling
- Resource allocation
- Planning and cost accounting
- Inventory control
- Line balance
- Process control
- Equipment and facilities monitoring and maintenance

Reliable, accessible, and analyzable data on lot location, equipment performance, facilities performance, and engineering parameters can be used to detect line balance or yield problems before they become catastrophic, thus improving the output of good products.

This early-warning capability is particularly important in the VLSI era because process tolerance is difficult to meet and more likely to go out of adjustment, and because wafers are more sensitive to contamination while awaiting processing. In addition, high equipment costs often mean that backup equipment is less likely to be available. By using early-warning methods and by reducing WIP (work in process), electrical yields can be raised significantly.

DATAQUEST sees a definite move of semiconductor manufacturers toward purchasing systems from merchant suppliers. Many are augmenting their in-house systems with commercial systems. Several manufacturers are working with merchant CAM system vendors to develop manufacturing plants (fabrication, test, and assembly) with fully functioning computer management. These efforts will lead to full factory automation, with automated cassette transport, in 1986.

The evolution of automation in semiconductor manufacturing will occur in the following order:

- Computer management of the manufacturing process
- Interfacing of the computer to the process equipment
- Arrangement of process equipment into "islands of automation"
- Automated cassette transport between islands of automation

DATAQUEST estimates that merchant CAM suppliers' sales will grow 233 percent from 1983 to 1984, from $12 million to $40 million. This growth will result from the many semiconductor manufacturers, who had already invested considerable sums in their own development, replacing their systems or augmenting them with commercial systems. Also, there is a growing recognition that CAM support is an integral part of the manufacturing facility. We expect this practice to continue as CAM system vendors improve their products and prove the performance of their systems. DATAQUEST estimates that the CAM system market will grow at a 41 percent compound annual growth rate (CAGR) from 1984 to 1988 to reach $160 million.

TECHNOLOGY

Figure 1 is a diagram of the type of commercially available CAM system that is being installed in fab areas in 1984. It is made up of a 32-bit minicomputer (the local host plus terminals), interfaces to process equipment, facilities monitors, a printer for reports, and an interface to the company management information system (MSI). Terminals are used as the predominant I/O method to communicate with fab personnel. Lot movement, operator instructions, and instrument reading all transfer over the terminal-host link. Terminals are placed at the beginning of the masking process (yellow room), at the end of etch and strip, at implant, and in the diffusion and thin-film areas.

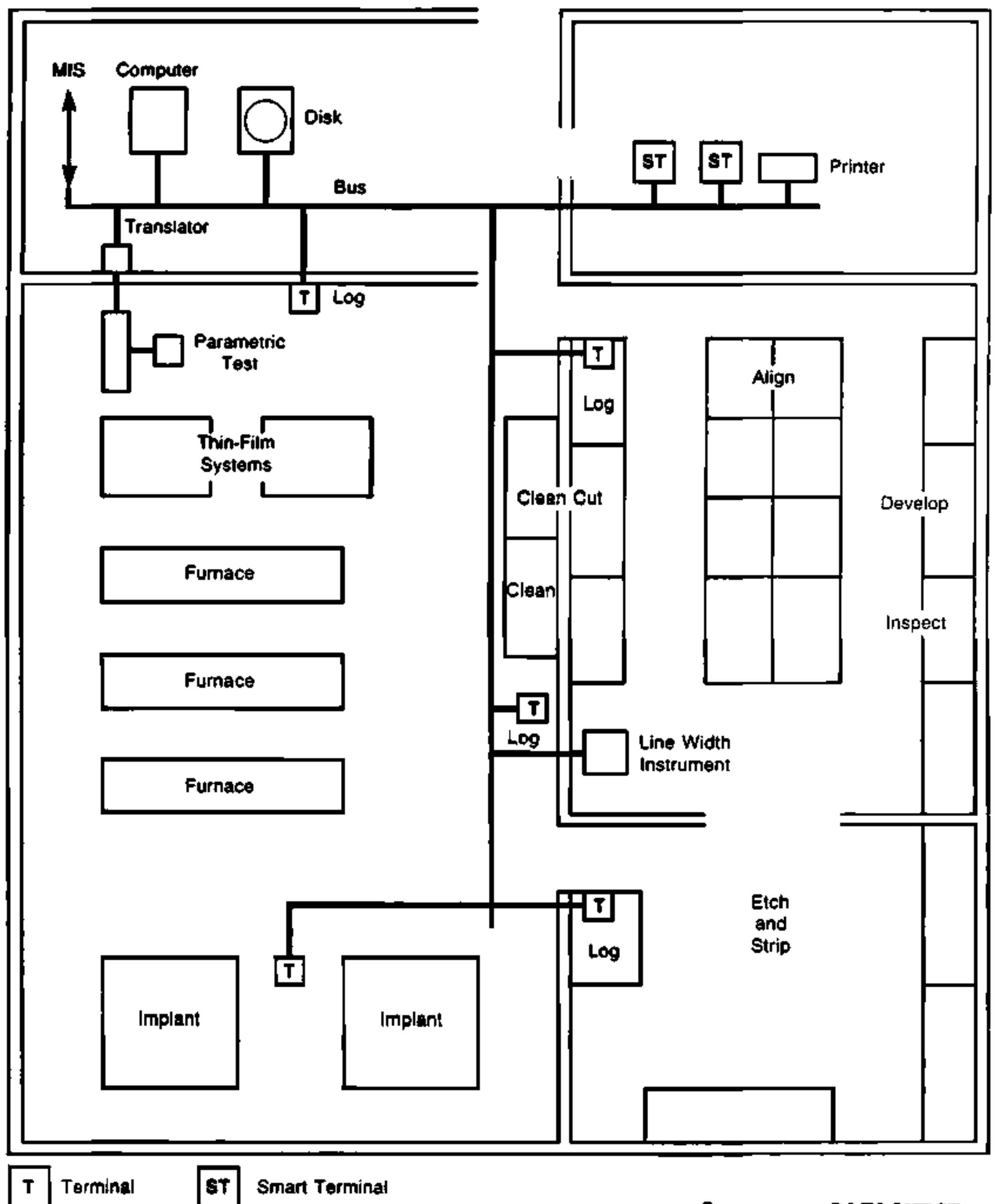
The computer controls the product, process, and equipment history files stored on disks, and computes updated yields as lot transactions occur. The computer also uploads information to the company MIS for compilation of financial results. In many cases, the computer comprises two CPUs (central processing units) operating in parallel: one satisfies routine tracking requirements and the second is a backup that can be used for engineering analysis or report generation without loading down the primary computer. Two disk storage systems may be used to ensure that the data base is secure.

The CAM systems for semiconductor fabs, which are being supplied in 1984 both internally and by vendors, provide the following services:

- Centralization of data, which is updated on a real-time basis, in one convenient location
- WIP (work in process) management and yield computation
- MIS data for computation of financial results
- Yield analysis in the form of lot histories and statistical analysis programs
- Documentation and specification control of the process at the location where the procedure is to be followed
- Lot scheduling by lot processing order to meet fab-out schedules
- Maintenance schedules, spare parts control, uptime, and failure mechanism control
- Equipment monitoring for performance and quality of operation

Figure 1

CAM SYSTEM ARCHITECTURE



Source: DATAQUEST
August 1984

CAM systems for semiconductor fabrication are used in a wide variety of configurations. Thus, the cost of a system varies from several thousand dollars to more than a million dollars. These systems include: desktop computers, used for computing wafer-start and line-balancing schedules; first-level systems run on 16-bit computers, used for local tracking within a larger system; full CAM systems run on 16- and 32-bit processors, for lot tracking, engineering analysis, and report generation; and large fab systems using coprocessors, providing the full cadre of fab manufacturing management.

The vendors of these systems are listed in Table 1. BTU/Bruce, Consilium, and IP Sharp are third-party software houses supplying application programs that run on hardware from other manufacturers. These companies install their software after the computer is installed and operational. Frequently, they participate in the selection and layout of the CAM hardware. CTX and Hewlett-Packard vend both hardware and applications software. Nanometrics sells a limited program for use in small fabs. Enhansys and BBN Research offer data analysis programs that can be purchased within the CAM software or as separate programs. As separate programs, the system cost ranges from $30,000 to $120,000.

Also shown in Table 1 is a list of semiconductor manufacturers and their choice of hardware on which to internally design CAM programs. These systems were developed before commercial programs were available.

Table 1

CAM SYSTEMS

Vendor	Product Name	Hardware Base
Large Systems		
BTU/Bruce	Fasttrack	Digital VAX Series plus Briton Lee
Consilium	Comets	Digital VAX Series
CTX	CTX 4000	CTX computer based on multiple 68000 processors
Fairchild	Incyte	Digital VAX Series
Hewlett-Packard	IC 10 PC 10 CA 10	HP 3000 plus multiple 1000s
IP Sharp	Promis	Digital VAX Series
Limited Systems		
Nanometrics	Nanonet	Codata based on 68000 processor
Engineering Analysis Systems		
Enhansys	Enhansys System	Runs on several hardware systems
BBN Research	RS/1	Digital PDP-11 or VAX
Internal Systems		
AMD		IBM
Fairchild		Digital
IBM		IBM
Motorola		Tandem
National		IBM
Texas Instruments		IBM

Source: DATAQUEST
August 1984

ANALYSIS

As of the beginning of 1984, merchant system suppliers had installed approximately 100 CAM systems in U.S. and European semiconductor manufacturing facilities. These installations are a mixture of systems that cover only fabs and ones that cover an entire manufacturing cycle. In addition to these systems, many of the larger merchant and captive manufacturers have developed and now use their own systems. There is a growing perception that CAM will be paramount in the race for share in future semiconductor markets.

CAM will provide the tools to wring the vestiges of inefficiency from the manufacturing process. The implementation of a CAM system can provide immediate gains in yield improvement, production scheduling, and learning curve improvement.

Yield improvement programs can be purchased separately from the tracking systems and can run on separate computers. By correlating and analyzing data coming from all of the manufacturing and test areas, these programs can identify process parameters that need to be improved. Once improved, the yield can be watched to obtain maximum process efficiency.

More efficient scheduling of material and time will help meet customer orders, which improves responsiveness in a competitive environment. In addition, better scheduling reduces manufacturing inventory and improves turnaround time. The improvement in turnaround time means that a wafer spends less time in a particulate laden environment, also increasing yields. However, current programs are limited in their ability to deal with many products and with many process flows, which is even more crucial in assembly and test because of multiple package types and multiple electrical grades for each product.

Low yields often accompany the introduction of new products because of the learning curve associated with new process conditions. With quicker turnaround times and early correlations made from process results, this learning curve can be accelerated, which gets a fab to higher yields more quickly. The analysis of information derived from the CAM system can quickly identify whether the yield losses are from manufacturing or design-induced problems.

Although the gains to be acquired justify the purchase of a CAM system, the choice of systems is not so clear cut. There are features that have not been fully developed and commitment to a system could make future changes costly. For instance, since equipment interfaces are not prevelant, CAM I/O must be through remote terminals. But the hiring of personnel necessary to input the information through a keyboard would be counter to the goal of reducing the number of people in the fab. We believe that the problems with this interim step on the way to full equipment interfaces must be solved in order to gain the experience necessary for real-time control of the manufacturing process. A solution might take the form of smart cards, bar code readers, or voice-actuated terminals.

Full factory automation (i.e., automated WIP transport) will come in two steps; soft automation and hard automation. Semiconductor manufacturers are reluctant to implement automatic cassette or wafer transport before these systems are adequately developed by equipment vendors. CAM systems provide the means for real-time control of the manufacturing process, or soft automation.

For soft automation, the SECS (semiconductor equipment communication standard) must be implemented on all process equipment. Equipment manufacturers have advertised this feature but have been remiss in developing the software programs needed to access it. Aggressive semiconductor manufacturers have tried to develop their own software but have had success only in isolated areas. One such area is the furnace area. These early successes have evolved into full CAM systems, such as the one vended by BTU/Bruce, a furnace manufacturer.

For hard automation, equipment will be arranged into "islands of automation." Several equipment vendors have introduced interfaces between their equipment. One such vendor, GCA Corporation, has introduced an integrated system that ties together the photoresist, photolithographic, and dry etch processes in one module. It will be these types of islands that will be linked together with automatic cassette transport.

Two types of cassette transport are evolving: the mail cart type and the track type. In the mail cart system, the cart moves cassettes between process equipment, guided by tape on the floor or by preprogrammed routing. This system is relatively flexible since process equipment location changes require only a rerouting of guiding tape or reprogramming. Two companies have announced cart-type systems: Veeco, with its Veebot, and a recent start-up, Flexible Manufacturing Systems (FMS), with its CIMS module. We expect others to enter this market soon.

In the track system, cassettes are transported in enclosed tunnels from one station to another. Such tunnels must be very clean to ensure minimal particulate contamination to the wafers during transport. This system is less flexible than the cart method, since changes in routing may necessitate mechanical changes to the track. However, the track system will run on simpler software programs than will the cart system. Varian and NACOM have introduced such products. Varian will ship the Autotrack in the last half of 1984.

For full factory automation, equipment reliability is of paramount importance because of the in-line configuration of automatic systems. At small fabs, where equipment redundancy is not possible, equipment malfunctions will seriously impede the work flow. Even at larger fabs with equipment redundancy, the malfunction of one piece of equipment in an island will reduce the throughput of the fab. In these cases, MTTR (mean time to repair) and MTBF (mean time between failures) become important parameters for the balancing of line throughputs. DATAQUEST believes that semiconductor manufacturers will demand specifications for MTTR and MTBF and will demand equipment uptime guarantees from equipment vendors in order to drive the industry toward the reliability needed for factory automation.

The development of CAM in Japan has proceeded differently than in North America. CAM systems have been developed in-house; thus, there is little standardization. Some of the more obvious characteristics of these systems are the use of bar code readers in place of terminals for logging material transfers, and the use of more complete communication links between processing equipment and computers. However, DATAQUEST sees no indication that Japanese semiconductor companies are significantly ahead of U.S. companies in the use of hard automation in fabrication. The higher yields of the Japanese companies are probably due to better analysis of problems, better discipline of operators, increased drive for quality, and shorter throughput times.

MARKET DATA

DATAQUEST estimates that total 1984 sales of CAM hardware and software systems for semiconductor fabrication in the United States and Europe will reach $40 million. We expect the size of this market to expand more rapidly than the overall rate of increase for semiconductor equipment sales. Many fab areas that are currently in operation without adequate CAM support will purchase systems to install in their operating fabs. In addition, plant expansions and start-ups will implement CAM systems on an increasing percentage basis. As more users become educated on the use of CAM capabilities, the requirement for computing power and additional services will grow. Table 2 presents our estimates of U.S. and European sales of CAM systems for 1983 through 1988.

Table 3 gives the sales history of companies supplying CAM systems for semiconductor manufacturing. All sales dollars are for combined hardware and software. BTU/Bruce, Consilium, and IP Sharp are third-party software houses and do not vend hardware. To equalize these companies for actual semiconductor-related revenue, 50 percent of sales must be subtracted. Sales are expected to increase 233 percent in 1984 over 1983, due to the number of new fabs being constructed and the recognition by the user market that CAM systems are needed to run a fab of any significant size.

Two companies not shown on Table 3 are Enhansys and BBN Research, which specialize in analysis programs. These programs can be purchased as part of the system offered by the system suppliers shown in Table 3, or they can be bought separately and run on off-the-shelf computers.

Robert McGeary

Table 2

ESTIMATED U.S. AND EUROPEAN SALES OF CAM SYSTEMS
(Millions of Dollars)

	1983	1984	1985	1986	1987	1988	CAGR (1983-1988)
Sales	$12.0	$40.0	$55.0	$80.0	$110.0	$160.0	67.9%

Table 3

CAM SYSTEMS SALES
(Millions of Dollars)

Company	1981	1982	1983	1984
BTU/Bruce			$ 1.0	$ 2.0
Consilium		$2.0	4.0	13.0
CTX		0.5	1.0	4.0
Hewlett-Packard	$4.0	4.0	4.0	11.0
IP Sharp		2.0	2.0	10.0
Total	$4.0	$8.5	$12.0	$40.0

Source: DATAQUEST
August 1984

September

September Newsletters

The following is a list of material in this section:

- The Automotive Semiconductor Market: The Race Continues
- High-Performance Silicon: The Next Generation Emerges
- Intel Committed To CMOS

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: September

THE AUTOMOTIVE SEMICONDUCTOR MARKET: THE RACE CONTINUES

INTRODUCTION

The requirements are tough and the demands are high, but today's auto industry continues its push for sophisticated electronics in state-of-the-art vehicles. Once dependent on sleek styling and faster speeds to sell their cars, auto manufacturers have now turned to the semiconductor industry for technology that will enhance their products and positions in a highly competitive marketplace.

This push by the auto industry represents a significant market for semiconductor manufacturers. In the past, despite slumping auto sales, the auto semiconductor market grew significantly because content per vehicle was on the rise. Today, however, due both to the increased use of semiconductors in automobiles and to an outlook for continued growth in U.S. auto sales, DATAQUEST believes that U.S automotive and light-truck semiconductor consumption will be $671 million in 1984, expanding to $1,156 million in 1989.

THE FIRST WAVE OF AUTO ELECTRONICS

As shown in Table 1, DATAQUEST estimates that the average semiconductor content in U.S. cars made a significant jump from $9.70 in 1978 to $40.60 in 1982. This dramatic growth in content drove the upswing in the overall auto semiconductor market despite the simultaneous decline in U.S. auto factory sales (see Table 2).

Foreign competition and federal agencies exerted severe pressure on U.S. manufacturers, forcing advances in fuel efficiency, exhaust emission control, safety, and vehicle downsizing. Since meeting emission standards while increasing fuel economy were goals that were largely at odds with each other, manufacturers turned to innovative design and engineering techniques using ICs to meet their goals. Similarly, advances were made in digital entertainment technology. Table 3 illustrates these increases as percentages of automobile unit shipments. Success in these areas opened the door for solid-state electronics in today's automobiles.

Table 1

SEMICONDUCTOR VALUE--AVERAGE U.S. VEHICLE

	1978	1982	1983	1984	1989
Auto	$9.70	$40.60	$51.60	$65.50	$105.00
Truck	$6.20	$26.00	$36.12	$49.13	$ 85.00

Source: DATAQUEST
September 1984

Table 2

U.S. FACTORY SALES
(Millions of Units)

	1978	1982	1983	1984	1989
Auto	9.5	5.8	6.8	8.0	8.5
Truck	3.7	2.2	2.7	3.0	3.1

Table 3

U.S. AUTOMOBILE FACTORY-INSTALLED ELECTRONIC EQUIPMENT
(Percent of Auto Unit Shipments)

	1980	1983
Entertainment		
Electronically Tuned Radio	5.4%	29.4%
Engine Electronics		
Fuel Injection	0.7%	25.6%
Feedback Carburetor	9.4%	55.4%
Antiknock	0.9%	5.0%
Idle Control	5.4%	39.3%
Spark Timing	5.4%	78.4%

Source: Ward's Automotive
DATAQUEST
September 1984

THE SECOND GENERATION OF AUTO SEMICONDUCTOR CONSUMPTION

The Auto Market: The Forces at Work

At present, 1984 is a good year for the auto industry. Table 2 reflects the recovery of U.S. factory sales since the lean years of the recession. An upswing began in 1983 that by all indications will move through 1984 and 1985. At the same time, U.S. market share is recovering from the intense competition of the early 1980s, when foreign auto manufacturers captured 27 percent of the U.S. market.

Overall, as a mature industry, the market will experience modest growth throughout the last half of the 1980s. The forecast of 1989 unit auto sales considers the following:

- There is great potential for catch-up buying. In the few years preceding 1983, auto industry analysts estimated that sales of motor vehicles were 14 million units below an average trend line. In 1983, the average age of cars on the road exceeded a 1982 peak of 7.2 years. That number is still rising.

- Demographic trends indicate a long-term aging of the U.S. population. A mature population increases the number of potential drivers and car owners and may also positively affect disposable income and consumer spending.

- As overall fuel efficiency and prices improve, consumers are purchasing larger cars with more options. These options play a considerable part in determining sales prices. The overall price of new cars in the United States is increasing due to both the rising number of options and to inflation.

  In the long run, this trend toward higher prices positively affects new auto sales. Higher prices tend to drive up the market value of used cars, which, in turn, increases trade-ins for new autos. In addition, higher valuations on used cars can also be realized on the open market, thus acting as a catalyst for consumers to sell and then purchase new autos directly.

- Auto manufacturers are taking great strides in automated design and manufacturing. By 1989, auto factory capacity will well exceed 8 million autos per year--a feat that is difficult to achieve in today's factories.

New Growth in Electronic Applications

The increase in average semiconductor content from $51.60 in 1983 to an estimated $105.00 in 1989 reflects the growing use of semiconductors in existing automotive technology and the use of ICs in new areas. These new functional areas are detailed, along with engine and entertainment electronics, in Figure 1, which graphically depicts the automobile of today and tomorrow. Table 4 breaks down these areas into the percentages of total semiconductor value per vehicle. DATAQUEST believes that growth in automotive semiconductor use has, to date, been fueled by entertainment and engine electronics. While new applications may be realized in these areas, we believe that future growth in the auto semiconductor market will largely be due to advances in body electronics and driver information features.

Body electronics experienced its first surge of growth between 1982 and 1984. We believe that as a percentage of the total, continued growth in this area can be expected due to innovations like voice-controlled trunks, automatic headlight adjustment, and antiskid braking.

Previously, cost, demand, and technology limitations inhibited the overall expected growth in driver information features (although one area, digital clocks, grew significantly). Now that setbacks have been overcome, DATAQUEST believes that driver information will be the fastest-growing segment between 1984 and 1989 with a compound annual growth rate of 30.5 percent in dollars per vehicle. Key applications include trip and navigation computers, all types of digital gauges, and voice warning systems.

Table 4

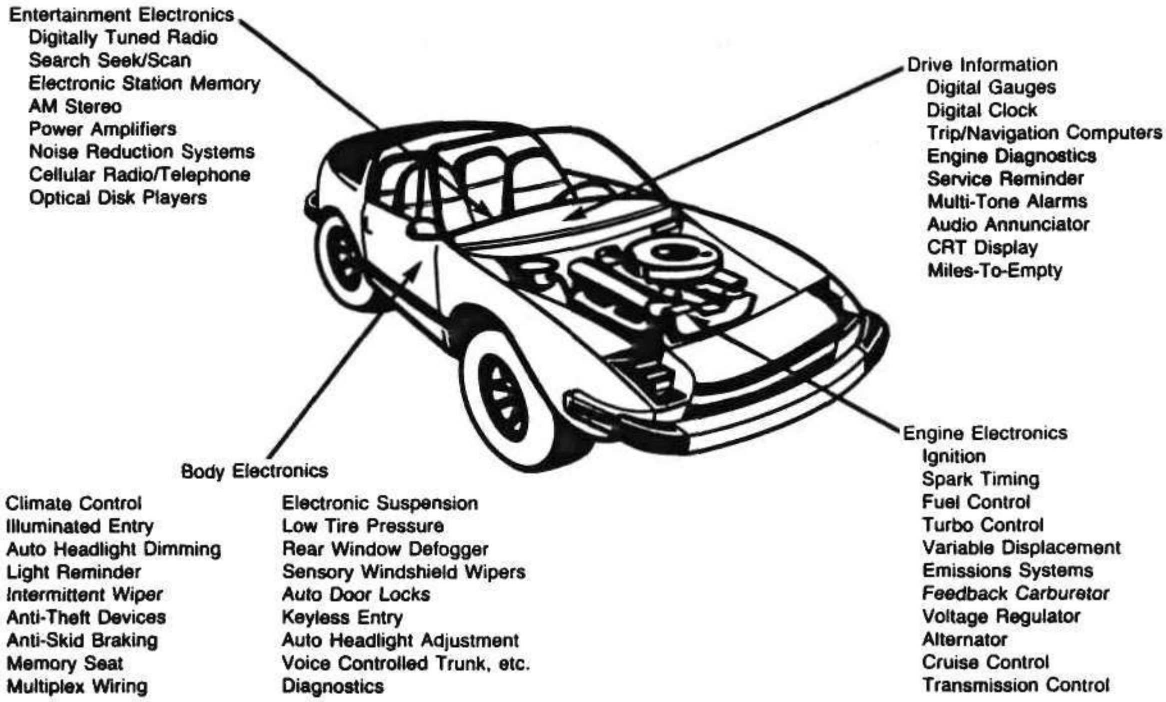
AUTOMOTIVE SEMICONDUCTOR CONTENT BY FUNCTIONAL CATEGORY
(Percent of Total Semiconductor Value)

	1978	1982	1983	1984	1989
Entertainment Electronics	26.8%	13.1%	14.1%	15.3%	13.9%
Body Electronics	13.4%	9.1%	9.8%	10.5%	11.0%
Driver Information	0.0%	7.1%	6.6%	6.4%	15.0%
Engine Electronics	59.8%	70.7%	69.6%	67.8%	60.1%
	100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
September 1984

Figure 1

ELECTRONICS IN PRESENT AND FUTURE AUTOMOBILES



Source: DATAQUEST

CONCLUSIONS

Overall, our 1989 automotive semiconductor consumption forecast is driven by ambitious opportunity in all areas, including:

- Continued growth in U.S. new vehicle factory sales
- Increased factory installation of already existing systems and applications
- Development of electronic automotive technology in all functional areas and accompanying increases in their factory installations
- Increased demand for semiconductor-intensive options, which is a function of the trend toward larger cars in the U.S. auto sales mix

As a mature industry, U.S. auto manufacturers have been rather atypical semiconductor end users. Most end users exist in a marketplace where intense competition has always been based on advantages in leading-edge electronics. For the auto industry, this kind of competition is relatively new, but the commitment to electronics and to working with the semiconductor industry has been established. We believe that such an effort can only bring successful innovation and prosperity to both players.

Anthea C. Stratigos
Gail Kelton-Fogg

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: September

HIGH-PERFORMANCE SILICON: THE NEXT GENERATION EMERGES

SUMMARY

The semiconductor industry can develop high-performance VLSI circuits faster than equipment manufacturers can use them effectively. Until IBM announced the PC/AT (for Advanced Technology), the Intel 80286 16-bit microprocessor was one of these circuits. IBM's announcement, however, heralds the beginning of a new generation of microprocessor-based systems. Memory management in microprocessor systems is an idea whose time has come. MPUs with memory management capability have been available since 1980 but have largely been ignored. DATAQUEST believes that products with memory management capability from all manufacturers will receive more attention. We believe that the concept will gain popularity because there will be a rush of IBM competitors designing equipment with similar or better features in an attempt to defend their meager market shares against IBM's new offering.

AVAILABILITY--THE CRITICAL ISSUE

DATAQUEST does not expect availability of the 80286 to be a problem in the industry. Volume shipments of the 80286, as shown in Table 1, began in the second quarter of 1983 and have grown rapidly. Intel is presently the only supplier, but AMD and Siemens both have a second-source license to manufacture and market the part. AMD expects to have the new chip in volume production by the second quarter of 1985. In addition, IBM has a license to manufacture the 80286 for its own consumption. Intel is also negotiating with a major Japanese supplier.

According to a company spokesman, Intel will ship "multiple millions" of the 80286 next year. In 1984, industry production of the 80286 will be 20 times greater than in 1983. Next year, the industry production is expected to increase tenfold.

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

Table 1

ESTIMATED INDUSTRY SHIPMENTS OF 80286 AND ALL 16-BIT MPUs
(Thousands of Units)

Shipments	1983	1984	1985
80286	13	300	3,000
All 16-Bit MPUs	7,138	14,230	27,030

Source: DATAQUEST
September 1984

There are still painful memories of the parts shortage problems brought on by the recovery, especially the severe shortage of Intel's 80186 during 1983. Speculation was rampant then that the shortage was caused by IBM's making large purchases of the 80186 for a future product. Not true. In fact, IBM appears to have leapfrogged the 80186. However, we believe that this will not affect availability of the 80186. Many personal computer makers were attempting to outdo IBM in the technology race by using the 80186. Even though they will now scramble to retrofit their designs with the 80286, they represent a small percentage of 80186 applications. Most of the other 80186 design commitments are in products that are not affected by IBM's recent move.

Even though we do not anticipate an availability problem, we do encourage close user-vendor relationships. Consequently, we recommend that companies contemplating use of the 80286 notify their selected vendors six to twelve months prior to ordering.

THE 80286--THE HEART OF THE PC/AT

The 80286 is a member of Intel's high-performance microprocessor family, which includes the 8088, the 8086, the 432, and the future 80386. Although the part is available in 6-, 8,- and 10-MHz clock speeds, IBM has chosen the 6-MHz version for its new computer. IBM claims that the PC/AT operates two to three times faster than the PC/XT. DATAQUEST's analysis, presented in Table 2, shows that the 80286 at 6 MHz is capable of operating six times faster than the 8088 operating at 4.77 MHz in the present PC/XT.

Table 2

EXECUTION TIME OF VARIOUS 8086 COMPATIBLE MPUs
(Time in Milliseconds)

	8088 4.77 MHz (msec)	8088 5 MHz (msec)	8088 8 MHz (msec)	8086 5 MHz (msec)	8086 8 MHz (msec)	8086 10 MHz (msec)	80286 6 MHz (msec)	80286 8 MHz (msec)	80286 10 MHz (msec)
Bubble Sort	3.824	3.648	2.280	1.824	1.140	0.912	0.620	0.465	0.372
Block Translation	3.119	2.976	1.860	1.488	0.930	0.744	0.552	0.414	0.331
XY Transformation	4,699.4	4,484.0	2,802.0	2,242.0	1,401.0	1,121.0	380.0	285.0	228.0
Parts Inspection	2,797.5	2,668.0	1,668.0	1,334.0	834.0	667.0	291.7	219.7	175.0
Relative Performance	1.00	1.05	1.68	2.10	3.35	4.19	6.17	8.22	10.28

Source: Intel Corporation
DATAQUEST
September 1984

In addition to the CPU functions, the 80286 contains four levels of protection, virtual memory capability, and memory management. The chip can directly address 16 Mbytes, and each task can have up to 1 billion bytes of address space because of the virtual address translation.

All product family members share a common architecture as well as compatible instructions and data types. Therefore, all application software written for the 8088 and 8086 will run on the 80286.

The 80286 has 130,000 active devices compared to approximately 29,000 devices for the 8086. The die was more than 108,000 square mils when it was introduced in 1982, but it was designed to be shrunk to 73,000 square mils.

LIMITS OF COMPATIBILITY

Higher performance is often achieved at the expense of compatibility with the past. Although software written for the earlier 8088 and 8086 is generally upward compatible with the 80286, some changes are needed to realize the full power of the new device. Application programs operating at the lowest privilege level are the easiest to convert and may not require any changes. Most of the required software changes are in the operating system. The changes are due to the added memory protection features and to the enhancements in the addressing structure to support virtual memory. The number of changes depends on the type of operating system, its internal structure, and the functions it performs. If the operating system must isolate tasks from each other and protect itself from less trusted tasks, then more source code changes are required.

Software changes are obviously needed to take advantage of the multi-tasking and multiuser features of the 80286. Most of the changes to the operating system relate to initialization and the interrupt table.

There are also some new instructions available to programmers. The 80186 had new instructions for fast index calculation, subroutine linkage, I/O data transfers, and program error detection. The 80286 includes those instructions and adds others for controlling its protection hardware.

The 80286 has two operating modes. One is called the real address mode and the other is called the protected virtual address mode, (usually referred to as the protected mode). In the real address mode, the 80286 "looks" just like the 8086 in terms of both address structure software development. In this mode, it is completely binary compatible with the 8086, but some software may require modification because of the transition from an 8-bit to a 16-bit data transfer.

ANALYSIS

DATAQUEST believes that a time lag of 3 to 5 years occurs between the introduction of a VLSI component and high-volume usage of the device. This is true for 16-bit microprocessors, which were introduced approximately 5 years ago and are now becoming a significant part of the total microprocessor market. The introduction of the PC/AT makes IBM the latest in a small group of personal computer manufacturers to use full 16-bit microprocessors. In spite of recent publicity about new 32-bit microprocessors, we believe that 16-bit microprocessors are about to enter the rapid growth phase of their product life cycle.

The advanced features available with the current generation of microprocessors will now receive more attention from potential designers. Products with features such as memory management, virtual memory, and instruction pipelining will become more widely used in many applications. In addition to Intel, other manufacturers of such products will benefit from this increased awareness. This greater interest will be caused by anticipation of declining prices due to higher production volumes, by more third-party software, and by increased user experience with advanced minicomputer-like concepts. Much to the delight of manufacturers of high-performance 16-bit microprocessors, the volume market has finally arrived.

Mel Thomsen

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: September

INTEL COMMITTED TO CMOS

SUMMARY

Intel emphasized its commitment to CMOS technology at a financial analysts' meeting held July 26, 1984, at the Palo Alto Hyatt, Palo Alto, California.

Andy Grove, President and Chief Operating Officer (COO) of Intel, was the first of three speakers introduced by Gordon Moore, Chairman and CEO. Mr. Grove was followed by Jack Carsten, Senior Vice President and General Manager, Components Group, and Ken Fine, General Manager, Microprocessor Division. The following key points were made during the meeting:

- Microcontrollers are currently the pacesetters for Intel. MCUs are the most in demand and the most available of Intel's products.
- Intel's memory output is lagging behind the market. To fuel the growth in MCU output, the memory area has been used as a capacity buffer.
- Intel will be phasing out all bipolar manufacturing by the end of 1985.
- Intel will be winding down its NMOS production and hopes to be out of the NMOS DRAM market by mid-1985.
- Intel's 256K CHMOS DRAM, which was announced in June, is the first 256K CMOS DRAM available. Intel does not expect to see a comparable product on the market for 18 to 24 months.
- Intel's largest fab facility, Fab 7, in Albuquerque, New Mexico, has begun processing 6-inch (150-mm) wafers. A production ramp of EPROMs and MCUs was begun in April 1984. Process problems caused a delay of the first volume output until July 1984. Yields have recently improved and production is now expected to double each month until October.

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- The CHMOS 80386 microprocessor is Intel's highest-priority MPU. This part will be introduced in 1985 and will have full binary compatibility with the 80286 and with all peripheral components. The 80386 will give two to three times the performance of the 80286 in an identical system and with the same memory management.

BUSINESS UPDATE

Intel's shipments are increasing at a rate of 10 percent per quarter, paced by factory production capabilities. Andy Grove explained that Intel expects this trend to continue during the third quarter. The company currently has a six-month backlog and is taking bookings for 1985.

Overall Trends

- Memory production capacity (especially RAM) is increasing.

- There is price pressure in the commodity area.

- Supply limitations in the value-added product areas continue. These value-added product areas include state-of-the-art memories as well as logic and memory combinations.

Trends by End Market

- In personal computer (PC) and related areas, the uncertainty about the next generation, combined with the enormous competition and weaknesses of small companies, have resulted in a somewhat volatile market.

- Other office equipment has been relatively insulated from the PC market and has exhibited continued growth in semiconductor use, although the rate of growth seems to be slowing.

- In the industrial, telecommunications, and military markets, growth has continued at approximately the same rate as last year.

Trends by Product

- Microcontrollers are the most in demand and the most available of Intel's products. Design-ins are at historically high levels, and the pervasiveness and breadth of the company's product line have rapidly increased.

- Memory capacity has been constrained somewhat because of the growth of MCUs.

- In the systems area, board business has been strong, but Intel's integrated systems have been delayed, since design times were longer than expected. Intel's estimates for this area have been adjusted down.

Trends by Geography

- Japan is Intel's weakest geographic market.
- The U.S. and ROW markets are good.
- The European market is good and has been improving at a steady rate, although it is still not as stable as the U.S. market.

CAPACITY AND TECHNOLOGY TRENDS

Jack Carsten began his talk by presenting DATAQUEST figures showing the projected growth of the CMOS DRAM market to $3 billion by 1988. By 1989, the CMOS IC market will be bigger than the entire IC market today. Intel is planning to increase CMOS as a percent of total revenue from 12 percent in 1984 to 50 percent in 1986.

Mr. Carsten then announced that Intel would be phasing out all bipolar manufacturing by the end of next year. DATAQUEST estimates that in 1983, bipolar memory and logic accounted for $60 million of revenue, or only 8 percent of Intel's total semiconductor revenue.

Mr. Carsten also voiced an increasing commitment to CMOS. Early CMOS devices were slower than HMOS devices but required less power. Intel's CHMOS, however, is as fast as HMOS, with power dissipation an order of magnitude lower. CHMOS will be built on the existing HMOS technology. N-well will be available with double-poly and advanced thin dielectrics, and P-well will be available with both double-metal and double-poly.

Intel's flagship product is the 51C256, a 256K CHMOS DRAM announced in June. It is the world's first 256K CMOS DRAM, and Intel does not expect to see a comparable product on the market for 18 to 24 months. In addition, Intel is still the largest supplier of 64K CMOS DRAMs. Intel began volume shipments of that part in March. The 51C256 has 230-microampere level standby power and plastic packaging. Access times are as low as 60 ns, using Ripplemode, or 120 ns in NMOS-type applications. Intel has had problems with plastic packaging in the past and is especially pleased to have resolved those problems.

More than 20 new products will be introduced by the end of 1984, all using the CHMOS technology. These will include a 64K CMOS EPROM and a 16K high-speed CMOS SRAM, which is now being sampled. CMOS versions of the 8086 and 8088 have not yet been introduced by Intel, but Harris Corporation has introduced and begun to manufacture them. Under the terms of a July 1984 technology exchange agreement between Intel and Harris, CMOS versions of Intel's N-channel MOS MPUs are being developed by Harris for production by both Harris and Intel.

Intel is slowing its production of NMOS products and hopes to be out of the NMOS DRAM market by mid-1985. Support of mature designs will be continued primarily through die contracting, since the demand for Intel's mature parts is growing, and some second sources have left the market. Other semiconductor manufacturers are licensed to fabricate the devices in die form, with Intel doing the assembly and testing. Intel will fully qualify die contractors and will sell and fully warrant all parts. There are presently three suppliers qualified, and Intel is discussing the possibility of some contracting with Matra-Harris. By the end of the year, die contracting should account for 5 percent of Intel's sales.

In discussing the capacity outlook, Mr. Carsten stated that production of new logic and memory products has been ramping up at unprecedented rates. VLSI products consume a disproportionate amount of wafer fab capacity, since they can take up to 10 times as much silicon as mature products, and they require a greater product complexity, as in CHMOS. Therefore, Intel will be expanding its existing capacity and will be adding new capacity, in addition to supporting mature designs through die contracting.

Intel will spend $350 million on capital additions in 1984 and expects to spend more than that in 1985.

Mr. Carsten finished his talk by discussing Intel's fab facilities. His remarks can be summarized as follows:

- Fab 5, in Portland, Oregon, is now processing and will continue to process largely 100-mm wafers.

- Part of Fab 6, in Chandler, Arizona, will be converted to 150-mm wafers by late 1985, but most processing will be of 100-mm wafers.

- Fab 7 is Intel's largest fab, located in Albuquerque, New Mexico. It began a production ramp in April 1984, producing EPROMs and MCUs. The fab processes 150-mm wafers and uses 100 percent wafer steppers and an all new equipment configuration. The plant is operating 168 hours a week. Intel is debugging all new 6-inch wafer processing equipment, and process problems caused a delay of the first volume output until July 1984. Yields have recently improved and production is now expected to double each month until October.

- Fab 8 is being constructed in Jerusalem, Israel. It is scheduled to begin processing of 150-mm wafers in mid-1985. The clean rooms are complete and operational and equipment is now being installed.

- Fab 9 is a second Albuquerque fab that is being built with a different construction philosophy. A large shell is being built that will house four modules. Construction has begun on the first module, which is scheduled to begin production in early 1986. This module will process 150-mm wafers. The other modules will be completed as the market dictates.

With these changes in fab capacity, approximately one-half of Intel's capacity will be in 150-mm wafers by 1986. These wafers have approximately 2.2 times the area of 100-mm wafers. By combining this increase in wafer size with die shrinks, Intel has been able to get 3 to 4 times as many dice per wafer. Mr. Carsten presented the following table to illustrate the reduction of component costs through preplanned shrinks. The example shown is the 8051 MCU.

Technology	HMOS	HMOS II	HMOS III
Edge Dimension (mils)	235	204	180
Relative Area	100%	75%	59%
Introduced	1981	1982	1984

MICROPROCESSOR EVOLUTION

Ken Fine introduced his talk by presenting the following information on the evolution of the 8086 microprocessor family:

Year	Microprocessor	Function
1974/75	8080/8085	Logic replacement
1978/79	8086/8088	Reprogrammable applications
1982	80186	Reprogrammable applications
1982	80286	Multitasking
1985	80386	Multitasking

He also stated that, according to DATAQUEST, the 8086 share of the 16-bit market has quadrupled in the last four years. Intel has three to four times the market share of the nearest competitor and has a second source in every major geographical area in the world.

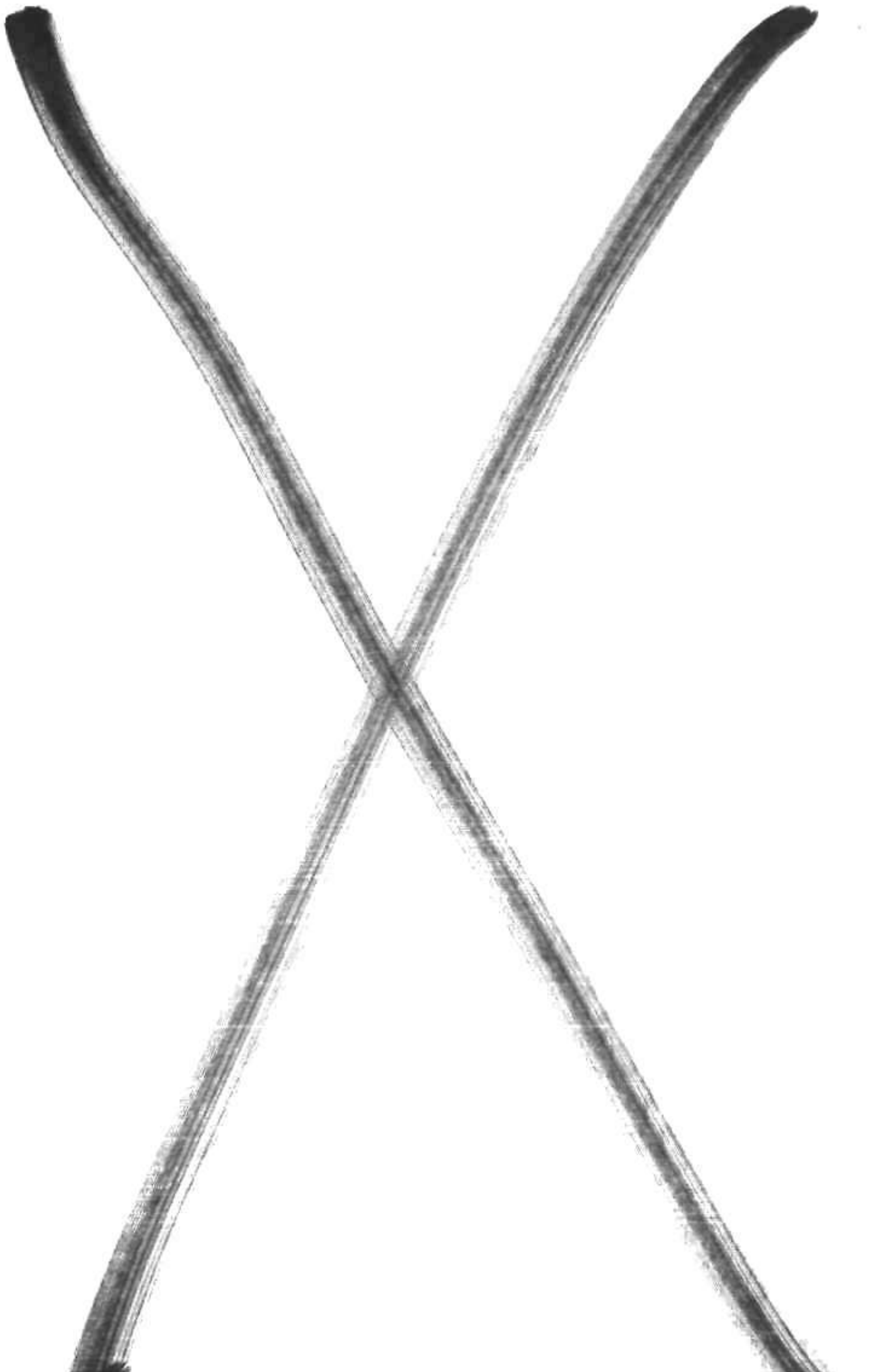
Shipments of the 80186 have had the steepest ramping rate of any Intel product. From 1983 to 1984, shipments increased by a factor of 14, and from 1984 to 1985, shipments are expected to double.

The time from design to production of the 80286 was one year longer than for the 80186, since this part incorporates on-board protection and therefore required some software changes. Shipments of the 80286 are expected to increase by a factor of 20 from 1983 to 1984, and by a factor of 10 from 1984 to 1985. Intel anticipates that this part will be accepted in high-end applications by the end of 1985.

Mr. Fine described the 80386 as Intel's highest-priority MPU. It will be introduced in 1985 and will have full binary compatibility with the 80286 and with all peripheral components (no software changes will be required). It will have two to three times the system performance of the 80286, in an identical system and with the same memory management, and it will be a CHMOS part.

Mr. Fine finished his presentation by describing some 80286 product enhancements, including a companion DRAM controller, and math, video, communication, and enhanced I/O coprocessors.

Susan Scibetta
Barbara Van



October Newsletters

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

Nielsen Dataquest

RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: October

LSI LOGIC OPENS NEW TEST AND ASSEMBLY PLANT

LSI Logic, maker of HCMOS application-specific ICs (ASICs) and supplier of design/simulation software, recently opened a 74,000-square-foot test and assembly facility in Fremont, California. The highly automated plant, located at the edge of Silicon Valley, reinforces the trend among leading-edge U.S. semiconductor suppliers toward onshore construction of back-end processing facilities.

BACKGROUND

The high-pin-count requirements of ASIC suppliers like LSI Logic demand sophisticated packaging technologies and high-speed functional testing. Offshore assembly and test facilities, such as those in Malaysia and the Philippines, have satisfied demands of previous-generation semiconductor devices. However, automation and turnaround requirements of the ASIC market have negated the benefits of historically inexpensive labor. Moreover, the current political climate of these offshore areas also presents a significant financial exposure for U.S.-based semiconductor suppliers.

INVESTMENT

The clean-room environments, automation, and complex, high-speed testing of LSI Logic's ASIC product line translate into a significant capital investment. The company claims that its new Fremont facility represents more than $40 million in building and equipment expenditures. DATAQUEST believes that this level of investment for onshore test and assembly facilities will become more commonplace as the trend toward automation continues, and that the capital expenditures associated with high-pin-count, back-end processing will rival wafer fab investments.

CAPACITY

LSI Logic's ASIC product line is focused on pin counts of 68 leads and above. The new facility can assemble and test packages from small DIPs to 238-lead pin grids. The automated bonding equipment has sophisticated pattern recognition abilities and accurately bonds up to 6 leads per second. When the Fremont facility is in full production, it will provide more than 2 million high-pin-count packages each month. The majority of the shipments will be in plastic epoxy, but the factory also supports the more expensive ceramic devices. Using a simple estimate of $10 for the average selling price of ASIC products, and assuming full production capacity, LSI Logic's new Fremont facility could produce $240 million in revenue annually.

Under construction in the adjoining lot is LSI Logic's new wafer fabrication facility. The highly automated, 5-inch wafer fab is scheduled for completion in the second half of 1985; it will produce sub-2-micron, high-speed CMOS ASIC devices. This will give the company very efficient, fast turnaround manufacturing without the need for long distance product movement.

ANALYSIS

DATAQUEST believes that LSI Logic's new Fremont facility is a significant step toward supporting the needs of the ASIC user. It reinforces the trend toward total onshore manufacturing by U.S. semiconductor suppliers. The capital investment required for this type of facility will put additional pressure on operating margins, but the long-term benefits for cost reduction and linearity certainly justify the risk.

Ken McKenzie
Katy Guill

SIS Code: 1984-1985 Newsletters: October

SILICON COMPILERS INC. ANNOUNCES NEW ASIC DESIGN SYSTEM

Silicon Compilers Inc., of Los Gatos, California, announced its new ASIC design system called Genesil this week. DATAQUEST believes that this electronic design automation (EDA) tool marks the beginning of a new generation of high-level design systems that allow system architects to do chip design. We believe that Genesil is one step beyond cell compilers and standard cell design and one step closer to true silicon compilers, which are being so widely discussed in the academic community.

BACKGROUND

A silicon compiler builds only the functions needed, strives for optimum implementation, and allows minimum interconnect wiring. A system engineer can use Silicon Compilers' Genesil to design a functional input in high-level terms. The initial design is a two-phase process that allows the user to do some architectural exploration with on-line feedback. Genesil allows interactive design with feedback on size, speed, and power estimates. At the outset, the user chooses a process that can be changed later; the system can then modify its files. Genesil generates three models for the user: topology, timing analysis, and functional simulation. After the chip is designed to the user's satisfaction, a tape is sent to the foundry.

ADVANTAGES

The major advantage in designing a VLSI chip with a silicon compiler is faster time to market. Silicon Compilers Inc. designed the MicroVAX chip for Digital Equipment in five months from start to tape using Genesil. A similar chip might have taken three years with conventional methods.

Another advantage is that the efficient use of silicon makes the chips less costly to manufacture. It is possible that this faster design time and lower overall cost could cause the ASIC market to grow faster than the current DATAQUEST estimate of $14.9 billion by 1990.

GENESIL DEVELOPMENT

Some of the milestones in Genesil's development are:

- July 1983--Initial trial of concepts and refinement of preproduction tools
- July 1984--Generation of design tools
- Third quarter 1984--Alpha site testing
- Fourth quarter 1984--Production release

The Genesil silicon development system uses the following hardware:

- VAX 11/750
- 4-Mbyte real memory
- 450-Mbyte Winchester disk
- 1,600-bpi, 9-track magnetic tape
- System console (up to four)

While developing, testing, and refining the Genesil system, Silicon Compilers Inc. completed the following projects:

- The VAX 1 chip for Digital Equipment Corporation
- An Ethernet controller for Seeq Technology
- The Graphics Raster Op Controller for Sun Microsystems

Silicon Compilers will be shipping its first systems beginning in October 1984. A CMOS function set will be available during first quarter 1985.

DATAQUEST COMMENT

DATAQUEST believes that other EDA suppliers are actively working on EDA tools that are similar in scope to Genesil. Thus, we see Genesil as leading a new wave of more sophisticated design tools for ASICs.

Katy Guill
Andy Prophet

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: October

RECORD SHIPMENTS OF MCUs AND MPUs IN FIRST QUARTER 1984--
100 MILLION UNITS SHIPPED

SUMMARY

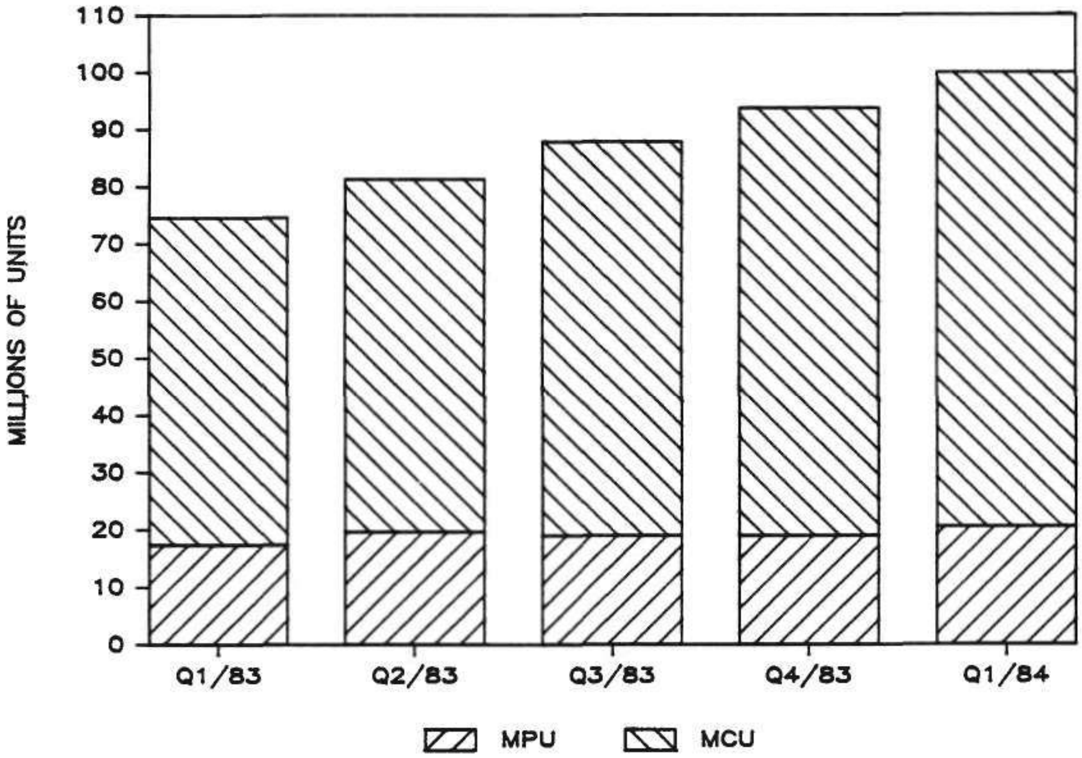
Total microcontroller and microprocessor unit growth was 6.5 percent from the fourth quarter of 1983 to the first quarter of 1984, as approximately 100 million units were shipped. DATAQUEST believes that this growth can be attributed to:

- Pervasiveness in the technology
- High levels of design-ins
- New process and advanced product developments in CMOS
- Yield improvements
- Increased production output
- Signs of expanded microcontroller production at the expense of other semiconductor devices
- Stable prices

Figure 1 shows the quarterly unit growth for MCUs and MPUs from Q1/83 to Q1/84.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT GROWTH Q1/83 TO Q1/84



Source: DATAQUEST

Table 1 shows the change from fourth quarter 1983 to first quarter 1984 of total microcontroller unit shipments.

- Larger bit size microcontroller device quarter-to-quarter unit growth rates are increasing.

- The lower density market segment maintains more than 50 percent of the market share.

Table 1

ESTIMATED WORLDWIDE MICROCONTROLLER SHIPMENTS FOR FOURTH QUARTER 1983 AND FIRST QUARTER 1984 (Thousands of Units)

		Q4/1983		Q1/1984		
MCU		Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth from Q4 TO Q1
4-Bit		45758	61.2%	45905	57.5%	3.0%
8-Bit		29016	38.8	33958	42.5	17.0%
16-Bit		25	0.0	30	0.0	20.0%
	Total	74799	100.0%	79893	100.0%	6.8%

Table 2 shows the change from fourth quarter 1983 to first quarter 1984 of total microprocessor unit shipments. Shipments of 16-bit microprocessors are growing in volume because some 8-bit designs are performance-limited and customers are shifting to 16-bit microprocessors. Also, 16-bit microperipherals have become available within the past two years.

Table 2

ESTIMATED WORLDWIDE MICROPROCESSOR SHIPMENTS FOR FOURTH QUARTER 1983 AND FIRST QUARTER 1984 (Thousands of Units)

		Q4/1983		Q1/1984		
MPU		Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth from Q4 TO Q1
8-Bit		16969	89.5%	18139	88.6%	6.9%
16-Bit		1978	10.4	2320	11.3	17.3%
Others		26	0.1	21	0.1	-19.8%
	Total	18973	100.0%	20480	100.0%	7.9%

Table 3 shows the change from fourth quarter 1983 to first quarter 1984 of leading 8-bit microprocessors.

- Z80 is still the largest volume 8-bit microprocessor shipped today.
- First quarter 1984 does not include Commodore 650X, because it is 100 percent captive. Fourth quarter 1983 does include Commodore's 650X unit shipments.

Table 3

LEADING 8-BIT MICROPROCESSORS
(Thousands of Units)

Device		Q4/1983 Units	Q4/1983 Percent of Shipments	Q1/1984 Units	Q1/1984 Percent of Shipments	Percent Growth from Q4 to Q1
Z80		6610	39.0%	7024	38.7%	6.3%
8085		2815	16.6	3307	18.2	17.5%
8088		1436	8.4	1809	10.0	26.0%
650X		2135	12.6	1610	8.9	-24.6%
6802		1350	8.0	1370	7.6	1.5%
Others		2623	15.4	3019	16.6	15.1%
	Total	16969	100.0%	18139	100.0%	6.9%

CMOS Technology--the Talk of the Town

DATAQUEST believes that the performance of CMOS will further fuel micro market growth. DATAQUEST also believes that revenue from this technology could be as much as 50 percent of total micro revenue by 1988. Mature NMOS products have been sustained to support existing designs, and demand is still firm for these products.

Table 4 depicts market share by technology for 8-bit microcontroller and microprocessor devices from Q1/83 to Q1/84, and clearly shows the rapid growth of CMOS during this period. Recent CMOS MPUs are the 65C02, the 80C85, a CMOS Z80, and the 80C88.

Table 4

UNIT MARKET SHARE BY TECHNOLOGY FOR
8-BIT MICROCONTROLLERS AND 8-BIT MICROPROCESSORS
FROM FIRST QUARTER 1983 TO FIRST QUARTER 1984

Device	Tech	Q1/83	Q2/83	Q3/83	Q4/83	Q1/84
8-Bit MCU	CMOS	7.90%	8.60%	8.00%	9.80%	10.30%
8-Bit MCU	NMOS	92.10	91.40	92.00	90.20	89.70
Total		100.00%	100.00%	100.00%	100.00%	100.00%
8-Bit MPU	CMOS	4.90%	5.60%	7.20%	8.60%	10.40%
8-Bit MPU	NMOS	95.10	94.40	92.80	91.40	89.60
Total		100.00%	100.00%	100.00%	100.00%	100.00%

ADVANCED MICROPROCESSORS

During the first part of 1984, several companies announced dramatic new microprocessor products. Motorola announced its 32-bit microprocessor, the 68020. The chip contains about 200,000 transistors and has the approximate data processing capability of a lasge computer. Speed, power, and the ability to address more memory are the key benefits for users of the 32-bit device. The 68020 is object code compatible with the 68000, and has added features such as on-chip instruction cache and coprocessor interface.

National Semiconductor announced its 32-bit microprocessor last fall and received much attention. Intel's 32-bit entry, the 80386, and Zilog's 32-bit product, the Z80,000, will not be introduced until 1985; however, we believe that the performance and features of each product will still capture market share.

Intel's 80186 16-bit microprocessor unit shipments have had the steepest ramp of any product in the history of microprocessors. The company shipped 18,000 units in the second quarter of 1983, and 195,000 units in the first quarter of 1984. In less than one year, the 80186 has increased tenfold. The 80186 is a high-integration chip. It is an enhanced version of the 8086, due to its many support functions on-chip. Intel's 80286 is a performance-enhanced device. The 80286 is software-compatible with the 8086, 8088, 80186, and 80188. It integrates MMU on-chip, and is designed for multitasking applications such as high-performance PCs, multiuser business systems, office and industrial automation, and data communications. Second sourcing will be available in 1985 to assure availability.

Table 5 shows the percent changes in estimated shipments from Q4/83 to Q1/84 for second generation 16-bit microprocessors. The easy conversion from the 8086 to the 80186 and 80286 has created high growth rates in these 16-bit devices. Current lead times for 80186 and 80286 are 20 to 40 weeks.

Table 5

ESTIMATED SHIPMENTS FOR LEADING 16-BIT MICROPROCESSORS FROM FOURTH QUARTER 1983 TO FIRST QUARTER 1984 (Thousands of Units)

	Q4/1983		Q1/1984		
Device	Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth from Q4 to Q1
8086	752	58.5%	938	55.4%	24.7%
68000	296	23.0	363	21.5	22.6%
80186	70	5.4	195	11.5	178.60%
Z8000	122	9.5	124	7.3	1.6%
80286	12	0.9	40	2.4	233.3%
32016	35	2.7	32	1.9	-8.6%
Total	1287	100.0%	1692	100.0%	31.5%

GEOGRAPHIC MARKET SHARE

Table 6 depicts the percent changes in microcontroller and microprocessor geographic market shares from Q1/83 to Q1/84. It indicates that:

- United States manufacturers have lost substantial market share in micro devices.
- 16-bit microprocessors experienced the greatest shift in market share.

Table 6

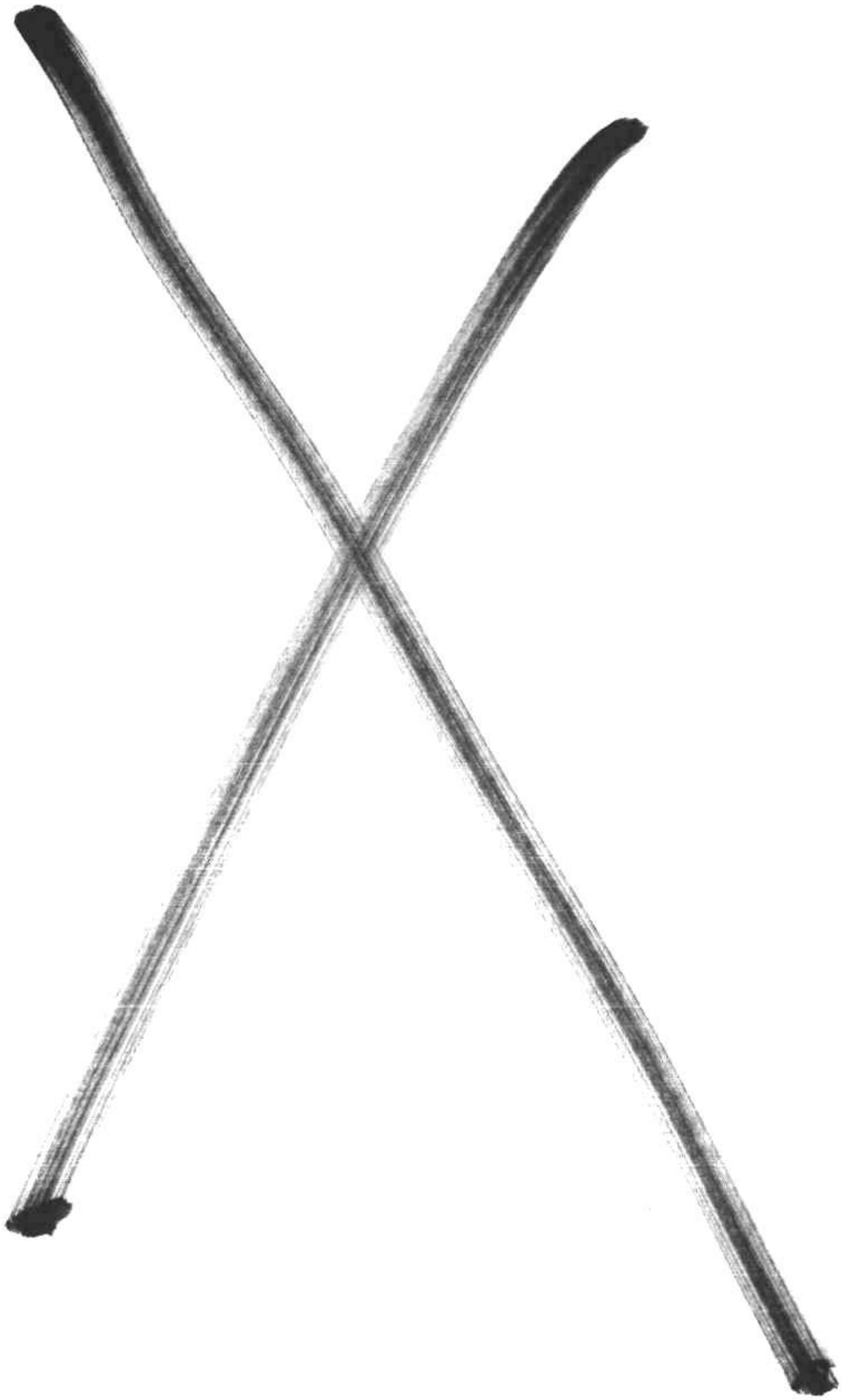
GEOGRAPHIC UNIT MARKET SHARE BY PRODUCT TYPE

	Region	Q1/83	Q2/83	Q3/83	Q4/83	Q1/84
4-Bit MCUs	United States	22.5%	22.2%	19.1%	18.0%	19.1%
	Japan	77.2	77.5	80.3	81.4	80.9
	Europe	0.3	0.3	0.6	0.6	0.0
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MCUs	United States	61.7%	58.7%	60.0%	58.9%	56.2%
	Japan	29.4	31.7	31.2	32.4	35.1
	Europe	8.9	9.6	8.8	8.7	8.7
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPUs	United States	67.9%	70.4%	66.0%	62.2%	60.3%
	Japan	28.3	25.0	28.0	31.4	33.4
	Europe	3.8	4.6	6.0	6.4	6.3
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
16-Bit MPUs	United States	86.4%	87.5%	83.2%	81.5%	73.8%
	Japan	11.8	10.6	12.9	15.1	21.0
	Europe	1.8	1.9	4.0	3.4	5.2
	Total	100.0%	100.0%	100.0%	100.0%	100.0%

CONCLUSION

In just the first quarter of 1984 manufacturers shipped MCU and MPU units equal to 40.5 percent of total 1983 microcontroller and microprocessor unit shipments. Overall micro shipments during the second quarter 1984 are expected to be higher than first quarter 1984. If this is the case, DATAQUEST expects that in 1984 close to 450 million units of microprocessors and microcontrollers will be shipped. Many of these micro devices will go into consumer applications, personal computers, office automation equipment, and telecommunication systems.

Janet Rey



November Newsletters

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

SIS Code: 1984-1985 Newsletters: November

AMD ANALYSTS' MEETING--
STAYING TOUGH

INTRODUCTION

Describing the semiconductor market as enjoying a respite from the boom of past months, Jerry Sanders, President of AMD, forecast two flat quarters. He attributed the softening in demand to inventory correction and the shakeout in the PC market. Speaking at the company's Analysts' Meeting in Palo Alto, California, on October 25, 1984, Mr. Sanders said that he expected many semiconductor purchasers to cancel backlogs and renegotiate contracts with their vendors.

CMOS PRODUCTS

Jim Downey, Senior Vice President, Operations, reiterated AMD's commitment to CMOS products. He explained that when device geometries reach the sub-2-micron level, CMOS becomes virtually essential. AMD currently has 29 CMOS devices in the development or early production stages.

CMOS Memories

Mr. Downey forecast that more than 50 percent of AMD's memory products would be CMOS by 1987. The company is currently prototyping a CMOS 256K DRAM and expects to introduce a 1-Mbit EPROM and a 256K ROM for production in fiscal 1986 (AMD's fiscal year begins in April).

AMD is currently in limited production with a 4Kx4 CMOS SRAM and expects to introduce an 8Kx8 device in the first quarter of 1985. Introduction of 16Kx4 and 64Kx1 CMOS SRAMs is expected in fiscal 1986.

CMOS Logic

AMD plans to introduce a number of CMOS telecommunication and data communication devices, as well as a CMOS version of the popular 8051 microcontroller. The company also announced its LL7000 CMOS gate array family.

BIPOLAR PRODUCTS

Despite the advances in CMOS capability, there are still some areas where bipolar technology is essential. The speed of bipolar ECL makes it the technology of choice for devices used in graphics and high-speed computation. AMD will introduce a 32-bit floating-point processor and a 16Kx8 bipolar PROM in the first quarter of 1985. The company is also introducing a family of ECL gate arrays. A bipolar microprocessor, the 29325, will be introduced before the end of the next fiscal year.

MICROPROCESSORS

AMD has seen a considerable decline in demand for the 8086/8088 microprocessors. The company is already sampling the 80186 and expects to be in production by the end of this year. AMD also expects to have limited production of the 80286 by the end of this year. Mr. Sanders expects 80286 demand to be even higher than the current optimistic forecasts.

CONCLUSIONS

As are most semiconductor companies, AMD is seeing a softening of prices for commodity products. However, prices for proprietary products still remain firm.

Steve Zelencik, Senior Vice President, Sales and Marketing, announced at the meeting that starting January 1, AMD will guarantee a 500-parts-per-million quality level for all its products for AC and DC electrical test over all temperature ranges. With its commitment to quality and an aggressive program of new product introductions, AMD seems well positioned to meet the current market situation.

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Barbara Van
Jean Page

Nielsen Dataquest RESEARCH BULLETIN

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INTEL ANALYSTS' MEETING

INTRODUCTION

The mood at the Intel Analysts' Meeting held in Palo Alto on October 24, 1984, reflected the softening in demand in the semiconductor marketplace. Describing current business conditions as "turbulent," Andrew S. Grove, President and COO, said that the business picture was, on balance, weaker than it had been three months ago. Intel expects the rate of revenue growth to decline over the next two quarters, although Mr. Grove specifically rejected the possibility of a decline in revenues.

PRICES

Commodity product prices have softened and are expected to continue to decline for the next two quarters. Prices for Intel's 8086 and 8088 microprocessor families and the 8051 microcontroller are expected to weaken as demand slows. The PC market shakeout has caused the slower growth rates for these products. Prices for the 80186 and the 80286 are expected to remain firm in the face of rapidly growing demand for these devices. Intel's CMOS DRAM products are commanding prices approximately twice those of NMOS DRAMs.

MEMORIES

Intel has no intention of being a commodity memory supplier. The company's strategy is to compete in high-margin niches of the memory market. Intel's shipments of EPROMs are currently capacity limited and are expected to remain so for the next two quarters.

Intel is seeing stronger orders for its CHMOS DRAM products. Prices are twice those of NMOS devices and the CHMOS products are expected to continue to command a premium. Although Intel has no competition in this area, CHMOS DRAMs represent only a small part of the company's total revenues.

MICROPROCESSORS

Demand for the 8086/8088 and 8051 families has declined significantly due to the turbulence of the PC market. These devices are expected to be readily available and prices are expected to weaken in the first half of 1985. Orders for the 80286 are extremely strong. Although shipments have increased rapidly throughout 1984, they will have to ramp up even more steeply in 1985 to satisfy orders. Intel expects substantial demand for this microprocessor because of its use in the recently announced IBM PC AT. Although orders for the 80186 are still growing rapidly, demand for this device is not as strong as that for the 80286.

DATA COMMUNICATIONS

A major portion of the meeting was devoted to a presentation on data communications networks, with emphasis on Intel's 82586 LAN coprocessor. Intel estimates that by 1988, 80 percent of PCs shipped will have on-board networking capability. David L. House, Vice President and General Manager, Microcomputer Group, described this as a new era of productivity. The PC revolution greatly enhanced personal productivity, and networking capability will offer similar improvements in organizational productivity.

CONCLUSIONS

Intel expects two flat quarters in the semiconductor industry as office automation and PC manufacturers work to adjust their inventories. The company sees no such order softening in other areas. Industrial, automotive, military, and telecommunications markets all show continued strength.

Start-up problems at Intel's Plant 7 in Albuquerque, New Mexico, are expected to continue to be a financial drain on the company until the second quarter of 1985. However, Intel expects to continue rapid expansion of its wafer fabrication capability. Capital expenditures for 1984 were $400 million and are expected to be about the same in 1985.

After weathering two quarters of inventory adjustment, and the associated softening of commodity prices, Intel expects the semiconductor industry to regain its momentum. Intel's book-to-bill ratio has been consistently higher than the industry average, and the increasing emphasis on value-added devices in Intel's product mix will help the company weather the next few months.

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Nielsen Dataquest RESEARCH NEWSLETTER

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MOS RAM SHIPMENTS
FIRST AND SECOND QUARTERS--1984

SUMMARY

Even pricing and extremely strong unit growth prevailed throughout the first half of 1984 in the MOS static and dynamic RAMs markets. By the end of the second quarter, the market had stabilized considerably from the rather chaotic conditions that existed in the fall of 1983 and into the first part of 1984. During the first half of 1984, large increases in production made steady progress toward bringing supply into balance with demand. Furthermore, beginning in the second quarter, adjustments in the demand side, primarily from shifts in the personal computer market, served to free up additional product for those user sectors that continued to have strong demand. As shown in Table 1, below, during the second quarter of 1984, the industry production rate for MOS static and dynamic RAMs was estimated to be $1.25 billion.

Table 1

ESTIMATED QUARTERLY MOS RAM REVENUES
(Millions of Dollars)

	1983			1984	
	3rd Qtr.	4th Qtr.	1983 Year	1st Qtr.	2nd Qtr.
Static RAMs	$185	$232	$ 700	$298	$ 374
Fast (≤100 ns)	38	45	145	63	82
Slow (≥120 ns)	147	187	555	235	292
Dynamic RAMs	490	613	1,826	696	871
Total	$675	$845	$2,526	$994	$1,245
U.S. Mfrs. SOM	39%	39%	39%	39%	39%
Japanese Mfrs. SOM	57	57	57	56	56
European Mfrs. SOM	4	4	4	5	5
	100%	100%	100%	100%	100%

Source: DATAQUEST
November 1984

Dynamic RAMs

Shipments of 64K dynamic RAMs in the first quarter of 1984 totaled an estimated 160.4 million units, followed by an additional 198.9 million units in the second quarter. Therefore, first half shipments in 1984 nearly equaled the entire annual shipments in 1983. Prices for 64Ks were extremely stable and were probably about $3.75 in the U.S. market. However, pricing in Japan in the first half was about $0.90 lower, or $2.85, with prices in Europe and the Rest of World (ROW) in the $3.10 to $3.35 range.

Shipments of 256K dynamic RAMs increased dramatically in the first half, totaling 2.6 million units in the first quarter and 6.8 million units in the second quarter. The merchant market was dominated by Japanese manufacturers, led by Fujitsu, Hitachi, and NEC.

Static RAMs

The static RAMs market continued to grow strongly in the first half of 1984, and most vendors in the bytewide 16K market were achieving higher prices than they were a year ago. Static RAM revenues for the first half totaled $672 million, an estimated 137 percent increase over the first half of 1983.

DEFINITIONS

The terms below are defined by DATAQUEST as follows:

Shipments

Unit shipments are estimates of actual product movements to all market channels, including:

- Manufacturer's internal use (boards and systems)
- Distribution (stocking distributor and user shipments)
- OEMs and end users (domestic and international)

Actual user consumption may be greater than or less than the estimated unit shipments, due to distributor stocking and manufacturers' inventories for internal use.

Shipments, as defined here, are not equal to production, since considerable unsold finished goods inventories may exist at the manufacturer. While these inventories may be stable in the long run and, therefore, production would match shipments, this is not necessarily true as production ramps up in the early part of product life cycles.

Samples

The "sample" designation (S) is assigned to new products that ship less than 1,000 units per quarter. The actual number of samples shipped does not enter into the row and column calculations in the table.

Price Estimates

We will often discuss prices or price trends in the text that accompany the tables. For any given device type in our classification scheme there is always a family of devices represented under a single heading; these devices may show large differences in price due to performance differences, lot sizes, sales channels, package types, special user requirments, and quality, etc., not to mention the specific situations of the manufacturer, the user, the market, and the time of sale.

Prices discussed in the text are intended to be averages of all products shipped in the class, i.e., total market revenues divided by total units. Specific premiums for performance or packages are often noted in the text, if significant and if the information is available.

PRODUCT MARKET SUMMARIES

DYNAMIC RAMS

Dynamic RAMs were a strong production force among suppliers of MOS memory products for the first half of 1984. Seemingly insatiable demand, high and stable prices, and extremely attractive margins, caused many MOS memory makers to shift wafer starts to DRAMs. This was often done at the expense of other products in their portfolios. Growth of the DRAM market, spearheaded by growth in the personal computer market, has outstripped sales of SRAMs and all nonvolatile memories for more than a year--in bits, units, and revenue. Despite a strong increase in supply, prices have declined only gradually since early in 1984.

4K Dynamic RAMs

Only three vendors remain in the 4K DRAM market. Estimates of their 4K DRAM unit shipments for the first two quarters of 1984 are shown in Table 2.

16K Dynamic RAMs, 3-Power-Supply

The 3-power-supply 16K dynamic RAMs appear finally to have gone over the hill. Unit shipments in the first and second quarters of 1984 dropped off sharply from the levels achieved late in 1983, and only inventory "fire sales" have served to keep the shipments as high as they are. Shipment estimates by participating vendors are shown in Table 3. Typical 3-power-supply 16K contract pricing was often in the range of $0.95 to $1.00, while the preponderance of the spot market business and product moving through distribution was sold at prices between $0.65 and $0.75. This indicates that the 16K dynamic RAM is still competitive on a strict price-per-bit basis with the newer 64K and 256K devices.

5-Volt 16K Dynamic RAMs

The 5-volt-only 16K dynamic RAMs market continues to be attractive, though it also has declined in units since the second half of 1983. Shipments in the second quarter of 1984 were down 30 percent from peak levels at the end of 1983, but prices, typically in the $1.75 to $2.00 range, were quite even with those achieved in late 1983.

Total shipments by vendor, shown in Table 4, indicate that the market continues to be dominated by five manufacturers: Fujitsu, Hitachi, Intel, Mostek, and Motorola.

64K Dynamic RAMs

Quarterly unit shipments by vendors of 64K dynamic RAMs are shown in Table 5. In addition to our customary breakout, we have estimated shipments for different part types in cases where one vendor sells more than one type of 64K dynamic RAM, such as CMOS versions or devices with different organizations.

Shipments in the first quarter rose 21 percent to an estimated 160.4 million units, and rose an additional 24 percent in the second quarter, up to 198.9 million units. The U.S. manufacturers' share of the total units shipped in the second quarter was estimated to be 42 percent, up from about 35 percent in the second quarter of 1983. European manufacturers--Inmos, Siemens, and Standard Telecom and Cable (STC) --maintained the European share of the market at about 3.5 percent of total units.

Prices in the U.S. market for the first half were about $3.75, although they were considerably lower in foreign markets where Japanese domination is more pronounced. If the total revenue of 64K dynamic RAMs is considered instead of total units, the U.S. manufacturers' market share probably exceeded 50 percent in the second quarter.

Because of the high margins that vendors are achieving in 64K dynamic RAMs, many manufacturers are focusing their efforts on producing these parts at the expense of other parts of their product portfolios. However, virtually every vendor is extremely watchful of product availability and the spot market because of still fresh memories of the severe 1981 and 1982 price erosion in the 16K dynamic RAM market. As the market moved toward equilibrium in the second quarter of 1984, uncommitted product occasionally appeared on the spot market and, from time to time, certain users decided not to take their allocations from their suppliers. However, neither of these conditions caused any long-term problems because there are still many manufacturers whose dynamic RAM requirements cannot be fulfilled through their normal contractual arrangements with their vendors.

The price and volume outlook for 64K dynamic RAMs through the rest of 1984 and into 1985 indicates that pricing probably will be quite strong to the end of this year, although an increasing fraction of the industry output will begin to move on the spot market at prices somewhat lower than those already contracted. Contract pricing for the third and fourth quarter shows only price declines of $0.10 to $0.25 per unit for most vendors. However, several vendors intent on taking advantage of the current high market prices are increasing their production considerably, and will undoubtedly have large quantities of uncommitted product available in the fourth quarter and the early part of 1985.

The potential for significant price erosion in the early part of 1985 is quite real, and we expect that beginning in the first quarter, the average billing price of 64K dynamic RAMs will drop between $0.20 and $0.40 per quarter to leave 1985 in the vicinity of $2.00 per unit. An important consideration is that there are a number of other high-profit product areas in which output can be increased should margins in 64K dynamic RAMs fall to unacceptably low levels. DATAQUEST feels that these production alternatives will break, to some extent, any precipitous price decline of 64Ks.

256K Dynamic RAMs

Production of 256K dynamic RAMs has increased dramatically since the fourth quarter of 1984, with unit shipments totaling 2.6 million units in the first quarter of 1984, and 6.8 million in the second quarter of 1984. Unit shipments by vendor are shown in Table 6. Japanese manufacturers, led by Fujitsu, Hitachi, and NEC, continue to dominate the market, although Mitsubishi, Oki, Texas Instruments, and Toshiba were all shipping moderately large volumes as well.

We estimate that AT&T Technologies (formerly Western Electric) was producing in excess of 200,000 units per month at midyear, but the internal demands of AT&T itself, by virtue of continuing contractual agreement with AT&T Technologies, have continued to keep almost all of that product inside. AT&T Technologies continues to look outside for production capacity (e.g., its reported attempt to purchase Inmos), while at the same time it increases its production capacity at its Kansas City works and plans for its large upcoming fab facility in Orlando, Florida.

Although virtually all of the product delivered in the first half of 1984 was 256Kx1 NMOS dynamic RAM, the second quarter did see some small quantities of CMOS samples available from Intel. These are the first CMOS 256K parts on the market, and feature both static column and ripple mode^R addressing schemes. Intel has also announced the future availability of 64Kx4s in CMOS in the first half of 1985.

As in the case of the 64K dynamic RAMs, there is a significant price difference between product purchased in Japan and product purchased in the United States. Second quarter pricing for 256K DRAMs in the United States probably averaged in the vicinity of $34 to $35, with the best pricing in the $30 to $32 per unit range. Pricing in Japan during the same time period appeared to be in the $21 to $25 per unit range. There are instances of several U.S. manufacturers purchasing 256K DRAMs for the U.S. market from their purchase locations in Japan.

Third and fourth quarter prospects for 256K dynamic RAMs lead us to believe that output will be much higher than we had earlier forecast, with world prices for the year in the $21 to $23 range and increasing product available from U.S. suppliers.

Table 2

ESTIMATED WORLDWIDE MOS 4K DYNAMIC RAM SHIPMENTS
(Thousands of Units)

	1983					1984	
Company	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr
AMD	0	0	0	0	0	0	0
AMI	0	0	0	0	0	0	0
Fairchild	0	0	0	0	0	0	0
Fujitsu	0	0	0	0	0	0	0
Hitachi	0	0	0	0	0	0	0
Intel	0	0	0	0	0	0	0
Intersil	0	0	0	0	0	0	0
Mostek	200	200	200	225	825	300	350
Motorola	175	50	50	25	300	25	25
National	100	100	50	0	250	0	0
NEC	0	0	0	0	0	0	0
SGS-Ates	75	100	200	50	425	100	50
Signetics	0	0	0	0	0	0	0
STC (ITT)	200	200	150	50	600	100	100
Texas Instruments	0	0	0	0	0	0	0
Total	750	650	650	350	2,400	525	525
Percentage Change From Previous Quarter	-13%	-13%	0%	-46%		50%	0%

Source: DATAQUEST
November 1984

Table 3

ESTIMATED WORLDWIDE 3-POWER-SUPPLY MOS 16K DYNAMIC RAM SHIPMENTS (Thousands of Units)

Company	1983 1st Qtr	1983 2nd Qtr	1983 3rd Qtr	1983 4th Qtr	1983 Year	1984 1st Qtr	1984 2nd Qtr
AMD	5,100	5,800	5,200	4,000	20,100	2,500	2,500
Eurotechnique	1,800	2,000	2,500	2,500	8,800	2,000	2,000
Fairchild	600	400	300	300	1,600	200	100
Fujitsu	4,000	3,500	2,500	2,500	12,500	2,000	1,800
Hitachi	3,000	3,000	3,500	3,500	13,000	3,000	3,000
Intel	1,500	1,000	1,000	1,000	4,500	800	500
Intersil					0	0	0
Matsushita	100	50	50	0	200	0	0
Mitsubishi	400	240	200	150	990	170	170
Mostek	4,300	5,500	4,500	3,500	17,800	2,500	1,500
Motorola	3,800	3,600	4,100	3,300	15,000	3,000	2,500
National	4,500	6,000	5,000	4,500	20,000	3,500	2,500
NEC	9,800	9,500	11,000	10,000	40,300	8,000	6,000
SGS-Ates	20	100	150	50	320	0	0
Siemens	3,000	3,000	3,000	3,000	12,000	3,000	3,000
Signetics					0	0	0
STC (ITT)	5,600	6,200	6,200	5,500	23,500	4,000	3,500
Texas Instruments	7,000	12,000	10,000	9,500	38,500	8,000	6,500
Toshiba	2,400	3,000	2,500	2,200	10,100	1,800	1,600
Zilog					0	0	0
Total	56,920	64,890	61,700	55,700	239,210	44,470	37,170
Percent Change From Previous Quarter	-14%	14%	-5%	-10%		-20%	-16%

Table 4

ESTIMATED WORLDWIDE 5-VOLT MOS 16K DYNAMIC RAM SHIPMENTS (Thousands of Units)

Company	1983 1st Qtr	1983 2nd Qtr	1983 3rd Qtr	1983 4th Qtr	1983 Year	1984 1st Qtr	1984 2nd Qtr
Fujitsu	1,500	2,000	3,000	3,000	9,500	3,000	2,500
Hitachi	3,000	3,500	3,500	3,500	13,500	3,000	2,000
Intel	2,000	1,700	1,500	1,500	6,700	1,500	1,500
Mostek	3,000	2,800	3,500	4,500	13,800	2,000	1,500
Motorola	2,200	3,300	4,000	3,000	12,500	1,600	2,500
National	0	0	0	0	0	0	0
Texas Instruments	250	350	400	400	1,400	500	500
Total	11,950	13,650	15,900	15,900	57,400	11,600	10,500
Percentage Change From Previous Quarter	45%	14%	16%	0%		-27%	-9%

Source: DATAQUEST
November 1984

Table 5

ESTIMATED WORLDWIDE MOS 64K DYNAMIC RAM SHIPMENTS
(Thousands of Units)

Company	MOS Process/ Organization	1983 1st Qtr	1983 2nd Qtr	1983 3rd Qtr	1983 4th Qtr	1983 Year	1984 1st Qtr	1984 2nd Qtr
AMD		S	10	100	250	360	500	1,000
Fairchild		0	0	0	S	S	10	25
Fujitsu	64K x 1	7,500	9,200	11,200	11,500	39,400	14,500	18,000
	16K x 4	S	100	300	1,000	1,400	1,500	2,000
	C 8K x 8				S	S	S	10
Hitachi	64K x 1	11,000	14,500	16,500	18,500	60,500	22,300	25,500
	16K x 4			S	S	S	10	25
Inmos	64K x 1	150	350	625	1,400	2,525	2,400	3,000
	16K x 4	S	50	250	600	900	1,200	1,800
	8K x 8		S	25	100	125	400	800
Intel	64K x 1	1,800	2,600	3,500	5,000	12,900	6,200	7,500
	C 64K x 1			S	S	S	50	250
Matsushita	64K x 1	80	400	1,800	3,000	5,280	4,200	6,000
	16K x 4						S	10
	8K x 8							S
Micron Technology		950	1,500	2,500	4,000	8,950	6,200	9,300
Mitsubishi	64K x 1	6,800	7,000	8,900	10,800	33,500	13,500	18,400
	16K x 4					0	S	S
Mostek		4,000	8,500	12,300	16,200	41,000	15,500	18,500
Motorola		4,000	6,300	8,900	12,000	31,200	11,000	13,100
National		0	S	10	150	160	500	1,200
NEC	64K x 1	8,500	12,000	15,000	18,000	53,500	21,100	23,600
	C 8K x 8				S	S	50	150
Oki Electric		2,200	4,000	6,500	8,000	20,700	11,000	13,500
Sharp					S	S	50	150
Siemens		350	500	1,000	2,000	3,850	3,000	4,000
STC (ITT)		15	75	100	100	290	200	400
Texas Instruments	64K x 1	7,400	8,500	9,000	13,700	38,600	17,000	22,000
	16K x 4	600	1,500	3,000	3,000	8,100	3,500	4,000
Toshiba		1,000	1,500	2,600	3,000	8,100	4,500	4,700
Total		56,345	78,585	104,110	132,300	371,340	160,370	198,920
Percentage Change From Previous Quarter		37%	39%	32%	27%		21%	24%

Source: DATAQUEST
November 1984

Table 6

ESTIMATED WORLDWIDE MOS 256K DYNAMIC RAM SHIPMENTS
(Thousands of Units)

Company	MOS Process/ Organization	1983 1st Qtr	1983 2nd Qtr	1983 3rd Qtr	1983 4th Qtr	1983 Year	1984 1st Qtr	1984 2nd Qtr
ATT Technologies		S	S	20	100	120	200	500
Fujitsu		S	30	150	300	480	600	1,800
Hitachi		25	50	175	400	650	700	2,200
Intel	C							S
Mitsubishi			S	10	50	60	50	50
Mostek	32K x 8			S	5	5	15	50
	256K x 1							
Motorola			S	S	0	0	0	0
National								S
NEC	256K x 1	S	S	100	200	300	800	1,500
	64K x 4						S	10
	32K x 8							
Oki Electric		S	S	5	10	15	50	100
Texas Instruments	256K x 1			S	S	S	10	100
	64K x 4						S	S
Toshiba		S	S	20	50	70	200	500
Total		25	80	480	1,115	1,700	2,625	6,810
Percentage Change From Previous Quarter			220%	500%	132%		135%	159%

Source: DATAQUEST
November 1984

STATIC RAMS

The static RAMs market continued strong throughout the first half with rising prices more common than the stable pricing that was seen in the dynamic RAMs market. In the first half, most manufacturers in all the varieties of the static RAMs market reported average selling prices between 10 and 25 percent higher than at this time a year ago. The sole exception was fast 16K static RAMs, where prices have not increased quite as dramatically as they have in the 2Kx8, 8Kx8, and 4K static RAM markets.

Tight capacity hastened the phasing out of production of mature densities at many vendors.

4K Fast Static RAMs

The 4K fast NMOS static RAMs continued quite stable in units through the first half of 1984. Estimated unit shipments by quarter for participating vendors are shown in Table 7. In the case of several of these vendors, prices achieved in the first and second quarters of 1984 were higher than those achieved in the second half of 1983, as capacity allocation requirements forced some vendors to reduce output and turn away the demand for increased volumes of this product.

4K NMOS Slow Static RAMs

Unit shipments of 4K NMOS slow static RAMs are shown in Table 8. Prices in the first half typically ran in the $1.10 to $1.20 range, and users occasionally had trouble getting the increased demand fulfilled from their vendors.

4K CMOS Static RAMs

Shipments of 4K CMOS static RAMs are shown in Table 9. The market in the first half found some vendors unwilling or unable to meet increased demand, resulting in stable and rising prices for makers who continued to be volume suppliers. Consequently, we expect to see some significant shifts in market shares during the coming year, based on willingness and ability to supply this mature market.

16K Fast Static RAMs

Production of 16K fast static RAMs increased sharply in the first half of 1984, due in large part to a significant increase in output by Inmos, the market leader. Prices remained steady from fourth quarter 1983. Estimates of production by vendors supplying the fast 16K are shown in Table 10.

Although the market as a whole is about 63 percent 16Kx1 versus 33 percent 4Kx4 (and 4 percent 2Kx8), vendors that have both 16Kx1 and 4Kx4 in production (Fujitsu and Inmos) are reporting about equal sales of each device. The newer, fast 2Kx8 market (45 ns and 55 ns), now supplied by Motorola and Toshiba, totaled about 650,000 units in the first half. These parts still command a good premium over the more established configurations, and at least three or four new entrants with fast 2Kx8s can be expected before year end.

CMOS's share is growing in fast 16Ks, too, with several vendors' second-generation devices being CMOS. AMD's 4Kx4, and Fujitsu's, Inmos', Intel's, and Sharp's 16Kx1s are now offered in CMOS. None of these devices was available in significant volumes during the first half, and Hitachi remained the dominant producer of fast 16Kx1s in CMOS at midyear.

16K Slow Bytewide Static RAMs

Growth of 16K slow 2Kx8 SRAMs continued during the first two quarters of 1984 at a much reduced rate compared to 1983. Estimated unit shipments by participating vendors are shown in Table 11. Market leader Hitachi's (33 percent share of market) decision to allocate additional wafer starts to 64K SRAMs meant that many users were forced to seek other suppliers to support their increasing demand. Strong increases in demand beginning late in 1983 also resulted in rising prices, primarily for the CMOS part-types.

The Japanese makers' share of the 16K 2Kx8 SRAM market has declined steadily from the early part of 1982: 98 percent share of units in first quarter 1982, down to 81 percent in second quarter 1984. However, as is the case with the 64K/256K DRAMs, they have more than made up their revenue losses in the succeeding generation.

In the second quarter, NMOS devices contributed 32 percent of the total units shipped; CMOS made up the other 68 percent of total units. This is almost identical with the second quarter of 1983 (31 percent vs. 69 percent) and the second quarter of 1982 (29 percent vs. 71 percent). Of the CMOS devices, about 40 percent used the 6Tx cell and 60 percent used the 4Tx cell.

64K Fast Static RAMs

Following up an outstanding series of papers on fast SRAMs at ISSCC in February, the first 64K fast static RAMs appeared from several vendors in the first and second quarters. By mid-1984, four vendors had shipped small quantities: Fairchild, Fujitsu, Hitachi, and Inmos. We can expect an equal number to sample in the second half, as well as for most of the early samples to move into low-volume production. Estimated 64K fast static RAM shipments for the first and second quarters of 1984 are shown in Table 12.

All devices seen in the open market are CMOS, although Fujitsu is reportedly using a fast NMOS part internally in its computer systems. Also, all devices offered in the first half of 1984 were organized 64Kx1, but both 16Kx4 and 8Kx8 fast 64Ks will probably be available by year end. Pricing for first half samples varied widely from $100 to more than $150 for low quantities, and may be expected to be from $60 to $80 by year end.

Initial speed offerings appear to be mostly in the 45 ns to 55 ns speed bins. But if the performance of devices described at ISSCC is any indication of potential, we probably will see 35 ns speeds available before year end and eventually will see 25 ns from the same design.

DATAQUEST has identified 22 separate 64K fast SRAM designs, all of which should be on the market by mid-1985. Of these designs, nine are 64Kx1, five are 16Kx4, and eight are 8Kx8. All but two are CMOS, and of the CMOS devices, only two are thought to be the full 6Tx CMOS cell structure.

64K Slow Bytewide Static RAMs

Unit shipments of slow 8Kx8 static RAMs grew an estimated 73 percent from the fourth quarter of 1983 to the first quarter of 1984, then another 45 percent into the second quarter. Estimated unit shipments are shown in Table 13. Hitachi remained the volume leader by a wide margin, but a total of seven vendors were shipping true SRAMs by midyear, plus Intel's NMOS iRAM™ and NEC's functionally similar CMOS pseudo-static RAM (PS RAM).

Prices, which had declined steadily throughout 1983 from about $80 to about $20, firmed up considerably in the first half of 1984. Contracted business remained steady at about $18 to $22 per unit, but new business came in at $26 to $30 each until mid-1984, by which time $22 to $25 was more common. Already, the total quarterly revenue generated in 64K SRAMs is comparable to that of 16K SRAMs and will certainly surpass 16K revenue by the end of 1984.

Suwa Seikosha has had quality CMOS capability for some time but no marketing vehicle of its own that would allow it to serve the larger market. The establishment of S MOS Systems in Santa Clara late in 1983 was designed to address Suwa Seikosha's U.S. marketing needs. With considerable fab expansion plans coming up for Suwa Seikosha in 1985, and a rather limited product line at this time, we can expect to see the company rapidly increase its 64K output in the coming year.

Intel's NMOS iRAM™ was shipping in excess of 250,000 units per month at midyear. Now that Intel's CMOS 64K dynamic RAM is also being shipped in production volumes, we can expect to see that technology brought over into the iRAM™ group, and for 64K CMOS iRAMs™ to appear soon, perhaps before year end 1984.

At least five or six additional slow 8Kx8 SRAMs can be expected in the next 9 to 12 months from Matsushita, National Semiconductor, Oki Electric, Sharp, and others. However, the long-term prognosis for replacement of true SRAMs by PS RAMs or CMOS DRAMs in small systems with low power requirements remains uncertain. But at 256K, the true SRAM die area penalty becomes a considerable burden, especially in view of the advanced CMOS DRAM technology of the Hitachi 288K PS RAMs and Intel's 256K CMOS DRAM product efforts.

Table 7

ESTIMATED WORLDWIDE NMOS 4K FAST STATIC RAM SHIPMENTS
(Thousands of Units)

	1983					1984	
Company	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr
AMD	525	725	800	1,000	3,050	700	900
AMI					0	0	0
Eurotechnique	150	170	200	200	720	200	200
Fujitsu	250	300	300	350	1,200	300	300
Intel	1,300	1,250	1,250	1,150	4,950	1,100	1,000
Intersil					0	0	0
Mostek					0	0	0
Motorola					0	0	0
National	400	400	600	650	2,050	650	550
NEC	200	250	300	450	1,200	450	500
STC (ITT)					0	0	0
Synertek	170	200	250	350	970	350	350
Texas Instruments	175	175	175	175	700	150	150
Toshiba	60	40	30	20	150	30	30
Total	3,230	3,510	3,905	4,345	14,990 14,990	3,930	3,980
Percentage Change From Previous Quarter	9%	9%	11%	11%		-10%	1%

Source: DATAQUEST
November 1984

Table 8

ESTIMATED WORLDWIDE NMOS 4K SLOW STATIC RAM SHIPMENTS
(Thousands of Units)

	1983						1984			
	-3rd Quarter-		-4th Quarter-		---Year---		-1st Quarter-		-2nd Quarter-	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
AMD	1,300	200	1,500	150	5,800	610	1,750	0	2,200	0
AMI					0	0	0	0	0	0
Commodore MOS					0	0	0	0	0	0
Eurotechnique	250		250		900	0	250	0	300	0
Fairchild	200		200		875	0	150	0	100	0
Fujitsu					0	0	0	0	0	0
GTE (EMM Prior 1980)					50	25	0	0	0	0
Hitachi	200		100		1,000	0	0	0	0	0
Intel	1,000		1,200		4,200	0	800	0	700	0
Intersil					0	0	0	0	0	0
Matsushita					0	0	0	0	0	0
Mitsubishi	300	50	180	60	1,260	300	150	150	150	150
Mostek					0	0	0	0	0	0
Motorola	1,900		2,200		6,800	0	3,100	0	2,200	0
National	4,000	100	4,500	150	15,600	600	4,000	150	3,000	150
NEC	2,200	110	1,900	100	10,000	425	2,700	60	2,200	35
Oki Electric	50		25		275	0	25	0	25	0
Synertek	250		300		1,450	0	350	0	400	0
Texas Instruments	200	50	200	50	800	170	200	50	200	50
Toshiba	2,400		2,400		9,900	0	2,200	0	2,400	0
Zilog					0	0	0	0	0	0
Total	14,250	510	14,955	510	58,910	2,130	15,675	410	13,875	385
Percentage Change From Previous Quarter	-1%	10%	5%	0%			5%	-20%	-11%	-6%

Source: DATAQUEST
November 1984

Table 9

ESTIMATED WORLDWIDE CMOS 4K STATIC RAM SHIPMENTS
(Thousands of Units)

	1983						1984			
	-3rd Quarter-		-4th Quarter-		—Year—		-1st Quarter-		-2nd Quarter-	
Company	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1	1Kx4	4Kx1
Cypress							S	0	5	0
Fujitsu	0	0	0	0	0	0	0	0	0	0
Harris	250	200	250	200	1,080	800	300	250	300	250
Hitachi	450	1,000	400	800	1,700	4,200	350	600	300	500
Fast										
Matra-Harris	200	150	200	150	800	600	250	180	250	200
Micro Power					0	0	0	0	0	0
Mitsubishi	70		50		390	0	120	0	180	0
Motorola					0	0	0	0	0	0
Fast		130		150	0	440	200	0	330	0
National	300	200	400	250	1,200	850	300	150	200	100
NEC	1,300		1,100		4,400	0	1,600	0	1,200	0
Oki Electric	50	50	50	50	200	200	25	25	25	25
RCA	50		50		200	0	100	0	100	0
Seiko										
Solid State Scientific	150	80	150	80	700	400	250	100	250	100
Toshiba	1,400	600	1,500	500	5,400	2,300	1,600	400	1,600	500
Total	4,220	2,410	4,150	2,180	16,070	9,790	5,095	1,705	4,740	1,675
Percentage Change From Previous Quarter	12%	-4%	-2%	-10%			23%	-22%	-7%	-2%

Source: DATAQUEST
November 1984

Table 10

ESTIMATED WORLDWIDE MOS FAST 16K STATIC RAM SHIPMENTS
(Thousands of Units)

		1983					1984	
Company	MOS Process/ Organization	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr
AMD	16K X 1		S	S	10	10	15	50
	C 4K X 4						S	5
Fujitsu	16K X 1	350	400	600	800	2,150	1,050	1,250
	4K X 4	150	200	350	600	1,300	800	1,000
	C 16K X 1						S	S
Hitachi	C 16K X 1	350	500	600	800	2,250	1,000	1,200
	C 4K X 4	S	S	10	25	35	50	75
IDT	C 16K X 1	25	40	75	100	240	130	150
	C 4K X 4	5	15	30	60	110	80	100
Inmos	16K X 1	400	450	600	750	2,200	1,500	2,000
	4K X 4	300	350	550	700	1,900	1,500	2,100
	C 16K X 1						S	S
Intel	16K X 1	0	0	0	0	0	0	0
	C 16K X 1						S	S
Mitsubishi	16K X 1	90	70	60	80	300	200	350
	4K X 4	S	S	S	20	20	80	150
Mostek	16K X 1	5	5	5	5	20	5	5
Motorola	16K X 1		S	S	5	5	10	25
	2K X 8			S	5	5	10	20
NEC	16K X 1	120	100	100	200	520	200	200
Sharp	C 16K X 1				S	0	S	25
STC (ITT)	16K X 1	S	10	20	50	80	100	200
	4K X 4		S	S	10	10	15	25
Toshiba	2K X 8	S	10	50	100	160	300	300
Total		1,795	2,150	3,050	4,320	11,315	7,045	9,230
Percentage Change From Previous Quarter		19%	20%	42%	42%		63%	31%

Source: DATAQUEST
November 1984

Table 11

ESTIMATED WORLDWIDE MOS BYTE-WIDE 16K STATIC RAM SHIPMENTS
(Thousands of Units)

		1983					1984	
Company	Type	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year	1st Qtr	2nd Qtr
AMD	N	400	775	850	700	2,725	1,000	900
Eurotechnique	N	50	100	150	250	550	250	300
Fairchild	N	5	10	25	50	90	50	50
Fujitsu	N	600	800	1,000	1,200	3,600	1,350	1,300
	C	450	700	1,000	1,400	3,550	1,500	1,750
Harris	C	15	20	50	150	235	250	300
Hitachi	C	5,500	8,000	10,000	11,000	34,500	12,500	13,000
IDT	C	100	150	200	250	700	300	350
Matra-Harris	C	250	350	400	500	1,500	600	750
Matsushita	N							S
	C							S
Mitsubishi	N	600	600	950	900	3,050	950	1,000
	C	90	420	160	350	1,020	350	600
Mostek	N	10	10	10	10	40	10	10
	C			S	25	25	75	150
Motorola	C	20	30	100	100	250	250	400
National	N	50	300	400	600	1,350	500	300
NEC	N	750	800	1,000	1,500	4,050	700	1,500
	C	500	750	1,900	2,300	5,450	2,600	2,000
Oki Electric	N	400	550	750	900	2,600	600	500
	C	500	650	800	1,100	3,050	1,000	700
RCA	C	150	450	700	850	2,150	1,200	1,200
Seiko	C	50	50	100	300	500	600	900
Sharp	C							
Synertek	N	700	1,000	750	900	3,350	1,100	1,300
Texas Instruments	N	250	350	400	450	1,450	500	500
Toshiba	N	2,200	3,100	3,800	4,800	13,900	5,800	6,500
	C	2,600	2,900	3,700	4,200	13,400	5,400	5,500
Total		16,240	22,865	29,195	34,785	103,085	39,435	41,760
Percentage Change From Previous Quarter		31%	41%	28%	19%		13%	6%

Source: DATAQUEST
November 1984

Table 12

ESTIMATED WORLDWIDE MOS FAST 64K STATIC RAM SHIPMENTS
(Thousands of Units)

Company	MOS Process/ Organization		1st Qtr	2nd Qtr
Fairchild	C	64Kx1	S	S
Fujitsu	N	64Kx1	S	10
	C	64Kx1		S
Hitachi	C	64Kx1		S
Inmos	C	64Kx1		S
Total			0	10
Percent Change From Previous Quarter				

Table 13

ESTIMATED WORLDWIDE MOS SLOW 64K STATIC RAM SHIPMENTS
(Thousands of Units)

Company	MOS Technology/ Type		1983 1st Qtr	1983 2nd Qtr	1983 3rd Qtr	1983 4th Qtr	1983 Year	1984 1st Qtr	1984 2nd Qtr
Fujitsu			15	40	75	150	280	300	600
Hitachi			100	450	800	1,100	2,450	1,800	2,500
Intel	N	iRAM	25	75	150	250	500	350	400
Mitsubishi				S	S	S	S	S	S
NEC					S	S	S	25	150
	C	PSRAM			S	10	10	25	75
Seiko					S	10	10	10	25
Sony									S
Toshiba			50	150	250	450	900	900	1,200
Total			190	715	1,275	1,970	4,150	3,410	4,950
Percent Change From Previous Quarter			138%	276%	78%	55%		73%	45%

Source: DATAQUEST
November 1984

CONCLUSION

Strong growth in unit shipments of dynamic and static RAMs during the first and second quarters of 1984 went far toward restoring reasonable order to the MOS RAM market. Prices and lead times left the first half stable. RAM revenues in the second quarter were up 90 percent compared to the second quarter of 1983--the low point before the market resurgence--and growth will likely continue into the first part of 1985. Beyond that time, a slowed aggregate unit/bit demand and expected significant price erosion across all RAM product lines will probably make it difficult for most RAM makers to continue to increase their total revenues in the latter part of 1985.

The growth of Japanese manufacturers' overall RAM market share was slowed as U.S. manufacturers sold at higher prices in the U.S. markets. Japanese makers shipped a much higher percentage into the lower-priced Japanese and Asian-Pacific markets. Japanese manufacturers, however, have instantly become dominant in the emerging new state-of-the-art generation parts: 64K SRAMs and 256K DRAMs. This undoubtedly will have significant consequences in the next two to three years, as the more mature devices (16K SRAMs and 64K DRAMs) decline both in absolute revenue and, more importantly, as a percentage of the total SRAM and DRAM market.

Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

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CONVERGENCE '84--A MEETING OF MAJOR INDUSTRIAL FORCES

OVERVIEW

Automotive and heavy equipment executives joined with leaders from the electronics industry October 22-24 to attend Convergence '84, the biennial vehicle electronics conference, held this year in Dearborn, Michigan. Foreign and domestic manufacturers of automobiles, trucks, buses, and construction and agricultural equipment attended seminars, panels, meetings, and social events with executives in the electronics and communications industries.

More than 1,500 executives discussed the major opportunities, issues, and challenges affecting the momentum with which electronics will sweep the transportation industry. Key issues discussed at the conference included the advent and application of power devices, the development of cost-effective and reliable sensors and actuators, and the implementation of total module communication (system integration) within vehicles.

The conference was jointly sponsored by the Vehicular Technology Society-Institute of Electrical and Electronics Engineers, Inc. (VTS-IEEE) and the Society of Automotive Engineers (SAE). The theme of the conference was "New Horizons in Vehicular Electronics." There were 12 technical sessions at Convergence '84, comprising a total of 62 presentations. In all, there were 47 papers from U.S. organizations, 8 from Europe, and 7 from Japan.

THE ISSUES FOR THE AUTOMOBILE MANUFACTURERS

Jerome G. Rivard, Chief Engineer at Ford Motor Company's Electrical and Electronics Division, gave an overview of automotive electronics for the future. For the most part, automotive and electronics manufacturers

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are well versed on the technology demands for the car of the future, which include:

- Vehicle downsizing coupled with the demand for more electronics will force a reduction in electronic system size and installation in more hostile environments within the vehicle. This will drive the demand for more innovative packaging techniques, especially surface-mounted devices and ceramic thick-film hybrid circuits.

- With an increase in electronic system applications, there is a tremendous need for more cost-effective, reliable sensors. These are needed for vehicle system monitoring, on-board diagnostics, new control function development, and existing system performance improvement.

- Power and smart power devices are critical technologies that also affect performance and reliability while lowering costs. Ford Motor Company estimates that by 1990, nearly 50 percent of automotive power transistors will be used in power switching applications. With the advent of multiplexing and the ability to replace the average 25 to 100 electromechanical relays per vehicle, DATAQUEST believes that power devices represent a significant opportunity.

- CMOS technology lends itself very appropriately to automotive applications, with its major advantage being low power consumption and low heat dissipation. With vehicle downsizing as an issue, CMOS devices can be placed closer to the vehicle areas that they control. Lower power requirements also minimize the size of a vehicle's charging system.

- Cost-effective, high-speed nonvolatile RAM and EEPROM devices are also needed by the automobile industry. The benefits of these devices lie in their ability to be programmed after vehicle assembly and to act as vehicle adjustment and diagnostic aids.

Other key technologies that were frequently discussed at the conference included display technology, voice recognition, speech synthesis, and the implementation of cellular radio and optical disk players. All represent major commitments and significant opportunities.

HEAVY EQUIPMENT--A DIFFERENT SET OF NEEDS

The "big guys" are dealing with a different set of issues. The technology demands that agricultural, construction, and trucking manufacturers are placing on the electronics sector are generally similar to those of their automotive counterparts. But for the most part, electronics technology has not heavily penetrated the vehicles built by heavy equipment manufacturers.

Agriculture and Construction--Reaping the Benefits of Technology

The sales volumes and consumer orientation that accompany automobile production are not evident in the heavy equipment segment of the business. So the call for electronics to spur growth in the once-ailing automobile industry can't easily be compared to the same call from the somewhat depressed equipment industries. Today, the majority of electronic systems in use in heavy equipment are displays and monitors.

In his presentation, Trevor O. Jones, Vice President and General Manager of TRW's Transportation Electronics Group, said that if electronics are to be implemented in heavy equipment, they must provide functional enhancements in an entirely cost-effective manner. And this must be done while meeting all reliability measures. The buying criteria for heavy equipment are very different from those for automobiles. As capital goods, the purchase of heavy equipment is highly related to cost/benefit analysis. Electronics in heavy equipment must do one or more of the following:

- Improve asset utilization
- Improve operator and machine productivity
- Improve both on- and off-machine operational safety
- Improve machine uptime
- Extend equipment life
- Reduce the skills required for operation
- Reduce operating costs
- Increase asset protection

Heavy equipment manufacturers plan to install control devices in their products within the next few years. The technologies that are expected to enter this marketplace are:

- Transmission control
- Engine control
- Electronic draft control
- Wheel slip control
- Closed-loop combine control
- Bulldozer blade control
- Remote vehicle control

Here again, it was said that significant barriers to these and other new systems lie in the lack of cost-effective sensors and actuators.

Truck and Bus Electronics--On the Road to Change

Dean P. Stanley, International Harvester Corporation's Vice President of Truck Group Engineering, stressed the tremendous change that the large motor transportation industry is undergoing. The Motor Carrier Act of 1980 deregulated the industry, thereby increasing the number of common carriers on the road, and thus, competition. This removed the stable revenue structure of the industry, making efficiency and cost-effectiveness major issues.

The 1982 Surface Transportation Assistance Act allowed the operation of larger, more productive vehicles. It affects design and operation costs, so semiconductor technology will be a major force in meeting the needs of truck makers and buyers. Here again, equipment must be simple to use and maintain, reliable, and cost effective.

Mr. Stanley pointed out that electronic applications already in today's large vehicles include:

- Cruise control
- Road speed governors
- Automatic engine shutdown
- Engine coolant level warning
- Recording speedometers and tachometers
- AM/FM radios and cassette decks
- Audible warning devices
- Speedometers
- Digital clocks
- Two-way radios
- PTO speed control
- Tachometers
- Panel lamp dimmers

Successful implementation of these devices, coupled with developments in electronic technology, will generate new applications. Key applications that will emerge within the next 2 to 10 years include:

- Engine timing
- Transmission shifting
- Vehicle security
- Steering
- Suspension systems
- Engine power
- Fuel injection
- Climate control
- Fuel economy
- Obstacle warning
- Axle loading
- Component condition
- Failure warning
- Routing
- Driver performance
- Component performance

- Seat attitude
- Brakes
- Cargo data
- Maintenance diagnostics
- Fuel tax information
- Vehicle location

In the future, electronic technology will also play a key role in meeting government regulations for vehicle emissions and driver safety. Mr. Stanley emphasized that commercial vehicle electronics offers challenges to all players to:

- Identify and develop electronic equipment and systems that meet requirements for low cost of ownership
- Establish roles among truck manufacturers and component and electronics suppliers to develop cost-effective on-board systems
- Integrate electronics technology with other truck design technologies

SOMETHING FOR EVERYONE

The most substantial trend that emerged at the conference was that all vehicle manufacturers want to eventually integrate the electronic systems on their vehicles. Construction and agricultural equipment manufacturers and truck, bus, and automobile makers intend to link the various electronic control modules and devices that are part of their vehicles.

The expectations for system integration are high, as is the tremendous willingess of vehicle manufacturers to work with electronics manufacturers to develop cost-effective and reliable technologies for multiplexing, local area networks, and communication protocols. DATAQUEST believes that semiconductor manufacturers who play a key role in facilitating total vehicle system communication will gain the strong benefits of early entry into a quickly emerging vehicle electronics market.

CONCLUSIONS

The Convergence conference is a premiere event. It offers a multitude of benefits for all players who are actively pursuing the challenges that electronic vehicle applications present. We believe that as this new market evolves, future conferences will be even more significant. We await Convergence '86 with great interest.

Anthea C. Stratigos
Gail Kelton-Fogg

Nielsen Dataquest RESEARCH NEWSLETTER

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GENERAL INDUSTRY UPDATE: A PROCESS OF ADJUSTMENT

SUMMARY

The semiconductor industry is facing two difficult quarters of inventory adjustment by end users. The weakened demand will shorten lead times and is already causing price pressure in commodity products. DATAQUEST forecasts that in the fourth quarter of 1984, U.S. semiconductor consumption will grow only 5 percent over the preceding quarter. Quarter-to-quarter growth in the first quarter of 1985 is expected to be 3.8 percent. Table 1 shows our estimates of quarterly growth for 1983 through 1985.

The book-to-bill ratio has declined steadily throughout 1984, reaching 0.84 to 1 in September. (See Figure 1.) Such a decline has previously been the forerunner of an industry recession that has been associated with an economic recession. However, although the economy is slowing, we do not believe that it is entering a recession. The situation suggests a process of adjustment rather than a downturn.

ECONOMIC TRENDS

Economic indicators suggest that, although the economy is slowing, it will continue to be healthy throughout 1985. The relatively low inflation rate suggests that the economy is not overheating, and that expansion will continue. The index of leading indicators rose 0.5 percent in August after two months of decline. September figures showed personal income rising by 0.9 percent and consumer spending rising by 1.4 percent over the previous month, suggesting continued consumer confidence in the economy. People are reacting to the realization that inflation has remained low, long-term interest rates are falling, and the money supply has remained in reasonable check.

Economic growth in other major countries has not reflected that of the United States. Europe's recovery remains slow, although at 1.3 to 1, the European semiconductor book-to-bill ratio is higher than that of the United States. This positive ratio is partly due to the fact that European semiconductor consumption patterns tend to lag those of the United States by three to six months.

The Japanese economy did not achieve the rapid growth experienced by the U.S. economy in the early part of 1984, and a slowdown is forecast for 1985. We believe that the slowdown in the United States could begin to affect Japanese exports before the end of 1984.

THE PROCESS OF ADJUSTMENT

In the past two or three months, semiconductor users' inventories have built up very rapidly, especially at companies involved in the office automation and personal computer markets. The euphoric expectations of earlier in the year have come face-to-face with a less buoyant economy and reality. As semiconductor users have seen demand for their own products increase more slowly than they had anticipated, they have lowered their expectations, and decreased or stretched out their semiconductor orders accordingly. In markets such as that for personal computers, where companies' anticipated market share added up to significantly more than 100 percent of the total available market, there have inevitably been disappointments and some disasters.

As demand has declined, products have become more available, prices have softened, and lead times have shortened. This situation has caused purchasers to cut back on purchases and in some cases to cancel and renegotiate orders to obtain lower prices. The problem feeds on itself, because as prices decline and lead times become shorter, purchasers decide that they no longer need to maintain the high inventory levels of the past months--causing a further decline in demand.

Semiconductor manufacturing capacity has expanded tremendously during the last few quarters. After their experience of emerging from the previous two recessions, semiconductor manufacturers were more ready to meet the upturn in demand when it occurred. U.S. merchant capital expenditures declined only 10.4 percent during the last recession in 1982, compared to a 53.2 percent decline in the recession of 1975, indicating a substantial increase in new fabrication capacity. Companies also increased their capacity by increasing the number of shifts operating at existing facilities.

This combination of high capacity and declining demand is usually the forerunner of a downturn in the semiconductor industry. However, such a downturn has always been associated with a decline in the nation's economy. For this reason, DATAQUEST views the current situation as a relatively short period of inventory adjustment. This view is supported by major semiconductor manufacturers who have seen demand declining only in the office automation market and not in the military, automotive, or telecommunications markets. Price pressure is occurring predominantly in the commodity devices area, and many high value-added devices, such as the newer microprocessor families, are still holding their prices. The turbulence caused by the period of adjustment will be a painful one for semiconductor manufacturers, but once excess inventory has been used up, buyers will return to buying patterns more closely related to the demand for their own products.

SEMICONDUCTOR INDUSTRY OUTLOOK

Although U.S. semiconductor consumption in 1985 is not expected to grow at the astounding 49.5 percent year-to-year rate forecast for 1984, DATAQUEST expects growth of 23.8 percent to a total of $15,432 million. Table 2 shows our estimates of U.S. semiconductor consumption for 1983 through 1985.

As shown in Table 1, the first quarter of 1985 is expected to grow by only 3.8 percent over the last quarter of 1984, as the period of inventory adjustment continues. The rate of growth in the second quarter of 1985 should increase to 5.3 percent over the first quarter with consumption estimated at $3,744 million. Historically, the third quarter of a year usually shows a slower growth rate than the second--we are estimating growth of 4.2 percent over the second quarter. In the last quarter of 1985, we expect a healthy 8.5 percent growth over the third quarter with consumption totaling $4,232 million.

The decline in consumption growth rates can most clearly be seen by comparing each quarter with the same quarter of the preceding year. This same-quarter growth rate peaked in the first quarter of 1984 when U.S. semiconductor consumption was 61.2 percent higher than the first quarter of 1983. Same-quarter growth rates in 1985 are decidedly less robust--the first quarter of 1985 is expected to be 31.6 percent higher than the first quarter of 1984, and the third quarter of 1985 is forecast to be only 19.6 percent higher than the same quarter of 1984. Such growth rates are, of course, only modest by semiconductor industry standards.

Semiconductor manufacturers are facing a difficult few months. We expect to see companies moving to stretch out their capital expenditure plans and rewrite budgets for next year. Many companies have already cut their hiring plans even if they have not imposed an outright hiring freeze. The book-to-bill ratio will probably not reach unity until early 1985. Since the ratio is a three-month rolling average, the very low bookings in September will affect October and November, and softening prices for new orders will also affect the next few months.

We expect price pressure and declining demand to fall unevenly on the various products. Companies with a high ratio of proprietary products to commodity products will fare better than those that are more focused on commodity products. Companies that achieved market share as overflow suppliers during times of shortage will now have to work very hard to retain user loyalty. In a market where purchasers are working to cut their supplier bases, it is even more important to retain status as a preferred vendor. Companies with single product lines are facing an especially difficult challenge.

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Frederick L. Zieber
Jean Page

Table 1

ESTIMATED QUARTERLY U.S. SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1983				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 294	$ 342	$ 371	$ 416	$ 1,423
Integrated Circuits	1,382	1,626	1,816	2,090	6,914
Total	$1,676	$1,968	$2,187	$2,506	$ 8,337
Percent Change from Previous Quarter	1.4%	17.4%	11.1%	14.6%	
Percent Change from Previous Year	7.1%	14.9%	30.1%	51.6%	26.1%

	1984				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 442	$ 491	$ 501	$ 520	$ 1,954
Integrated Circuits	2,260	2,586	2,760	2,905	10,511
Total	$2,702	$3,077	$3,261	$3,425	$12,465
Percent Change from Previous Quarter	7.8%	13.9%	6.0%	5.0%	
Percent Change from Previous Year	61.2%	56.4%	49.1%	36.7%	49.5%

	1985				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 529	$ 549	$ 558	$ 582	$ 2,218
Integrated Circuits	3,026	3,195	3,343	3,650	13,214
Total	$3,555	$3,744	$3,901	$4,232	$15,432
Percent Change from Previous Quarter	3.8%	5.3%	4.2%	8.5%	
Percent Change from Previous Year	31.6%	21.7%	19.6%	23.6%	23.8%

Source: DATAQUEST

Figure 1

BOOK-TO-BILL RATIO--1984

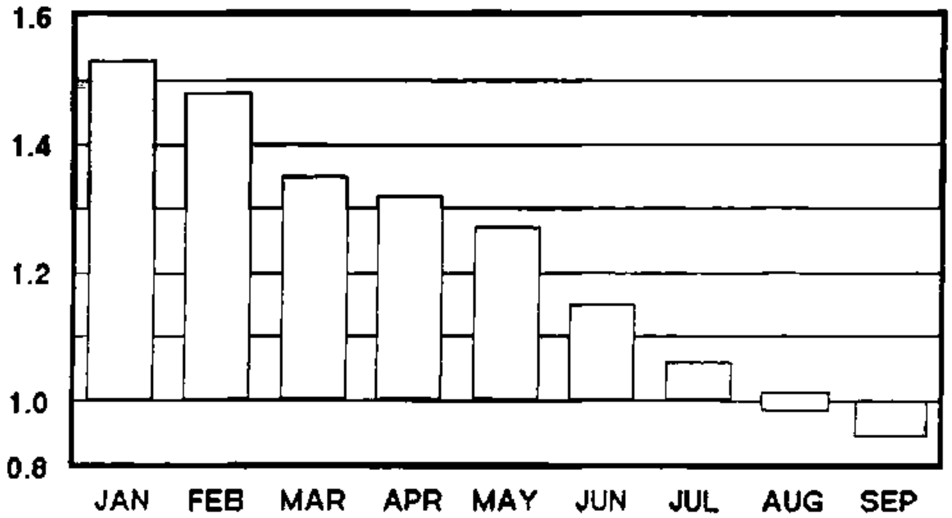
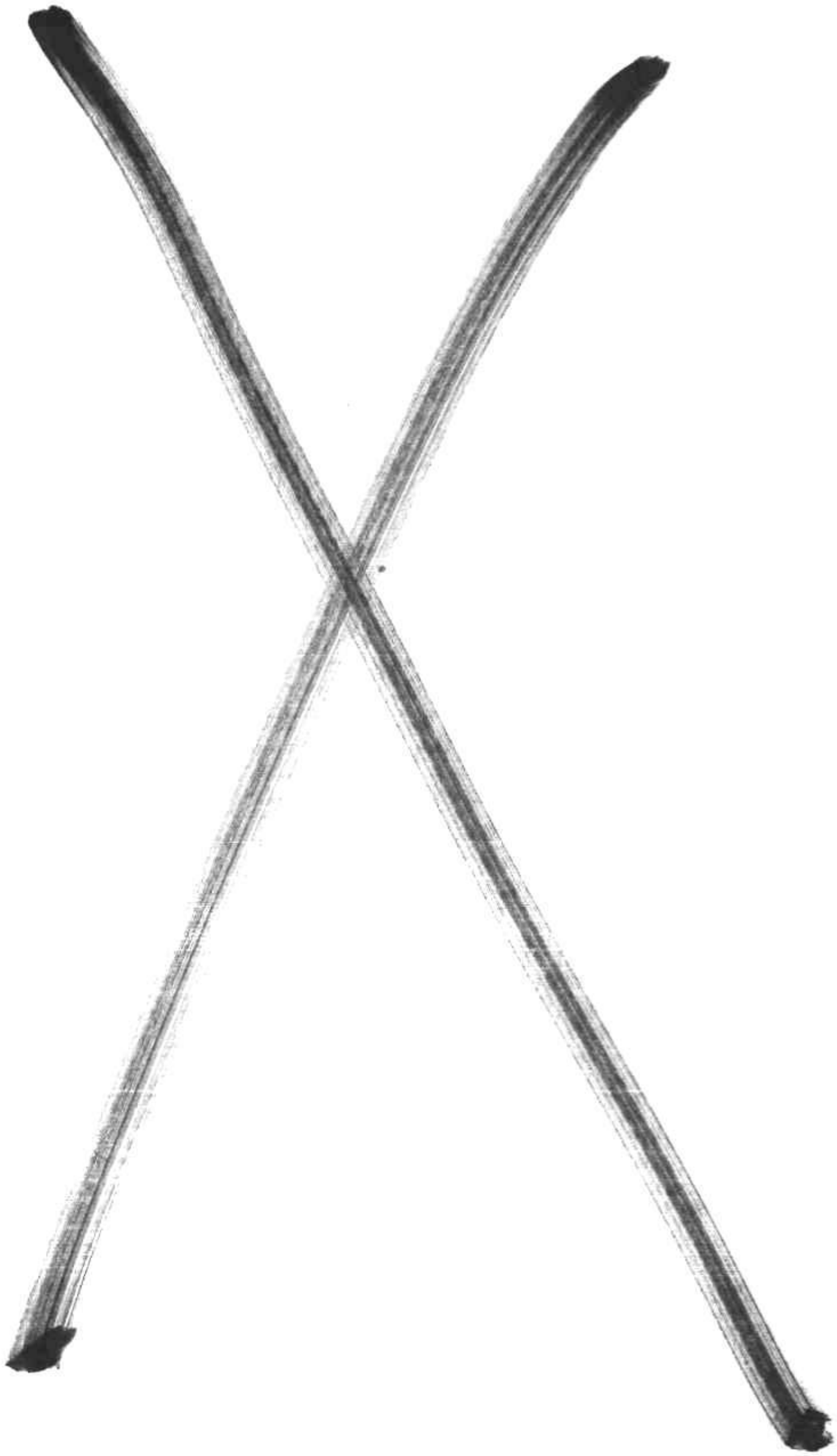


Table 2

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

	1983	1984	1985
Discrete Devices	$1,423	$ 1,954	$ 2,218
Integrated Circuits	6,914	10,511	13,214
Total	$8,337	$12,465	$15,432

Source: DATAQUEST



December Newsletters

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

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

FINAL 1983 MARKET SHARE SUMMARY

SUMMARY

Semiconductors had a strong growth year in 1983. Most product categories experienced significant growth; the strongest was MOS digital technology. DATAQUEST noted growth of 26.7 percent in total semiconductors; 33.6 percent in ICs; 40.6 percent in MOS digital; and 9.2 percent in discrete/opto (see Table 1).

Table 1

WORLDWIDE SEMICONDUCTOR CONSUMPTION
1982-1983

Category	Percent Growth 1982-1983
Total Semiconductor	26.7
Total IC	33.6
MOS Digital	40.6
Total Discrete/Opto	9.2

Source: DATAQUEST

SEMICONDUCTOR MARKET SHARE

For the top 30 semiconductor manufacturers, revenues increased by 27.9 percent. The company mix by regional base included 9 Japanese companies with an average revenue increase of 37.7 percent; 5 European companies with an average increase of 9.7 percent; and 16 U.S. companies, with an average increase of 24.8 percent. European companies actually experienced stronger growth than the figure would indicate; the rate appears artificially low as a result of reporting in dollars, which were exceptionally strong against European currencies. Several manufacturers increased their market positions, exceptional among them was AMD, which moved from fourteenth place to tenth place in 1983 (see Table 2).

Table 2

1983 vs. 1982 SEMICONDUCTOR RANKINGS
(Millions of Dollars)

1983 Rank	1982 Rank	Company	1982 Revenues	1983 Revenues
1	1	Texas Instruments	$ 1,305	$ 1,638
2	2	Motorola	1,219	1,547
3	3	NEC	1,075	1,413
4	4	Hitachi	877	1,181
5	5	Toshiba	714	983
6	6	National	673	875
7	7	Intel	625	775
8	8	Fujitsu	465	688
9	10	Matsushita	426	600
10	14	AMD	329	505
11	11	Fairchild	410	500
12	9	Philips	457	482
13	13	Mitsubishi	338	440
14	12	Signetics	340	435
15	15	Siemens	329	333
16	18	Sanyo	241	329
17	19	Mostek	220	315
18	17	RCA	273	297
19	20	Sharp	192	279
20	16	G.I.	296	255
21	22	SGS-Ates	175	230
22	27	Oki	134	229
23	25	Thomson	148	195
24	21	ITT	190	185
25	23	Harris	156	180
26	24	AMI	156	162
27	31	Analog Devices	101	145
28	28	TRW	120	144
29	26	TELEFUNKEN electronic	143	134
30	32	MMI	70	131
Total			$12,197	$15,605

Source: DATAQUEST

INTEGRATED CIRCUIT MARKET SHARE

The rankings of the leading integrated circuit (IC) manufacturers shifted considerably throughout the listing of the top 25 participants. Many of the Japanese companies moved upward in the listing. We believe that some of the gain illustrated for the Japanese is due to the strength of the yen against the dollar in 1983. Of the 25 leading IC manufacturers listed in Table 3, 9 were Japanese, 3 were European, and 13 were U.S.-based. Average growth for the top 25 companies was 35.6 percent.

Table 3

1983 vs. 1982 INTEGRATED CIRCUIT RANKINGS
(Millions of Dollars)

1983 Rank	1982 Rank	Company	1982 Revenues	1983 Revenues
1	1	Texas Instruments	$1,155	$ 1,535
2	2	NEC	791	1,093
3	3	Motorola	791	1,060
4	6	Hitachi	607	912
5	5	National	620	820
6	4	Intel	625	775
7	8	Fujitsu	427	618
8	7	Toshiba	428	613
9	11	AMD	329	505
10	9	Signetics	340	435
11	10	Fairchild	333	423
12	12	Matsushita	249	367
13	13	Mitsubishi	244	337
14	15	Mostek	220	315
15	14	Philips	230	259
16	23	Oki	121	216
17	17	RCA	185	211
18	21	Sanyo	146	204
19	19	Harris	156	180
20	18	Siemens	160	178
21	22	SGS-Ates	126	177
22	24	Sharp	115	164
23	20	AMI	156	162
24	25	Analog Devices	101	145
25	26	MMI	70	131
Total			$8,725	$11,835

Source: DATAQUEST

DIGITAL MOS MARKET SHARE

A list of the top 20 digital MOS manufacturers, Table 4, illustrates that the Japanese made significant position moves in 1983. Growth experienced by Japanese companies was 52.6 percent, while U.S. companies increased by only 27.8 percent. Position gains were noted by many companies, including Mostek, AMD, and Philips. The average growth rate for these leading MOS producers was 38.8 percent.

Table 4

1983 vs. 1982 DIGITAL MOS RANKINGS
(Millions of Dollars)

1983 Rank	1982 Rank	Company	1982 Revenues	1983 Revenues
1	2	NEC	$ 547	$ 786
2	1	Intel	573	720
3	5	Hitachi	390	638
4	3	Motorola	425	607
5	4	Texas Instruments	400	572
6	6	Toshiba	311	458
7	7	Fujitsu	280	418
8	9	Mostek	220	315
9	8	National	235	305
10	12	AMD	146	224
11	15	Oki	106	197
12	13	Mitsubishi	137	189
13	11	AMI	156	162
14	17	Matsushita	89	160
15	16	Sharp	100	145
16	14	RCA	108	133
17	10	G.I.	174	113
18	20	Philips	61	100
19	18	Synertek	88	96
20	19	Rockwell	80	83
Total			$4,626	$6,421

Source: DATAQUEST

DISCRETE/OPTO MARKET SHARES

Of the top five manufacturers in the discrete/opto market, four were Japanese. Motorola remained the leader in discretes with 1983 revenues of $487 million. The average growth for the leading 15 manufacturers in this category was 14.2 percent. Most of the rapid growth experienced by the individual companies shown in Table 5 is due to optoelectronics (optos). The entire optoelectronics industry grew by an estimated 26.0 percent, compared with 5.0 percent for discretes. The strength in optos came from the Japanese.

Table 5

1983 vs. 1982 DISCRETE/OPTO RANKINGS
(Millions of Dollars)

1983 Rank	1982 Rank	Company	1982 Revenues	1983 Revenues
1	1	Motorola	$ 428	$ 487
2	2	Toshiba	286	370
3	3	NEC	284	320
4	4	Hitachi	270	269
5	6	Matsushita	177	233
6	5	Philips	227	223
7	7	Siemens	169	155
8	10	Hewlett-Packard	102	130
9	8	G.I.	110	128
10	13	Sanyo	95	125
11	9	TRW	105	118
12	17	Sharp	77	115
13	11	G.E.	100	112
14	14	Mitsubishi	94	103
15	15	Thomson	88	96
Total			$2,612	$2,984

Source: DATAQUEST

NOTE

This newsletter is a summary of the data reported in the finalized study of the Market Share Analysis. These data are available with the notebook holder of your service. For details of any of the company revenue statistics mentioned, please refer to the index of tables attached to this newsletter.

Barbara A. Van

INDEX OF TABLES

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

GATE ARRAY IMPACT ON THE ASIC MARKETPLACE

This newsletter covers the highlights of the Gate Array service section in the Semiconductor Industry Service (SIS) Products and Markets notebook.

OVERVIEW

The predominant message of the gate array marketplace is that everything happening is covered by one word--service. The phenomenal growth of gate arrays is in one way or another related to service. For instance:

- Merchant and captive suppliers must provide service.
- The competition must offer more service than their peers.
- Electronic design automation (EDA) provides service at a lower cost.
- Users measure the amount of service they receive from suppliers.

Each individual company must address the market by asking how it can provide its customers with the most cost-effective service.

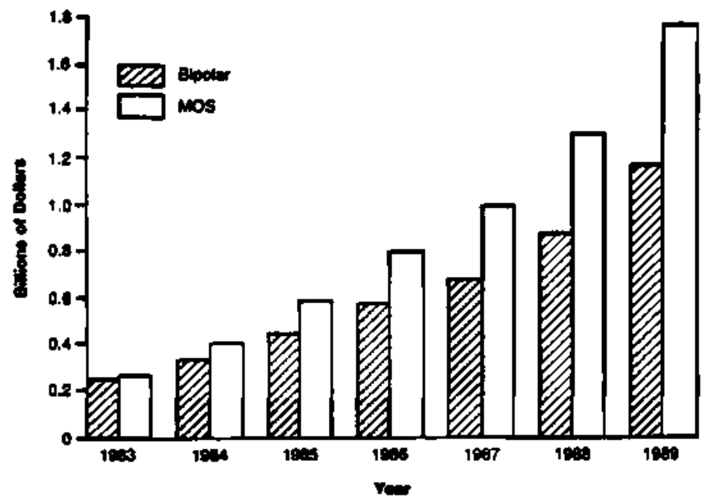
DATAQUEST believes that service revenues can be substantial and include high margins. The successful companies in this business will make money on service. In the long run, it will not be possible to provide the service the market desires unless it is profitable. We believe that the users are willing to pay.

From its very modest beginnings in 1979, the gate array market grew at a compound annual growth rate (CAGR) of 66 percent through 1983. The MOS portion grew at a 78 percent CAGR and the bipolar portion at a 55 percent CAGR. But the most spectacular growth is yet to come. DATAQUEST believes that this market will reach $2.5 billion to

$3.5 billion by the end of the decade. The overall growth of the gate array market from 1983 through 1989 is illustrated in Figure 1.

Figure 1

ESTIMATED WORLDWIDE GATE ARRAY CONSUMPTION



Source: DATAQUEST
December 1984

TRENDS

Applications

Of all the ASIC product families, gate arrays are having the most comprehensive impact on the $184 billion electronic equipment industry. They offer a system manufacturer:

- Lower manufacturing costs through savings in assembly costs
- Lower power consumption
- Higher system reliability
- Design security
- Shorter time to market
- Low-cost incremental features

Supplier-User Interface

Gate arrays offer different expectations for suppliers and users. Both parties would like to have a standard product with the flexibility of gate arrays. The following items outline the different wants of both parties.

- User wants
  - Quick delivery of the prototype units
  - Easy-to-use EDA tools that require a minimum amount of time to learn
  - Prototype units that work the first time
  - Low development and production costs
  - Convenient design centers and training
- Supplier wants
  - Minimum user involvement
  - Maximum production volumes
  - Few design changes

The availability of friendlier EDA tools is resolving some of the differing expectations. It is also the driving force behind the 50 percent per year growth rate in the EDA marketplace.

Alternate Sourcing

DATAQUEST believes that there will be a constant stream of alternate-source agreements over the next three years. With more than 80 companies actively engaged in the gate array market, and with no dominant supplier, the need for a real alternate source will grow in importance. Unfortunately, there are real alternate sources and there are alternate sources that exist in name only.

TECHNOLOGY

Future Prospects

The gate array business has changed rapidly over the last three years. Products, technologies, and vendors have all mushroomed. Major portions of the user community have adopted gate arrays, while others are still wondering how serious and how real all of these new concepts are. Table 1 summarizes the three major technologies in terms of cost, speed, and power.

Table 1

GATE ARRAY TECHNOLOGY COMPARISON

Process Technology	Cost per Gate	Speed (MHz)	Power (Watts)
CMOS	$0.015 to $0.045	10 to 80	0.01 to 0.1
TTL	$0.02 to $0.05	30 to 150	0.1 to 1.5
ECL	$0.03 to $0.10	100 to 250	2 to 10

Source: DATAQUEST
December 1984

The MOS segment is expected to be the dominant technology, with more than 60 percent of the market by 1990. We believe that this rapid growth will fuel the following major trends:

- Merchant gate array suppliers will surpass the captive suppliers by adding design centers and other service-related features to their product lines.

- Captive suppliers will continue to grow and many will become merchant suppliers. For example, VTC Inc. recently became the merchant arm of Control Data Corporation's captive semiconductor activity. Other merchant/captive suppliers include: Fujitsu, Hitachi, Honeywell, NEC, Oki Electric, Plessey Ltd., Siemens, and Toshiba.

- The market will take on a worldwide scope:

    - The Japanese will become aggressive suppliers in both Europe and the United States.

    - The European suppliers will dominate the European market, with U.S. and Japanese suppliers taking moderate shares.

- There is currently a significant shift away from standard logic to gate arrays.

- Standard products will be embedded in gate arrays to achieve higher levels of integration.

- The use of third-party EDA workstations in the design process will continue to increase.

All this adds up to a unique set of opportunities and problems. The opportunity is that system manufacturing costs can be lowered considerably if designs are converted to gate arrays. The problem is that conversion is difficult and some companies may find themselves falling behind in the competitive race.

Table 2 shows the 1983 through 1989 forecasts of gate array consumption by region. Table 3 shows the top ten suppliers of gate arrays, who supplied approximately 61 percent of the market in 1983.

Katy Guill
Andy Prophet

Table 2

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

Region	1983	1984	1985	1986	1987	1988	1989
Worldwide Total	513.0	737.5	1,028.9	1,364.6	1,670.7	2,175.5	2,930.9
MOS	259.9	402.3	583.8	794.4	992.8	1,300.1	1,768.6
Bipolar	253.1	335.2	445.1	570.2	677.9	875.4	1,162.3
North American	280.5	384.2	524.6	695.6	802.0	1,000.5	1,345.8
MOS	147.2	203.6	263.9	364.5	441.1	553.3	757.7
Bipolar	133.3	180.6	260.7	331.1	360.9	447.2	588.1
Japanese	101.0	179.1	254.8	380.5	466.2	611.9	794.4
MOS	51.0	99.4	173.3	253.8	309.2	406.2	530.7
Bipolar	50.0	79.7	81.5	126.7	157.0	205.7	263.7
Western Europe	128.0	170.3	241.7	272.8	371.0	500.2	674.4
MOS	58.2	95.4	139.2	162.0	218.9	296.6	404.6
Bipolar	69.8	74.9	102.5	110.8	152.1	203.6	269.8
Rest of World	3.5	3.9	7.8	15.7	31.5	62.9	116.3
MOS	3.5	3.9	7.4	14.1	23.6	44.0	75.6
Bipolar	0.0	0.0	0.4	1.6	7.9	18.9	40.7

Source: DATAQUEST
December 1984

Table 3

ESTIMATED 1983 WORLDWIDE SHIPMENTS
TOP TEN GATE ARRAY COMPANIES
(Millions of Dollars)

Company	1983
Fujitsu	$64.6
Ferranti	$43.4
Texas Instruments	$43.0
LSI Logic	$32.4
NEC Electronics USA	$28.7
Interdesign	$26.2
Motorola	$24.1
Siemens	$18.1
Signetics	$17.9
Toshiba	$14.0

Source: DATAQUEST
December 1984

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

GENERAL INDUSTRY UPDATE: ADJUSTING TO THE SLOWDOWN

SUMMARY

In view of the rapid slowdown in the U.S. economy and stronger pressure on prices than we anticipated, DATAQUEST has revised its U.S. semiconductor consumption estimates downward. We estimate a decline in dollar volume of 6.5 percent in the fourth quarter of 1984 compared with the previous quarter. Our forecast for the first quarter of 1985 is for a further decline of 2 percent compared with the first quarter of 1984. We expect consumption to grow by 6.4 percent in 1985 over 1984. Table 1 gives DATAQUEST's estimates for quarterly semiconductor consumption growth for 1983 through 1985. However, unit consumption continues to increase, and the current decline is predominantly price driven. Although the outlook for the semiconductor industry in the immediate future is more pessimistic than in our previous newsletter ("General Industry Update: a Period of Adjustment," November 9, 1984), we still expect sustained but slower growth in the nation's economy during 1985.

The book-to-bill ratio declined to 0.61 to 1 in November and is expected to remain depressed into 1985. Billings also declined in October for the first time since July.

ECONOMIC TRENDS

The U.S. Commerce Department's index of leading economic indicators fell in October to 163.8, from a revised September estimate of 165 (1967 = 100). This was the third drop in five months. Although this decline suggests that the current economic slowdown could continue into the first months of 1985, most economists expect a modest return to growth rather than the beginnings of a recession.

The sharp increase in the money supply (M1) reported for the week of November 19, together with the recent decline in interest rates, had allayed the fears of some economists that slow growth in the money supply could push the economy into a recession. However the sharp decline in the money supply in early December has caused some concern. The Federal Reserve Board is likely to move to increase the money supply, possibly by lowering the discount rate to 8 percent from the current 8.5 percent.

Unemployment declined from 7.4 percent in October to 7.0 percent in November. This decrease is a positive sign, although some of the improvement may be seasonal.

Although industrial production rose in most European countries in October, Europe never participated in the strong recovery achieved in the United States during the early part of 1984. We expect the European economies to be adversely affected by the current slowdown in the U.S. economy.

The level of consumer spending during the Christmas season could well determine whether we return to a path of economic growth or continue the current slowdown. The outlook, based on the high level of retail sales in November, is reasonably good, with consumer confidence remaining high.

TODAY'S SEMICONDUCTOR MARKET

The process of adjustment that we discussed in our previous newsletter is continuing. Although we still believe that inventory adjustment must work its way through the system before semiconductor consumption can get back on a strong growth path, we have seen a worsening of conditions over the past month--the book-to-bill ratio declining to 0.61 to 1 in November and expected to remain low into the first quarter of 1985; most semiconductor companies experiencing cancellations and stretchouts on orders; and prices for commodity products declining much more rapidly than was anticipated. Semiconductor users are still working through the inventory buildup that developed when lead times were longer. Because of concern over shortages, companies built inventories that were not only higher than usual, but also out of mix when they accepted partial shipments.

The softening of the economy led semiconductor users to reduce their own expectations of sales, and this led to further declines in orders. The personal computer market is still very slow, and major computer companies such as IBM and Digital Equipment Corporation have cancelled or reduced orders.

The other significant factor in the decrease in dollar volume is the rapid decline in the prices of commodity products. Memory devices, such as the 64K DRAM, have declined in price by as much as 40 percent. Unit shipments continue to increase as new fabrication capacity comes on stream. The increase in capacity puts additional price pressure on the commodity market.

Because the slowdown is in prices, commodity products have been hit much harder than the more specialized products that have a limited number of suppliers. Companies that have developed a base of value-added products with less price elasticity will fare better in the months ahead than companies that are heavily dependent on commodity devices for their revenues.

SEMICONDUCTOR INDUSTRY FORECAST

DATAQUEST forecasts a decline of 6.5 percent in U.S. semiconductor consumption in the fourth quarter of 1984 compared with the preceding quarter. Consumption in the first quarter of 1985 is expected to decline a further 2 percent compared with the fourth quarter of 1984, to $2,988 million. After quarter-to-quarter growth rates of 3.9 and 4.4 percent in the second and third quarters respectively, consumption is forecast to grow by 8.7 percent in the fourth quarter of 1985 compared with the third quarter. Semiconductor consumption in the United States is expected to increase by 6.4 percent in 1985 over the 1984 figure, with most of the growth taking place in the last quarter of the year. We forecast the 1985 total to be $12,857 million compared with $12,089 million in 1984. Slow growth or no growth in the first quarter of a year has a cumulative effect on the forecast for subsequent quarters.

Despite the current slowdown in the economy, unit consumption of semiconductors continues to rise. We expect the economy to improve in the coming year, but at a slower rate than was experienced in the first half of 1984. A return to economic growth will make the difficult period of adjustment reasonably short, and we expect semiconductor consumption to return to its historic growth patterns in the second half of 1985.

Frederick L. Zieber
Jean Page

Table 1

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(Millions of Dollars)

	1983				
	Q1	Q2	Q3	Q4	Total Year
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Percent Change from Previous Quarter		17.4%	11.1%	14.6%	
Percent Change from Previous Year					

	1984				
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Total	$2,702	$3,077	$3,261	$3,049	$12,089
Percent Change from Previous Quarter	7.8%	13.9%	6.0%	(6.5%)	
Percent Change from Previous Year	61.2%	56.4%	49.1%	21.7%	45.0%

	1985				
	Q1	Q2	Q3	Q4	Total Year
Discrete Devices	$ 466	$ 471	$ 485	$ 499	$ 1,921
Integrated Circuits	2,522	2,634	2,756	3,024	10,936
Total	$2,988	$3,105	$3,241	$3,523	$12,857
Percent Change from Previous Quarter	(2.0%)	3.9%	4.4%	8.7%	
Percent Change from Previous Year	10.6%	0.9%	(0.6%)	15.6%	6.4%

Source: DATAQUEST
December 1984

Dataquest
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The Dun & Bradstreet Corporation

RESEARCH
NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

HIGHLIGHTS OF DATAQUEST'S SEMICONDUCTOR INDUSTRY CONFERENCE--PERVASIVENESS--ITS TIME IS HERE!

SUMMARY

The Semiconductor Industry Service's Tenth Anniversary Conference was set in San Diego at the Hotel Del Coronado. The event attracted a record crowd of approximately 450 attendees. The mood was upbeat as clients looked past the current market weakness to a semiconductor industry of unprecedented size.

The conference theme was "pervasiveness"--the penetration of semiconductors into new and unique applications. In support of this concept, well-known industry speakers discussed changes within the industry in terms of history, geography, new products, end markets, and the future.

This newsletter summarizes the topics discussed at the Semiconductor Industry Conference. Conference notebooks were distributed to all conference attendees and were sent to subscribers who could not attend the conference. Clients wishing to read specific speeches should contact their SIS notebook holder or conference attendee.

SPEAKER HIGHLIGHTS

A sample of conference highlights follows:

- Fred Zieber, DATAQUEST. ". . . we are going to experience several difficult months, a couple of quarters, as we go through this period of adjustment of inventories and other excesses. . . . We expect more rapid growth to resume. Long-term growth of the industry will continue. Pervasiveness has just begun."

- Chuck Thompson, Motorola. "If the $200 billion semiconductor guesstimate comes true . . . in 1995, $1 million worth of semiconductors will be included in each piece of equipment delivered to 10,000 military end users; $250 thousand worth of semiconductors will be included in each of 400,000 businesses; $250, in each of 40 million vehicles; $300, in each of 200 million homes; and $30, consumed by each of 700 million people."

- Jim Riley, DATAQUEST. "To keep your competition out . . . you have to decide, am I a commodity, a super niche, an application-specific or dedicated product supplier? . . . Pick a spot and live with it."

- John Cornell, Harris. "Highly integrated systems will be made possible by the convergence of CMOS design automation and advanced packaging technologies, and will ensure growth and innovation in the new information technology age."

- T.J. Rogers, Cypress Semiconductor. ". . . around mid-1979 is when everything crossed over, and I say for the last five years all technologies have had the same speed. . . ."

- Roger Smullen, Applied Micro Circuits. "Within the logic market, we are seeing a continuing push toward higher performance . . . visualization of this trend indicates consistent performance improvements of approximately two orders of magnitude every decade."

- John Abram, Arrow Electronics. "In the next several years, there will be three or more distributors selling in the billions each . . . these distributors will be global companies."

- Jack Carsten, Intel. ". . . about 500 companies tried to manufacture automobiles. . . . What struck me was the similarity to the current list of personal computer manufacturers. . . . I wonder how many of those are going to be around in another ten or twenty years."

- Charles Phipps, Texas Instruments, revisited Pat Haggerty's original perspective on pervasiveness. Mr. Haggerty's view of the future was remarkably prescient.

ASIC TRENDS

The market for application-specific integrated circuits (ASICs) has expanded phenomenally. DATAQUEST estimates that there are currently more than 130 suppliers in the merchant market, and the market is expected to reach $9.8 billion by 1989. The expansion of the product is due largely to the advent of better CAD equipment, improved technology, and the customer's need for specialized circuitry. Roger Smullen notes that, "Semicustom design approaches are bringing the custom cost and performance of LSI and VLSI levels of integration to the logic designer."

In a speech titled "ASICs Come of Age," Henri Jarrat gave a progress report on the market and compared ASICs with microprocessor developments. Mr. Jarrat projected that, "We will see more and more of the world's 200,000 to 300,000 systems engineers becoming silicon architects and creating their own application-specific integrated circuits, and that's the key ingredient to the explosive ASIC growth."

Doug Ritchie discussed system design requirements and stressed the need to bridge the "CAD gap." He defined this gap as the lack of understanding of the whole perspective by the silicon designer, who focuses on the chip, and by the system designer, who focuses on the environment of the chip. It is important "to provide more modularity between CAD worlds," and Mr. Ritchie calls for interface formats to bridge the "CAD gap." Wilf Corrigan also stressed the need to provide service to the customer and to develop good software in his speech entitled "Systems, Software, and Silicon."

SEMICONDUCTOR EQUIPMENT--KEY TO PERVASIVENESS

Bill Bottoms reviewed developments in the equipment market and the implications for electronics pervasiveness. Technology developments have enabled the continued reduction in cost of electronic functions. Circuit sizes have decreased and yields have improved. Mr. Bottoms noted that, "Over the next few years, the role played by the equipment industry in the continued expansion of the pervasiveness of solid state electronics by reducing costs will continue to increase."

OPPORTUNITIES IN JAPAN

In a speech on Japanese involvement in VLSI, Jerry Crowley discussed activity in computing and communications. Japan is presently working on fourth- and fifth-generation computers. The Japanese are also actively installing an Integrated Network System (INS) that will link the office with the home, through large amounts of electronic devices. These systems represent guaranteed market opportunities within Japan for industrious manufacturers. For suppliers that can produce product in favored technologies such as CMOS, ECL, and gallium arsenide, these Japanese systems represent an excellent opportunity.

SEMICONDUCTORS--HISTORY AND FUTURE

Many of the speakers looked to historic trends in contemplation of the future. Product life cycle and replacement were evaluated, end-market proliferation was explored, and industry analogies were made. Jack Carsten made a very interesting comparison between semiconductors and engine industries of the past. In his speech, he noted that, like semiconductors, steam engines, internal combustion engines, electric motors, and jet engines all recorded very high growth periods and exhibited learning curve behavior. Additionally, for these historic industries, "Product maturation was tied to saturation of their end industries."

Semiconductors have not begun to saturate their end industries. We believe that they will continue to experience strong growth into the future, as new applications and technologies develop. Pervasiveness--its time is here!

WORKSHOPS

In addition to the main conference proceedings, workshop sessions were offered. These workshops included sessions on memory devices, microprocessors, CAD/CAM and ASICs, equipment and technology, geographic trends, and user requirements. All sessions featured informal settings, with discussion groups and question and answer periods.

The following are some of the topics discussed in the conference workshops:

- Procurement problems in Japan
- Surface-mount packaging
- Factory automation trends
- Product feature diversification in memory devices
- Microprocessors--history and future
- Merchant capital spending activities

CONFERENCE 1985

Our next SIS conference is planned for Tucson, Arizona. Once again, we expect to have a large attendance, so we are asking participants to make their reservations early to assure themselves a place at the conference.

Barbara Van

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

MOTOROLA UPDATE 1984

SUMMARY

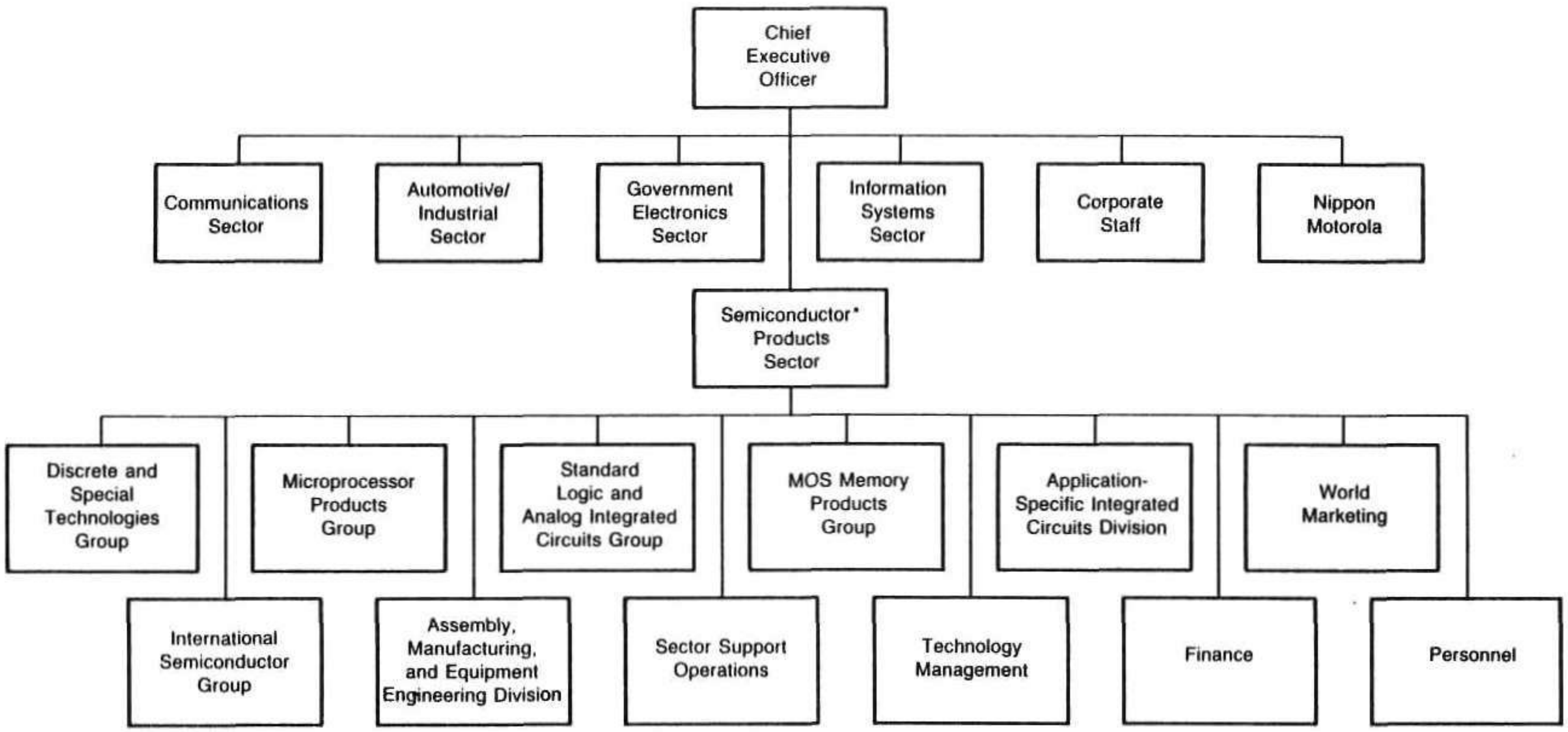
Motorola is the second largest merchant semiconductor manufacturer in the world, with 1983 sales of $1.547 billion. We expect the company's 1984 sales to be in the $2.1 billion range. Motorola management expects the company to grow above the industry as a whole, and plans to achieve this by expanding the company's product capability, by continuing very high levels of research in critical new product areas, and by serving customers' needs more effectively than the competition does. Motorola evaluates its current product portfolio, new product development, and manufacturing expertise to balance the maximization of margins and market penetration. With significant expertise and market presence in the areas of microprocessors, CMOS, MOS, DRAMs, bipolar LSI, optoelectronics, and all major discrete product areas, we expect Motorola to remain a leader in the worldwide semiconductor industry.

CORPORATE STRUCTURE

Motorola's Semiconductor Product Sector is headquartered in Phoenix, Arizona. It is here that management plans its business and marketing strategies for domestic and worldwide activities. In addition to the semiconductor sector, there are four major businesses that report to Motorola's chief executive office at the corporation's headquarters in Schaumburg, Illinois. These businesses include Communications, Automotive/Industrial Electronics, Government Electronics, and Information Systems. For details on the company's organizational structure, see Figure 1.

Figure 1

MOTOROLA ORGANIZATION CHART



* Note: On November 16, 1984, Motorola restructured its Semiconductor Products Sector. The Bipolar IC and MOS IC Groups were divided into the Microprocessor Products Group, MOS Memory Products Group, Standard Logic and Analog Integrated Circuits Group, and the Application-Specific Integrated Circuits Division.

Source: DATAQUEST
December 1984

MARKETING FOCUS

Motorola is running neck and neck with Texas Instruments for the number one position in worldwide semiconductor sales. The difference between these two companies was only 6 percent in 1983. Motorola believes that it has a chance at the number one slot in 1984; DATAQUEST expects the company's sales to grow slightly above the industry through 1989. In the 1989 time frame, Motorola believes that the products planned should provide it with a product mix that will match that of the industry.

Worldwide marketing headquarters are located in Phoenix, Arizona. Operations reporting to the Vice President and Director of Worldwide Marketing include Strategic Marketing, Strategic North American Sales, Geographic and Distributor Sales, System Sales and Engineering, and Marketing Administration. The North American Sales organization consists of more than 1,000 persons. There are more than 50 sales offices in the United States, and a similar number throughout the world. Motorola has a progressive policy toward equal employment opportunities; for example, a significant number of its U.S. sales force are women. The U.S. sales organizations focus on more than 30 strategic accounts, 5,000 geographic accounts, and thousands of distribution accounts.

Motorola works closely with its strategic OEMs and distributors. For example, the company has established a computer-to-computer vendor/customer network with its distributors that allows Motorola to respond to orders swiftly and also to monitor distributor inventory order levels. They are now looking to expand this system to OEM customers. Motorola has also established a "team sell" approach to establish a rapport and to support distributor customers. Distribution presently accounts for about 23 percent of Motorola's total sales. This is slightly lower than the industry average, which is to be expected with such a large direct sales organization.

PRODUCT/TECHNOLOGY FOCUS

Discretes

DATAQUEST believes that Motorola is currently the world leader in discretes. If it achieves its planned growth rate, it should remain in this position. The discrete group is a profit and investment center for Motorola, which is committed to the discrete market. Even though many products within the portfolio may be considered mature, these markets continue to grow in dollar volumes and Motorola continues to increase its market share. In addition, Motorola is adding new products to these lines to increase their served market and maintain their position as a broad line supplier to the overall industry.

Motorola is actively involved in all of the major discrete and opto product areas, with the exception of small signal diodes, LED lamps, and LED displays. It is the number one discrete supplier in the areas of small signal transistors, power transistors, RF products, low- and medium-power thyristors, rectifiers, and zener diodes. The company also maintains a strong presence in other discrete/opto markets such as opto couplers, slotted couplers, IR emitters, and fiber optics.

The portfolio mix and Motorola's discrete business is changing. In addition to its major mature product families, new products are being developed, bringing new technologies and opportunities to the Motorola portfolio. These new technologies often combine discrete and integrated circuit technologies to provide new products containing substantial added value. Examples of these include integrated sensing devices, SMARTpower™ ICs, complex IC opto couplers, and monolithic microwave ICs (MMICs).

Motorola's present product portfolio mix contains approximately 25 percent high technology products and 75 percent mature products. We expect this mix to change over the next five years to a 50-50 mix of mature and advanced technology products. This change in the group's product mix will also likely raise the average selling price and offer improved profit potential.

Other exciting growth areas in the discrete group are RF products including modules for CATV and cellular radio applications, FETs, power MOSFETs, and GEMFETs. In addition, new products in the area of opto couplers, fiber optics systems, and pressure sensors all provide new areas of expansion for Motorola. In pressure sensors, Motorola has a unique application in the area of blood pressure monitoring. The product is being used in hospital operating rooms, and can be built so economically that it is used disposably. This unique feature eliminates problems in disinfecting these products, and provides a substantial market for Motorola.

Motorola is making substantial investments in its discrete manufacturing areas in both capacity expansion and modernization. Floor space will be added during 1985, and substantial resources will be committed to facility modernization. The company continues to manufacture its own silicon and GaAs materials, which allows it greater flexibility, control, and cost-effectiveness within its overall operations.

Bipolar

The bipolar area is having a very good year in terms of both growth and profitability. Growth is occurring in all market segments and product lines in digital, linear, and military businesses.

Bipolar Digital

Motorola gained market share in TTL-compatible memories with its MOSAIC (Motorola Oxide-Isolated Self-Aligned Implanted Circuit) version of the 93422 RAM family. Advanced process technologies have also produced competitive-performance, 16K-density, ECL-compatible RAMs, which are scheduled for introduction early next year. With successful entries to this market, Motorola may challenge the Japanese dominance of the ECL memory market.

We believe that key new part introductions in the MECL (Motorola Emitter-Coupled Logic) 10KH and FAST (Fairchild Advanced Schottky Transistor) logic families have led to an increased share of market. Continued quality and yield enhancements of low-power Schottky logic (LS-TTL) have been combined with significant capacity expansions to keep pace with growth in personal computers and computer peripherals. New high-performance prescalers and microperipheral circuits indicate the group's technical leadership and serve growth markets such as cellular radio, telephone, and CATV. The Raster Memory System demonstrated earlier this year will serve the next generation of video displays.

Motorola's bipolar digital semicustom product line includes a broad range of TTL arrays, ECL arrays, multifunctional arrays, and programmable logic. In 1983, the company noted very strong growth in all these product areas, and Motorola is presently receiving customer inputs on about two bipolar arrays per day. The growth rate of this product area is expected to be in excess of 50 percent for the next several years. We believe that this will be true in all geographic regions, and there could be even greater growth in Japan.

Bipolar Linear

The linear operation continues its emphasis on surface-mount technology by moving into high-volume production of SOIC in the 8-, 14-, and 16-pin narrow-body packages. Nearly 40 different linear devices have been introduced, and expansion of the product portfolio and production capacity will continue throughout this year and next year. Current low volume capabilities in the 20-, 28-, and 44-lead plastic-leaded chip carrier (PLCC) will also grow to volume manufacturing by the first quarter of 1985.

Products for the telecom market, which started with the single-chip electronic telephone circuit (ETC) MC34010/MC34011, have been complimented with the new push-pull tone ringer MC34017, the MC34014 Speech Network, and most recently with the MC34018 Electronic Speakerphone Network for hands-free communications systems.

Motorola's linear group continues to emphasize automotive products, which are largely custom devices enhanced by new standards such as the MC3334 High-Energy Ignition Circuit and the MC3484V2/V4 2- and 4-amp Solenoid (Injector) Drivers. Prototype production has recently begun on a Power BIMOS High-Side Switch.

New bipolar op amps with the performance of JFET-type op amps were introduced this year in the MC34071/MC34072 and MC34074 single, dual, and quad devices. These are the first of an entire new series of devices that feature single-supply, high-speed, high-capacitive drive and micropower capabilities.

Several new products were introduced in the voltage regulator, interface, and consumer areas, where Motorola continues to emphasize a broad linear product line.

New technologies include use of the MOSAIC process to develop linear circuits functional beyond 700 MHz, and high-voltage process test chips that have exhibited breakdown voltages of more than 500V.

MOS

MOS facilities are located internationally. The company has design facilities in Tokyo, Japan; San Francisco, California; Austin, Texas; Phoenix, Arizona; Geneva, Switzerland; and Israel. Although the design headquarters are in Austin, Texas, a significant amount of design work is done in the remote centers. Wafer fabrication is located in Austin, Texas; Phoenix, Arizona; East Kilbride, Scotland; and Aizu-Wakamatsu, Japan. Assembly is done in Korea; Malaysia; the Philippines; Chandler, Arizona; and Austin, Texas, depending upon product and demand.

In the U.S., the major fab facility is located in Austin, Texas. This site has approximately 750,000 square feet, including a new HCMOS wafer module with 1.5-micron processing capability. During May of 1984, a new 150-acre site in the suburb of Oak Hill, Texas, was occupied by the Microprocessor Products Group.

Microprocessors

Motorola's strategy for microprocessors/microcontrollers is to have a cost-effective component with small die size and competitive performance, and then to develop I/O devices to optimize the product's market demand. An example of this product strategy is the 6805, an 8-bit microcontroller. Motorola has developed many specialized variations of the original 6805 component. These adaptations were derived from customized designs that were later turned into standard products. In this fashion, Motorola was able to swiftly develop its 6805 product offerings. There are presently 30 variations of the 6805 family, all with different I/Os.

Motorola has been in CMOS technology since the early 1970s. It initially got into the low- to mid-performance range of the market, which was the high-volume sector. CMOS products that are now being introduced can take advantage of their early experiences. DATAQUEST believes that Motorola has a leadership position in CMOS MCUs. It is also extremely strong in the automotive market, where it is the number one semiconductor supplier in the United States.

8-Bit MPUs and MCUs

Motorola is continuing its high level of activity in the 8-bit MCU marketplace. It has announced its high-end 8-bit CMOS MCU, the 68HC11A8, which will serve as the cornerstone of its 1985 offerings. Motorola reports that design-in activity on the MCU is extremely high.

The company will also continue to exploit its favorable CMOS MCU position and its capability for integrating electrically erasable memory onto the MCU. Motorola developed the first CMOS MCU with EPROM.

Motorola has also introduced a new serial system that is becoming a standard communications interface between MCUs and various other peripherals within systems. It is referred to as SPI, the serial peripheral interface.

The 68HC04 is another new product. It is technically a low-end 6805 8-bit MCU that has the same instruction set as the 6805, but has a small die that allows it to compete with space-efficient 4-bit devices.

16- and 32-Bit MPUs

Shipments of 16-bit MPU devices have been growing steadily. DATAQUEST estimates that worldwide merchant revenues related to these CPU devices will reach $908 million in 1988. Peripheral circuits may complement CPU sales at the rate of 3:1. Motorola expects to see large-volume applications for 16-bit MPUs in the areas of automotive high-speed controllers and digital signal processing. Intel, perhaps Motorola's strongest competitor in 8- and 16-bit MPUs, established its 16-bit product on the market early and became a stronghold of IBM PC and IBM look-alike products. Motorola perceives its strength to be in the high-performance portion of the market, such as graphics controllers and workstations. However, the Motorola 68000 is the heart of Apple's Macintosh PC.

Motorola has recently introduced the 68020 MPU. This product is software-compatible with the 68000 family and is targeted toward the high-performance end of the market. The 68020 has been designed in HCMOS; it is the first 32-bit MPU product designed in this technology. It has an enhanced architecture with onboard cache and a general coprocessor interface. The 68020 is expected to penetrate the market more rapidly than its predecessor, the 68000, because the 68020 will be offered as both a single-board microcomputer (VM04), and as a chip. Motorola's major competitor in the 32-bit market is presently National Semiconductor. In the next twelve months however, both Intel and NEC are expected to enter the market.

Motorola's 68020 is presently being sampled, and peripheral products are also being readied. A floating point coprocessor, the 68881, is presently in silicon and is planned for sampling in the second quarter of 1985. A memory management unit (MMU), the 68461, is presently being offered as a gate array, with a chip version on the way. The chip version, the 68851 MMU, is planned for silicon in the second quarter of 1985, with samples expected in the third quarter. Several DMA controllers are also being sampled and are moving into production. A parallel interface/timer, the 68230, and a variety of data communication peripherals round out the peripheral support for the 68000. Motorola, together with its alternate sources, currently offers 6 CPUs and 23 peripherals for the 68000 family.

MOS Memory

In the memory group, Motorola participates in three major product areas; DRAMs, SRAMs, and nonvolatile memories. The company is focusing on product line expansion within each of these areas with advanced performance devices.

While Japanese suppliers have the dominant share of the 64K market, Motorola believes that it is and will continue to be a viable supplier. Motorola plans a significant increase in its 64K DRAM production in 1985.

Believing that the price parity between the 64K and the 256K will occur in early 1986, Motorola plans to follow an aggressive and competitive pricing policy on its 256Kx1 DRAM. The 256K DRAM product that it is presently sampling is a triple poly N-channel device that is yielding well to the 120-nanosecond speed specification. Production start-up on this device is scheduled for first quarter 1985, and will be ramped up throughout the year. The next 256K DRAM offering will be both an x1 and an x4 product in CMOS; sampling is planned for late 1985. Motorola's 1Mb DRAM development program is also presently staffed and in progress.

In the static RAM (SRAM) area, Motorola is focusing on the fast market (25 to 70ns range). The group plans to offer a 16Kx1 part in N-channel this year. It began shipping a fast NMOS 2Kx8 SRAM earlier this year. In the first quarter of 1985, two new products are planned: a 4Kx4 and an 8Kx8. The 64Kx1 version is planned in the third quarter. All three devices will be offered in CMOS and will use 1.5-micron design rules.

To broaden its nonvolatile product line, Motorola will introduce a CMOS 256K EPROM in 1985. The product will also be offered as a one-time-programmable (OTP) device. These devices will be complemented by a CMOS 256K mask ROM. With developments of these key components, the memory group anticipates a transition to the megabit level.

MOS Logic

In MOS logic, Motorola designs, manufactures, and sells MOS integrated circuits. These devices include the standard "Building Block" CMOS logic families, dedicated LSI standard products, and custom/semicustom products.

In the standard logic area, Motorola is one of the world's industry production leaders in the mature commodity standard CMOS metal gate logic family. In 1981, Motorola introduced the first device in the CMOS logic family known as "High-Speed CMOS Logic." Today, Motorola continues to be one of the leaders in this family in both volume production and number of part introductions. About 120 devices have been introduced to date, with 185 devices expected by year-end 1985.

Motorola's special-purpose products area focuses on special applications; specifically data conversion, PLL frequency synthesis, display drivers, smoke detectors, speech products, encoders/decoders, and analog circuits. The largest growth is in the data conversion, display driver, and speech product areas. Motorola will be focusing on these three key areas in the future. It also plans to add surface-mount packaging capabilities in 1985.

In the custom area, Motorola has been a major supplier for several years. It produces devices that have been designed both by Motorola personnel and by customers' engineers. In 1983, Motorola entered the CMOS semicustom marketplace with the introduction of its HCMOS three-micron, double-layer metal macrocell array family. In 1985, this family will be optimized and produced in its state-of-the-art 2-micron HCMOS process facility. At present, a major development effort is under way to introduce a new HCMOS standard cell family in 1985. This family, along with the macrocell array family offering, will make Motorola a major supplier of HCMOS semi-custom products.

The Hi-Rel and Telecom Logic Operation has achieved a reasonable market share due to its strategic focus and support of its demanding customers. In the telecom area, Motorola is committed to the design and manufacture of advanced CMOS ICs for communications equipment. The group has recently introduced its Universal Digital Loop Transceiver (UDLT) family. The UDLT family allows simultaneous voice and data transmission for the modern office. Present applications are over 26 AWG and larger twisted-pair cable within the distance of 2 kilometers.

Military

Military products are presently offered through a separate segment of each of the three major product areas: bipolar, MOS, and discrete. Products offered in the commercial market are qualified for military applications through rigorous testing and special packaging to U.S. Department of Defense military standards. DATAQUEST estimates Motorola's military mix to be approximately 70 percent bipolar, 20 percent discretes, and 10 percent MOS.

The military business is one of the fastest-growing segments of the industry, as the semiconductor content of military systems continues to escalate yearly. Even with slowdowns in military spending, the market continues to grow rapidly due to new applications that are being developed. DATAQUEST believes that Motorola's dramatic military sales growth is due to its broad mix of products and reputation for quality. In 1984, Motorola's military sales grew in excess of 120 percent, and continued strong growth is expected in the future.

WAFER PROCESSING TRENDS

Motorola is focusing on upgrading its fab lines, as follows:

- Standardization of front-end lines
- NMOS lines switching to HMOS

- One fab dedicated solely to 64K DRAM
- Two out of eight MOS modules are 5-inch lines
- One line is changing to 6-inch

FACILITIES

Motorola has major facilities throughout the world. In addition to being the largest semiconductor supplier in the United States market, it also focuses on being a major supplier in Japan, Europe, Latin America, and Asia/Pacific. DATAQUEST estimates Motorola's 1983 regional sales as follows: United States, 69 percent; Europe, 18 percent; Japan, 3 percent; and ROW, 10 percent. In the future, Motorola expects to increase its presence in all regions of the world.

European operations are headquartered in Geneva, Switzerland, with approximately 20 sales offices scattered over the continent. In addition to the many sales offices, 100 distributors and reps also offer support to this multilingual region. Motorola has established a product sales focus among its European facilities.

There are three major production facilities in Europe: Toulouse, France; East Kilbride, Scotland; and Munich, W. Germany. The Toulouse facility is a business center for discrete and most bipolar products. There are also fabrication capabilities at this facility for rectifiers, power transistors, linear devices, and LS devices. East Kilbride is a business center for MOS products, and wafer fab capacity exists for CMOS, NMOS, and HMOS technologies. The facility is presently producing the 68000 MPU series; it is also working on ROMs and SRAMs. In the future, Motorola expects to produce 64K DRAMs at this site. In Munich, Motorola conducts the business focus for bipolar logic, zener diodes, gate arrays, and microsystems. The Munich facility produces microsystems but does not currently have fab capability. Motorola has recently purchased additional land to supplement this facility.

Recent investments in Europe include MOSAIC processing for the Toulouse plant, an automated assembly line for plastic-packaged power transistors, and a new HCMOS wafer fab and automated assembly module in the East Kilbride facility. Remote design centers for gate arrays are also being established in Europe.

Asia/Pacific

Motorola's headquarters in the Asia/Pacific region are in Hong Kong. The facility has approximately 110,000 square feet and has final test/quality control capabilities. Major markets in the region include Hong Kong, Taiwan, Korea, Singapore, Australia/New Zealand, and the People's Republic of China. This expansive region is covered by 6 sales offices and approximately 14 distributors. Motorola plans to build design centers for gate arrays in this area in the near future.

Japan

Nippon Motorola is presently headquartered in Tokyo. Its President and Representative Director is Dr. Toshiaki Irie, who was formerly the General Manager of II (the second) LSI Division at NEC. Nippon Motorola comprises two product sectors: semiconductors and communications. The semiconductor product sector has a design operation in Tokyo, three sales offices and eight distributors throughout Japan, and a factory in Aizu-Wakamatsu. This factory makes Motorola the second U.S. company with fab in Japan. The factory has CMOS, NMOS, and HCMOS manufacturing capabilities, and an automated IC assembly line.

LAMEX

Motorola refers to the regions of Latin America, India, and Israel as LAMEX. LAMEX headquarters are in Phoenix, Arizona. Sales offices are located in Mexico and Brazil, with distributors covering the remainder of the sales regions. Discrete fabrication, assembly, and test are performed in Guadalajara, Mexico.

CONCLUSIONS

DATAQUEST believes that Motorola is strategically well situated to ride the tides of semiconductor demand. Sales and profits have expanded phenomenally worldwide, and facilities have been ramped up to meet the market's demands. DATAQUEST expects Motorola to achieve a significant sales increase in 1984, with sales ranging around $2.1 billion. Research and prototyping are continuing in many new and emerging market areas, to keep up with the more application-specific needs of Motorola's customers. We expect Motorola to remain one of the leading worldwide semiconductor manufacturers due to its perception and satisfaction of the market's needs.

Barbara A. Van

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

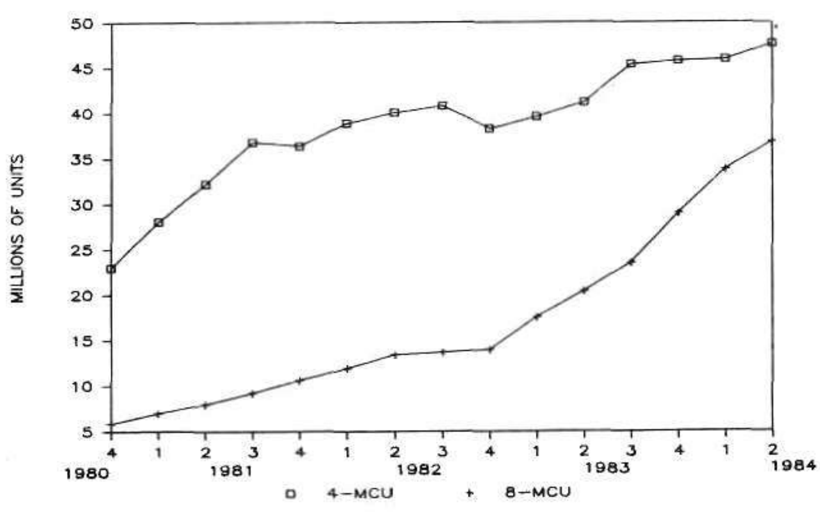
SECOND QUARTER 1984 MICROPROCESSORS AND MICROCONTROLLERS UPDATE

Microcontrollers are continuing their high level of activity in the marketplace. Eight-bit MCUs are more in demand and more available today. The rapid growth of 8-bit MCUs has been strong in the last five quarters, as shown in Figure 1. These devices were up 35.46 percent in the first half of 1984 from the second half of 1983, and up 87.14 percent from the first half of 1983.

In the first half of 1984, shipments grew due to industrial, electronic typewriter, and printer applications. The leading unit shipments of 8-bit MCUs in second quarter 1984 remained the same as in first quarter 1984: 8048, 8049, 6809, and 8051.

Figure 1

4- AND 8-BIT MICROCONTROLLER SHIPMENTS
FOURTH QUARTER 1980 TO SECOND QUARTER 1984



Source: DATAQUEST

The 4-bit marketplace is stable and is splitting into two segments, very low-priced devices and high-functionality devices. Although for many applications there is no need to convert to an 8-bit data path, in other applications one 8-bit MCU is replacing two or three 4-bit MCUs. In some cases, 8-bit MCUs are the most cost efficient, and experienced designers appreciate the 8-bit architectures.

In the first half of 1984, shipments of 8-bit MCUs accounted for 43.2 percent of total MCU unit shipments. DATAQUEST believes that 8-bit MCUs will ship more than 4-bit MCUs in 1985. To further fuel the growth of the 8-bit MCU market, many new designs have been announced including CMOS versions of popular NMOS devices, integration of EEPROM onto the MCU, and CMOS devices with EPROM on chip. Some CMOS 8-bit MCU die are small enough to compete with 4-bit devices. Table 1 shows the change in total microprocessor shipments from the first quarter of 1984 to the second quarter of 1984.

Table 1

TOTAL MICROCONTROLLER UNIT SHIPMENTS
FIRST QUARTER 1984 TO SECOND QUARTER 1984

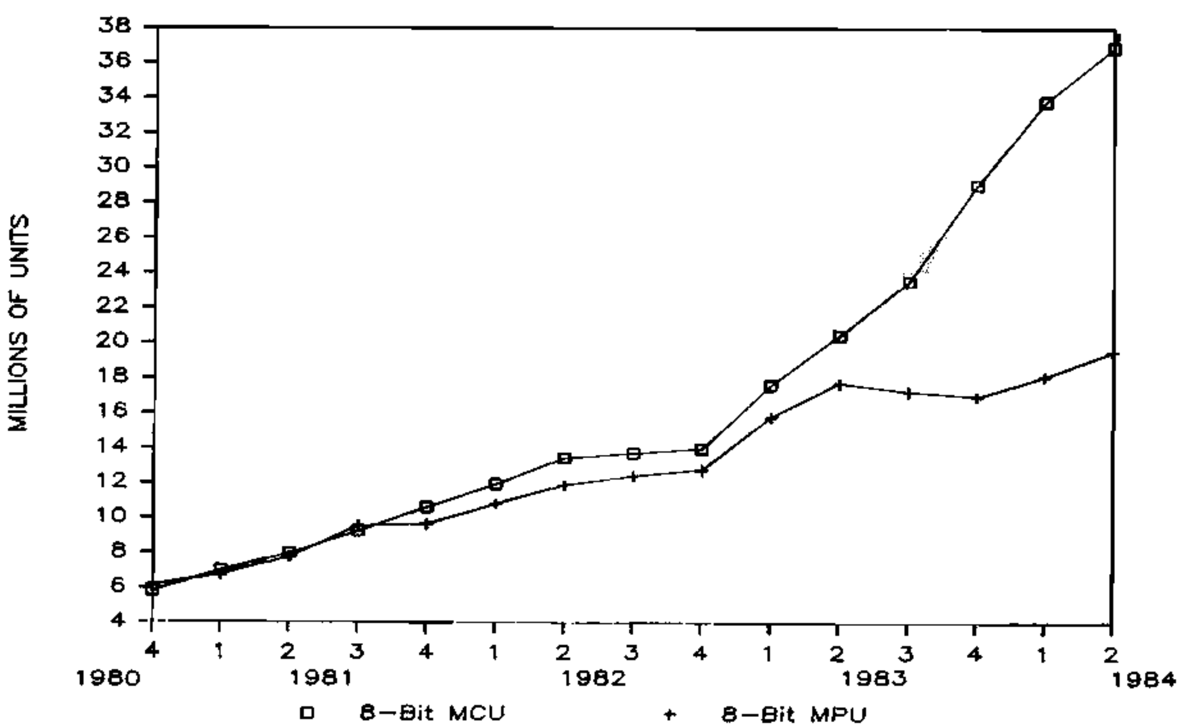
		Q1/1984		Q2/1984		
MCU		Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth Q1 to Q2
4-Bit		45905	57.60%	47604	56.00%	3.70%
8-Bit		33816	42.40	37391	44.00	10.57%
16-Bit		30	0.00	30	0.00	0.00%
	Total	79751	100.00%	85025	100.00%	6.61%

Source: DATAQUEST

Figure 2 compares 8-bit MPU shipments and 8-bit MCU shipments. Both 8-bit MPU and MCU shipments followed similar growth patterns until 1983, when the 8-bit MCU surged dramatically. The 8-bit MPU grew at a slower pace due to the downturn in video games and home computer markets; both the Z80 and 6502 were big players in these areas. MCUs also have taken away some market share from MPUs because second-generation MCUs have more features, more memory, more value-added features, and may replace MPUs in design renewals. During the first half of 1984, 8-bit MPUs overall were up 9.53 percent from the second half of 1983.

Figure 2

8-BIT MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENTS
FOURTH QUARTER 1980 TO SECOND QUARTER 1984



Source: DATAQUEST

Table 2 shows the change in total microprocessor shipments from the first quarter of 1984 to the second quarter of 1984. Total worldwide shipments of MPUs during the second quarter of 1984 were up approximately 6.64 percent from the first quarter of 1984. Shipments of 8-bit microprocessors were up approximately 6.72 percent, while 16-bit microprocessor shipments increased 4.85 percent.

Table 2

TOTAL MICROPROCESSOR UNIT SHIPMENTS
FIRST QUARTER 1984 TO SECOND QUARTER 1984

		Q1/1984		Q2/1984		
MPU		Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth Q1 to Q2
8-Bit		18137	88.53%	19356	88.60%	6.72%
16-Bit		2300	11.37	2433	11.18	4.85%
Others		20	0.10	48	0.22	140.00%
	Total	20487	100.00%	21847	100.00%	6.64%

Source: DATAQUEST

Table 3 shows the change in shipments of the leading 8-bit MPUs from the first quarter of 1984 to the second quarter of 1984. During the second quarter, the 650X product line gained momentum in the MPU marketplace. This could indicate the continuing strength of the Apple IIe and IIc.

Table 3

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
FIRST QUARTER 1984 TO SECOND QUARTER 1984
(Thousands of Units)

		Q1/1984		Q2/1984		
Device		Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth from Q1 to Q2
Z80		7024	38.7%	6950	35.9%	-1.1%
8085		3307	18.2	3660	18.9	10.7%
650X		1610	8.9	2291	11.8	42.3%
8088		1809	10.0	2167	11.2	19.8%
6802		1342	7.4	1359	7.0	1.3%
Others		3045	16.8	2929	15.2	0.7%
	Total	18137	100.0%	19356	100.0%	7.5%

Source: DATAQUEST

The 16-bit MPU was introduced approximately five years ago and is now becoming a significant part of the total microprocessor market. Some analysts believe that 16-bit MPUs became legitimate due to IBM's introduction of the PC AT. During the first and second quarters of 1984, 16-bit MPUs shipped approximately 4.8 million units. However, the 16-bits made up only 11.18 percent of total MPUs shipped during the first half of 1984 and grew only approximately 4.89 percent from the first quarter of 1984 to the second quarter of 1984. Growth of first-generation 16-bit MPUs (the 9900/80 and CP-1600 product lines) is declining. Second- generation MPUs (the 8086, 80186, 80286, 68000, and Z8000 product lines) made up 80 percent of the total 16-bit MPUs shipped in the first half of 1984. This market is experiencing rapid growth. We expect 1985 to be the year of tremendous 16-bit MPU growth. Table 4 shows the percent changes in estimated shipments of second-generation 16-bit microprocessors from the first quarter of 1984 to the second quarter of 1984.

Table 4

ESTIMATED SHIPMENTS FOR SECOND GENERATION
16-BIT MICROPROCESSORS
FIRST QUARTER 1984 TO SECOND QUARTER 1984
(Thousands of Units)

	Q1/1984		Q2/1984		
Device	Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth from Q1 to Q2
8086	938	55.41%	980	46.34%	4.5%
68000	363	21.46	438	20.71	14.6%
80186	195	11.53	385	18.20	97.44%
Z8000	124	7.34	203	9.60	63.7%
80286	40	2.37	70	3.31	75.0%
32016	32	1.89	39	1.84	21.9%
Total	1692	100.00%	2115	100.00%	23.7%

Source: DATAQUEST

Table 5 shows market share by technology for 8-bit microcontroller and microprocessor devices from the second quarter of 1983 through the second quarter of 1984, and indicates CMOS growth during this period. DATAQUEST believes that by 1986, approximately half of all 8-bit MCUs shipped will be CMOS. Strong users will be the automotive, communications, and industrial markets.

Table 5

UNIT MARKET SHARE BY TECHNOLOGY FOR
8-BIT MICROCONTROLLERS AND 8-BIT MICROPROCESSORS
SECOND QUARTER 1983 TO SECOND QUARTER 1984

Device	Tech	Q2/83	Q3/83	Q4/83	Q1/84	Q2/84
8-Bit MCU	CMOS	8.52%	7.97%	9.68%	10.07%	10.06%
8-Bit MCU	NMOS	91.48	92.03	90.32	89.93	89.94
Total		100.00%	100.00%	100.00%	100.00%	100.00%
8-Bit MPU	CMOS	5.55%	7.13%	8.49%	10.29%	10.68%
8-Bit MPU	NMOS	94.45	92.87	91.51	89.71	89.32
Total		100.00%	100.00%	100.00%	100.00%	100.00%

Source: DATAQUEST

Table 6 depicts the percent changes in microcontroller and microprocessor geographic market share from the second quarter of 1983 to the second quarter of 1984.

Table 6

GEOGRAPHIC UNIT MARKET SHARE BY PRODUCT TYPE

	Region	Q2/83	Q3/83	Q4/83	Q1/84	Q2/84
4-Bit MCUs	United States	22.2%	19.1%	18.0%	19.1%	18.1%
	Japan	77.5	80.3	81.4	80.9	81.9
	Europe	0.3	0.6	0.6	0.0	0.0
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MCUs	United States	58.7%	60.0%	58.9%	55.2%	56.4%
	Japan	31.7	31.2	32.4	36.1	33.9
	Europe	9.6	8.8	8.7	8.7	9.7
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPUs	United States	70.4%	66.0%	62.2%	60.3%	60.1%
	Japan	25.0	28.0	31.4	33.4	32.5
	Europe	4.6	6.0	6.4	6.3	7.4
	Total	100.0%	100.0%	100.0%	100.0%	100.0%
16-Bit MPUs	United States	87.5%	83.2%	81.5%	73.8%	78.8%
	Japan	10.6	12.8	15.1	21.0	13.9
	Europe	1.9	4.0	3.4	5.2	7.2
	Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST

Second quarter 1984 proved to be a good quarter overall for the MCU and MPU market segments. However, we expect shipments to slow down slightly in the third quarter, booking to continue to be unstable, and prices to drop slightly. DATAQUEST believes that during the second half of 1984, MPUs and MCUs will outperform other products in the industry.

Janet Rey

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: December

SEMI INDUSTRY FORECAST
ECONOMIC TRENDS: PERILS AND PROMISES

At the Semiconductor Equipment Manufacturers' Institute forecast meeting held in Santa Clara, California, on December 12, the two speakers from the semiconductor industry presented differing views of the outlook for 1985. Wilfred J. Corrigan, President and CEO of LSI Logic, described the situation as "moving from overheated expansion to flat growth." He expects the excess inventory problem to be solved by the end of the first quarter of 1985. Charles E. Sporck, President and CEO of National Semiconductor Corporation, painted a somewhat darker picture. Mr. Sporck believes that the inventory problem is more severe than was previously believed, and is now extending beyond the personal computer area. He suggested that 1985 would be "a lousy year."

The two speakers also addressed different aspects of the semiconductor equipment industry in their speeches. Mr. Corrigan discussed "The Changing Interface Between Semiconductor Manufacturers and the Equipment Vendor," while Mr. Sporck spoke on "Forecasting Future Semiconductor Equipment Capital Spending Patterns as Driven by the Leading Edge of Technology."

WILFRED J. CORRIGAN, LSI LOGIC

Mr. Corrigan said that the facilities additions of the past 12 to 14 months are not yet fully on stream. We are looking at a period of very high capacity. The coming months will be a time for reassessment, with semiconductor manufacturers reconsidering their plans about moves to 6-inch wafer equipment and other advanced process techniques. There will be a demand for tactical fabs--small facilities where capability is more important than capacity.

There is a need for closer relationships between vendors and users of semiconductor equipment. The high capital cost of equipment means that users need to run it 7 days a week, 24 hours a day. Such operation requires strong service and support from equipment vendors. Automation is the key to improved yields in the future, but it must be truly reliable.

If U.S. semiconductor equipment manufacturers are to be successful, they must meet the challenge of Japanese manufacturers. Manufacturers must stress quality, reliability, and above all, service.

CHARLES E. SPORCK, NATIONAL SEMICONDUCTOR CORPORATION

Mr. Sporck stated in his presentation that the high level of capital spending necessary to remain competitive in the semiconductor industry is far more difficult for U.S. companies to achieve than for companies in Japan. Using DATAQUEST capital spending estimates, Mr. Sporck showed that Japanese semiconductor companies' capital expenditures as a percentage of sales are consistently higher than those of U.S. companies. Current estimates suggest that many U.S. companies will decrease their capital spending in 1985 versus 1984, while Japanese companies expect to increase spending in 1985.

U.S. companies are at a disadvantage because of the high cost of capital in this country. A recent government report showed that the cost of capital in 1981 in the United States was 16.6 percent, compared with only 9.2 percent in Japan. One reason for the lower cost of capital in Japan is the high rate of personal savings. Over the past ten years the average Japanese worker has saved 18 percent of his income, compared with 6 percent saved by the average U.S. worker. The Japanese economic system is structured so that the money saved is available to Japanese industry.

A second difference between the United States and Japan is the high debt-to-equity ratio that is common in Japan. Loans, rather than equity, are the main source of funds for Japanese companies, and Japanese investors are looking for returns on their investments rather than equity growth. The result of this situation is that the main concern of a Japanese company is to service its debt. For this reason, a Japanese company will fight to gain market share, even at the expense of profit margins. Investors in the United States, on the other hand, are looking for equity growth and react very rapidly to changes in a company's performance. This means that U.S. companies must work hard to look good in the short term. In order to compete with Japanese semiconductor manufacturers, U.S. companies need a supply of "patient money" rather than the volatile capital of today's investors.

Although manufacturers can work to plan capital spending wisely, the basic problems must be addressed by the U.S. government. Among them:

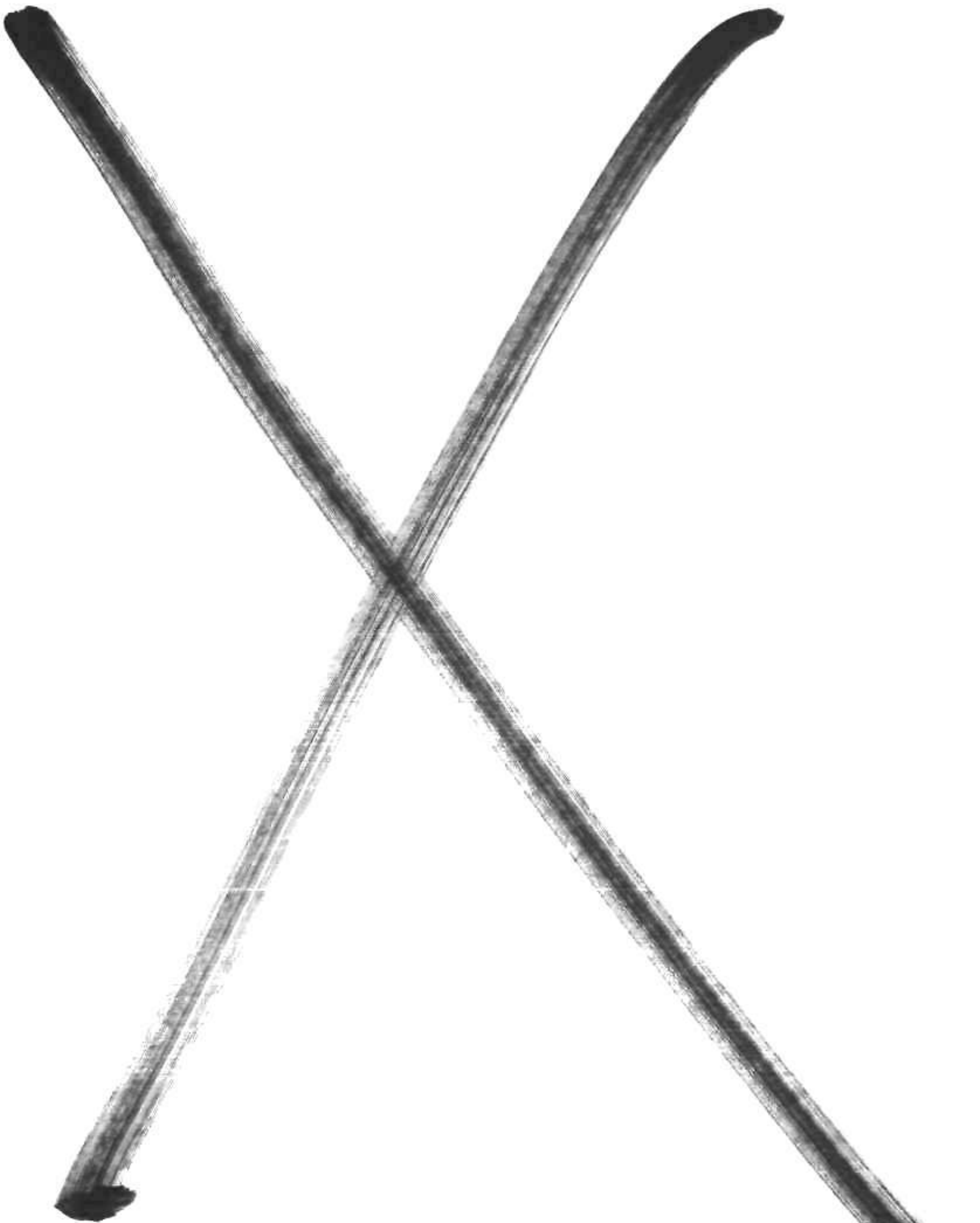
We need a macroeconomic policy that creates a more stable economic environment. In spite of the increasing pervasiveness of semiconductors, the industry is not immune to changes in the economy.

The government must create incentives to save. Tax exemptions or lower tax rates for savings could help increase the supply of lower-cost capital.

The government must develop investment incentives for industry. The R&D tax credit should be made permanent, and investment tax credit policies should be reviewed. Realistic depreciation schedules for rapidly obsolete equipment are also essential to encourage sound investment.

Although no one of these actions can eliminate the disadvantage under which U.S. companies operate, each can contribute to alleviating it.

Joe Grenier
Robert McGeary



January Newsletters

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

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: January

A NEW JAPANESE ASIC SUPPLIER--LSI LOGIC PULLS OFF A COUP

Kieske Yawata, NEC's most experienced executive in dealing with the United States, recently joined LSI Logic as president of the company's Japanese subsidiary, Nihon LSI. This is a remarkable occurrence that may foreshadow significant changes in the relationship between U.S. and Japanese businesses. Our thoughts on the significance of this matter are as follows:

- LSI Logic, one of the leading gate array suppliers, has recruited a seasoned executive to help the company penetrate the Japanese market.

- Nihon LSI was financed with Japanese capital in a manner more characteristic of Silicon Valley. The company plans to eventually go public on the Japanese stock market. Arrangements of this sort may lead to U.S.-style venture capital activities in Japan in the future.

- U.S.-affiliated companies may claim a significant share of the Japanese gate array market as Japanese companies are claiming a significant share of the U.S. RAM market. This could underscore the U.S. strength in software and applications and the Japanese strength in quality manufacturing.

- A Japanese executive has left NEC after a 25-year career. This is most uncharacteristic and may foreshadow increasing job mobility in Japan. Mr. Yawata was reportedly attracted by the opportunity to run his own show. (In early 1984, Chuck Wood, chief operations officer and senior vice president at NEC America, left the company to become CEO and president of Excyte, a start-up company in Sunnyvale. During the same year, Dr. Irie, chief research engineer of semiconductors at NEC, went to Motorola. This raises concerns about management people at NEC America.)

We believe that this action is a coup for LSI Logic. Taking the long view, we believe that it will benefit the Japanese economy as well. We believe that spectacular advances could be made if American entrepreneurism and applications and software capabilities could be coupled with Japanese manufacturing know-how.

Howard Bogert
Andy Prophet

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: January

PRELIMINARY 1984 MARKET SHARE RESULTS

SUMMARY

The semiconductor industry had an exceptional year in 1984, in spite of a slackening of demand in the last quarter. DATAQUEST estimates that worldwide semiconductor sales grew approximately 45.2 percent for the year. Strongest growth was noted by companies with high concentrations in MOS, specifically memory and microprocessor devices. Several significant rank changes can be seen in the following tables of total semiconductor, IC, and digital MOS revenues for Japanese and U.S. suppliers.

Total Semiconductor Market Share

Our preliminary data indicate that the average growth rate of semiconductors among the top ten suppliers was 53.7 percent. Major U.S. companies grew by approximately 47.8 percent, while Japanese suppliers grew by 60.1 percent. NEC moved into second position for total semiconductor revenues, moving ahead of Motorola by one place. All other positions remain unchanged, as shown in Table 1.

Integrated Circuit Market Share

Average growth among the top ten integrated circuit suppliers was 59.5 percent. Ranking throughout the list changed slightly as Intel moved ahead of National for the number five slot. Fujitsu also bumped Toshiba for seventh place. Detailed market share data are shown in Table 2.

Digital MOS Market Share

Among the top ten suppliers in digital MOS, average growth was 66.4 percent. As shown in Table 3, the ranking of the top three manufacturers remained unchanged, with NEC still in the number one

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position. Exceptional strength in MOS memories enabled Texas Instruments to displace Motorola in fourth place. Growth in excess of 100 percent moved AMD from tenth to eighth position in 1984 and Mitsubishi also joined the ranks of the top ten.

Note: The data presented are a summary of a larger study that will be published within the next month. Market share data will offer 1984 company revenues for the following categories: semiconductors, integrated circuits, digital bipolar, bipolar memory, bipolar logic, digital MOS, NMOS, PMOS, CMOS, MOS memory, MOS microprocessor devices, MOS logic, linear, discrete, and optoelectronic devices. Seven years of history will also be available with the study. The market share study will be available to Semiconductor Industry Service notebook holders.

Barbara A. Van

Table 1

ESTIMATED 1984 VS. 1983 SEMICONDUCTOR REVENUES AND RANKINGS
(Millions of Dollars)

1984 Rank	1983 Rank	Company	1983 Revenues	1984 Revenues	Percent Change
1	1	Texas Instruments	$1,638	$2,408	47.0%
2	3	NEC	$1,413	$2,270	60.7%
3	2	Motorola	$1,547	$2,097	35.6%
4	4	Hitachi	$1,277	$1,977	54.8%
5	5	Toshiba	$ 983	$1,561	58.8%
6	6	National	$ 914	$1,263	38.2%
7	7	Intel	$ 775	$1,253	61.7%
8	8	Fujitsu	$ 673	$1,165	73.1%
9	9	Matsushita	$ 600	$ 944	57.3%
10	10	AMD	$ 505	$ 928	83.8%

Source: DATAQUEST

Table 2

ESTIMATED 1984 VS. 1983 INTEGRATED CIRCUIT REVENUES AND RANKINGS
(Millions of Dollars)

1984 Rank	1983 Rank	Company	1983 Revenues	1984 Revenues	Percent Change
1	1	Texas Instruments	$1,535	$2,301	49.9%
2	2	NEC	$1,093	$1,841	68.4%
3	3	Motorola	$1,060	$1,499	41.4%
4	4	Hitachi	$ 912	$1,496	64.0%
5	6	Intel	$ 775	$1,253	61.7%
6	5	National	$ 864	$1,203	39.2%
7	8	Fujitsu	$ 605	$1,072	77.2%
8	7	Toshiba	$ 613	$1,035	68.8%
9	9	AMD	$ 505	$ 928	83.8%
10	10	Signetics	$ 435	$ 765	75.9%

Table 3

ESTIMATED 1984 VS. 1983 DIGITAL MOS REVENUES AND RANKINGS
(Millions of Dollars)

1984 Rank	1983 Rank	Company	1983 Revenues	1984 Revenues	Percent Change
1	1	NEC	$786	$1,426	81.4%
2	2	Intel	$720	$1,153	60.1%
3	3	Hitachi	$638	$1,094	71.5%
4	5	Texas Instruments	$572	$ 865	51.2%
5	4	Motorola	$607	$ 803	32.3%
6	6	Toshiba	$458	$ 770	68.1%
7	7	Fujitsu	$406	$ 735	81.0%
8	10	AMD	$224	$ 480	114.3%
9	8	Mostek	$315	$ 467	48.3%
10	12	Mitsubishi	$223	$ 443	98.7%

Source: DATAQUEST

Nielsen Dataquest
RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: January

NEW WORKSTATIONS FUEL GROWING PROGRAMMABLE LOGIC MARKET

Designing and using programmable logic arrays (PLAs) just became easier. We expect recently announced advanced workstations to fuel this rapidly growing market. PLAs require Boolean equations for programming, which makes them unfamiliar territory for some engineers. The fundamental issue driving this market is to train engineers in how to use PLAs--the key user-friendly CAD tools.

On the forefront of user-friendly PLA workstations are Assisted Technology Inc. of San Jose, California, and Data I/O Corporation of Redmond, Washington. This week, Assisted Technology announced its new IBM PC XT-based advanced workstation for designing PLAs without writing logic equations. Both Assisted Technology and Data I/O recently announced that their logic design languages have been adapted to run on Valid Logic Systems' workstation. These announcements are expected to accelerate the growth of the PLA market. Currently:

- DATAQUEST estimates that PLA growth will exceed 28 percent CAGR for the years 1984 to 1989, as shown in Table 1.

Table 1

ESTIMATED WORLDWIDE CONSUMPTION OF PROGRAMMABLE LOGIC
(Millions of Dollars)

	1984	1985	1986	1987	1988	1989	CAGR 1984-1989
Total PLA	$ 190	$273	$353	$421	$536	$667	28.6%
MOS	$ 0.5	$ 21	$ 42	$ 74	$134	$232	241.4%
Bipolar	$189.5	$252	$311	$347	$402	$435	18.1%

Source: DATAQUEST
January 1985

- The CMOS segment is growing and is expected to be approximately one-half of the total PLA market by the end of the decade.

- There are 8 companies delivering parts and 25 potential players. Of the potential entrants, 80 percent have indicated that they will use the CMOS process.

PLA WORKSTATIONS

Assisted Technology's CUPL-GTS (Gate Translation System) turns an engineer's IBM PC XT into a workstation for programmable logic. The CUPL-GTS includes a high-resolution graphics board, mouse and interface, and logic compiler CUPL. Also included is CSIM, a simple stimulus/response function table simulator for PLAs.

This is a major step in the advancement of user-friendly CAD tools. CUPL-GTS allows the hardware designer to design PLAs by drawing schematics with the mouse. The self-teaching system is menu driven, with interactive prompts for the user. Placing a logic function in a PLA is as easy as choosing "translate" from the command menu. Output from the IBM PC is via an RS-232 port to drive a logic programmer unit such as those made by Stag Microsystems and Valley Data Science.

CUPL-GTS supports all manufacturers' PLAs, including the new erasable PLAs. In some cases, this gives the designer the freedom to place the same logic schematic into different PLAs or, basically, to use a second-source socket.

Both Assisted Technology with CUPL and Data I/O with ABEL (Advanced Boolean Expression Language) recently announced that their software will run on version 7.0 of Valid's Scaldsystem I, II, and IV. Both CUPL and ABEL are already compatible with the IBM PC XT and Digital's VAX running under VMS or UNIX. Each program compiles Boolean equations, truth tables, or state diagrams into fuse maps for programmable devices including PROMs, PLAs, and all integrated fuse logic (IFL).

DATAQUEST OPINION

DATAQUEST believes that the real boom in the PLA market will happen as more user-friendly workstations become available. The advantages of PLAs include: faster working parts for engineers, lower up-front costs, and unprogrammed parts, which can be held in inventory. These advantages, coupled with the growth of some of the higher gate count PLAs, are expected to have a negative impact on the low end of the gate array market.

Katy Guill
Andy Prophet

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: January

STANDARD LOGIC--STILL IN THE RACE

This newsletter presents highlights of the recently issued SIS Standard Logic service section in the Products and Markets binder.

OVERVIEW

DATAQUEST believes that during the next five years, standard logic will face a number of important issues that center on competing technologies and end-market applications. These issues include:

- The impact of gate arrays and other application-specific ICs (ASICs) on capturing design from standard logic
- The ability of the newer ECL families to gain market share
- The impact of the high-speed CMOS (HC/HCT) families on the 74C/4000 series

In spite of these issues, we believe that the standard logic market will hold its own and continue to grow at a 5.9 percent compound annual growth rate (CAGR) from 1984 to 1989.

GATE ARRAYS AND ASIC IMPACT

Currently the revenue for standard logic is approximately equal to the merchant ASIC market. On the other hand, there is mounting evidence that the total ASIC market will shift in both dollars and gates shipped before the end of the decade. Figure 1 shows the estimated crossover point at which the total number of gates shipped by gate array suppliers will surpass the number of those shipped by standard logic manufacturers.

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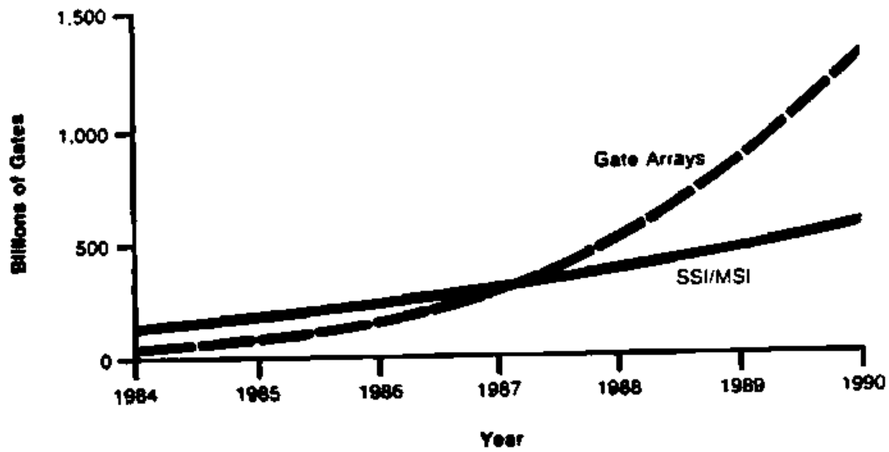
Figure 1

IMPACT OF GATE ARRAYS ON
SEMICONDUCTOR LOGIC FUNCTION SHIPMENTS



Source DATAQUEST

STANDARD LOGIC TRENDS

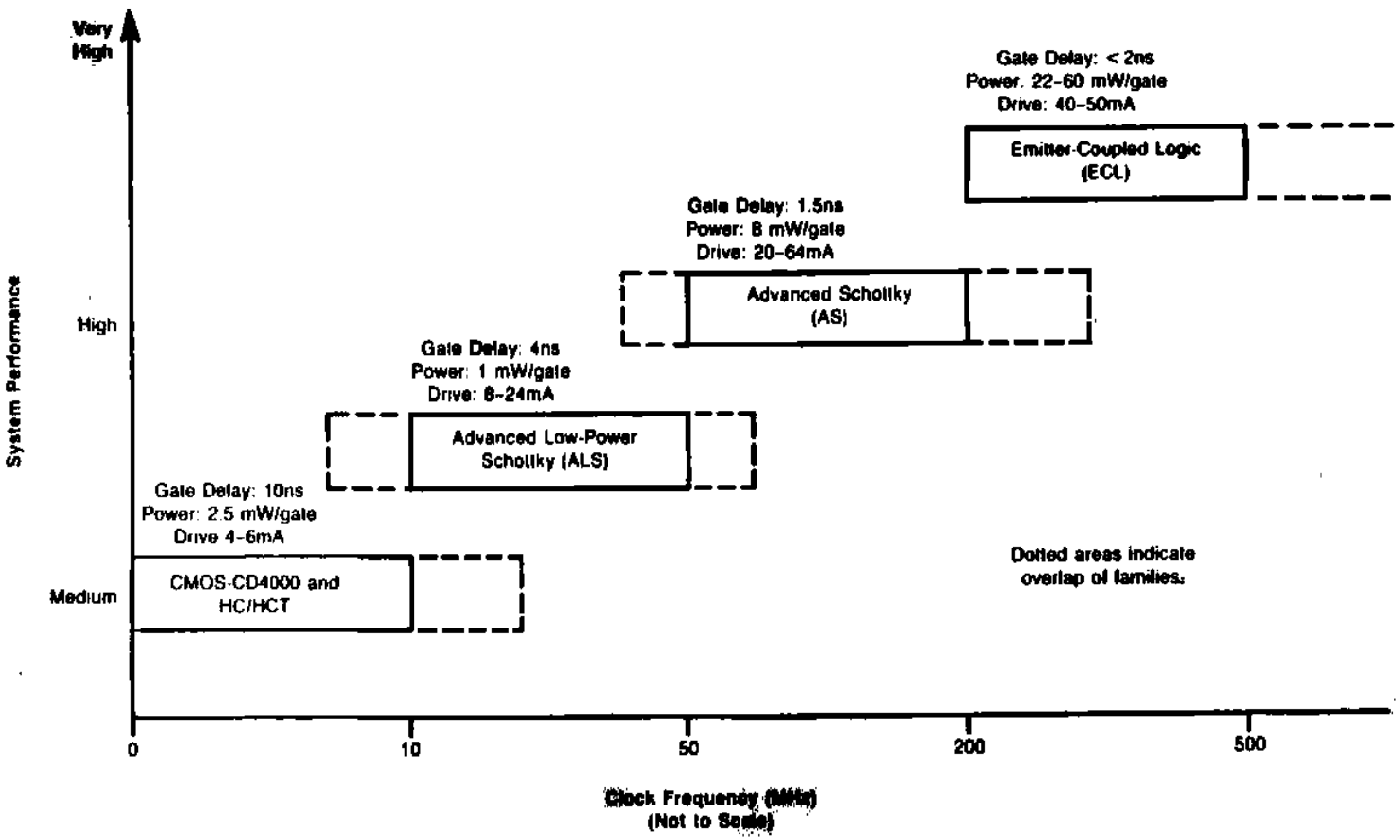
Presently, system designers and machine architects work with a spectrum of standard logic components from which they make their design choices. The basis for these design choices traditionally has been the speed/power criteria. Boundaries are not sharply defined, and some of the options for a system are based on different clock frequencies as shown in Figure 2. Frequency ranges and the logic families with which they are traditionally associated include:

- Below 10 MHz--CMOS standard logic where low power is mandatory
- 10 MHz to 50 MHz--ALS-TTL and LS-TTL logic
- 50 MHz to 200 MHz--AS-TTL logic
- 200 MHz and greater--ECL logic

However, crossing these boundaries are HC and HCT CMOS, which often extend into the low end of the region reserved for ALS-TTL logic. Similarly, AS-TTL logic components are often used in designs where the clock frequencies exceed 200 MHz, and ECL is often used where clock frequencies are less than 200 MHz.

Figure 2

STANDARD LOGIC COMPONENTS
SPECTRUM OF USE BASED ON SYSTEM FREQUENCY



Source: DATAQUEST

CMOS

For medium-performance systems (10 MHz) such as the 8-bit and 16-bit personal computer systems, NMOS microprocessors and NMOS memories rather than CMOS microprocessors and memories are by far the dominant type of technology for processing and storage functions, respectively.

The two major issues that are of concern to CMOS manufacturers today are: to fill sockets with 5V CMOS logic that is compatible with current CMOS microprocessor-based designs, and to go after the LS-TTL market with CMOS drop-in counterparts that offer low-power operation at LS drive levels and fanout. In upcoming designs, HCT CMOS is being used as a direct low-power replacement for many LS-TTL applications. HCT has the most flexible interface of any logic family. Also important is that the logic "zero" noise immunity of HCT CMOS is the same as that of TTL, which allows the use of the same printed circuit board's stripline and decoupling techniques.

DATAQUEST expects that HCT CMOS, which now has a 40 to 50 percent share of the CMOS market, will decrease to 30 percent by 1987 as more low-power systems become completely CMOS. We do not expect that HC and HCT CMOS logic will replace all TTL systems, since TTL designs are well entrenched and numerous.

One of the brightest prospects for CMOS logic is the trend for systems to use voltages as low as 2 volts. These systems will consist entirely of CMOS chips, since CMOS is the only digital logic family that can operate at such low voltages. Such systems will offer extremely low power dissipation. For example, a system running from a 3-volt source consumes about one-third the power of a 5-volt system. Important fringe benefits include reductions in noise, electromagnetic interference (EMI), and logic errors due to cross coupling.

AS and ALS

The logic demands for high-performance systems (10-200 MHz), including 16-bit and 32-bit microprocessor-based systems and bit-slice machines, are filled by Schottky TTL and standard logic. DATAQUEST believes that high-performance systems designed during the latter part of the 1980s will continue to demand more favorable speed/power performance from Schottky logic devices. While the TI and Fairchild families will compete aggressively for these niches, we believe that the best system designs will result from selecting devices from different manufacturers to produce the optimum combination of performance, package count, and power consumption.

ECL

The primary markets for ECL are the computer, military communications, and instrumentation sectors. For these very high-performance systems (200 MHz and greater), the ECL 10KH and 10K families are the preferred choice. Motorola's new ECL process called MOSAIC (Motorola Oxide Self-Aligned Implanted Circuits), which uses scaled transistors, makes it possible to implement ECL functions that have up to 1,000 gates per chip. This new process is used in Motorola's MECL 10KH family.

DATAQUEST believes that users designing very high-performance systems can expect 10K ECL logic components to provide cost-effective alternatives to Fairchild's higher power and only slightly faster F100K logic. We also expect that the higher density and more complex functions that cannot be economically manufactured in existing ECL processes will be possible using the ECL 10KH MOSAIC process.

What Does This Mean?

DATAQUEST believes that HC and HCT CMOS and TTL gate propagation delays will tend to approach the delays of ECL, and that there will also be a decrease in the difference of power dissipation between CMOS on one hand and TTL and ECL on the other. When this narrowing occurs, we believe that a more meaningful system parameter, system throughput, will be used to compare the different standard logic families.

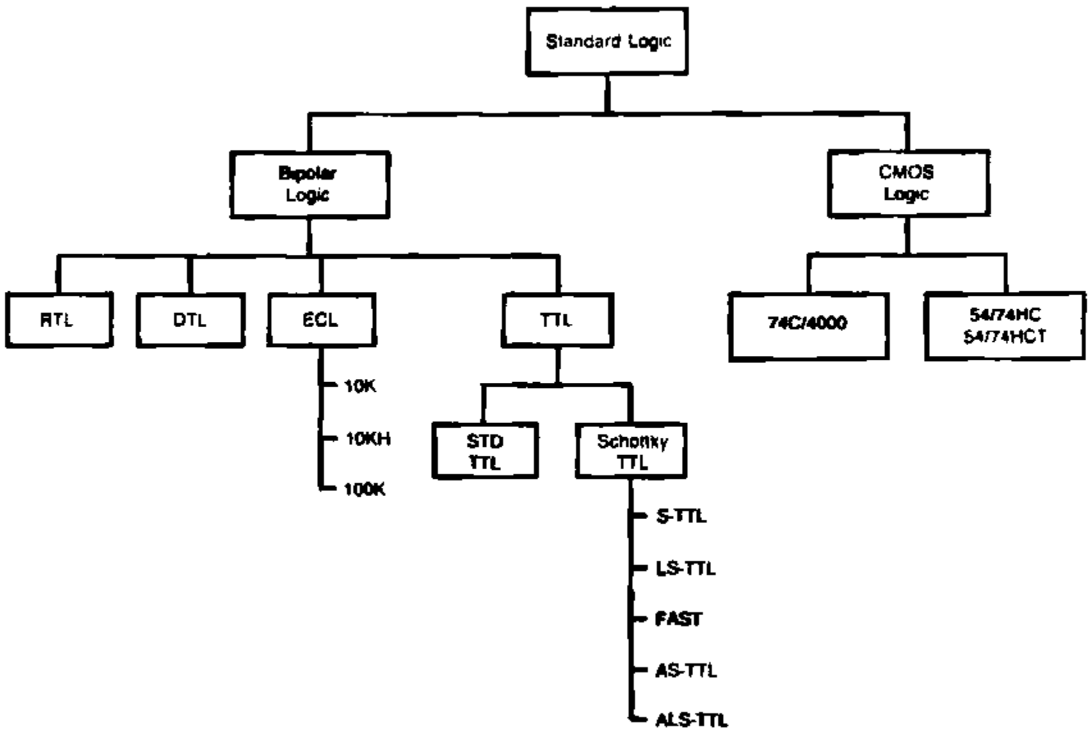
Toward the end of the decade we expect that the particular strengths of bipolar logic components, i.e., their ability to drive long capacitive lines, will ensure the dominance of bipolar standard logic, TTL, and ECL in very high-speed, nonrecursive applications.

The standard logic family tree as defined by DATAQUEST is shown in Figure 3. The suppliers of standard logic by part type are shown in Table 1, followed by the estimated consumption of standard logic in dollars in Table 2.

Katy Guill
Andy Prophet

Figure 3

STANDARD LOGIC FAMILY TREE



Source: DATAQUEST

Table 1

STANDARD LOGIC SUPPLIERS

	BIPOLAR										MOS		
	STD-TTL	S-TTL	AS	FAST	LS-TTL	ALS	ECL-10K	ECL-100K	DTL	OTHER	4000/74C	74HC	74HCT
North American Companies													
Advanced Micro Devices					X								
Fairchild Semiconductor	X	X		X	X		X	X	X		X	X	
GTE Microcircuits												X	
Mitel Corporation												X	
Motorola				X	X	X	X	X			X	X	X
National Semiconductor	X	X	X		X	X					X	X	X
RCA Corporation											X	X	X
Semi-Processes Inc. (SPI)												X	X
Signetics Corp.	X	X		X	X		X	X			X	X	
Supertex												X	X
Texas Instruments	X	X	X		X	X			X	X		X	
Universal Semiconductor												X	X
Zytrex Corp.												X	
West European Companies													
Ferranti	X				X								
Matra-Harris Semiconductors												X	
Philips	X	X		X	X		X	X			X	X	
Plessey						X						X	
SGS-ATES Componenti Electronici					X							X	
Japanese Companies													
Fujitsu Microelectronics (FMI)	X				X		X					X	
Hitachi, Ltd.		X			X			X				X	
Matsushita Electronics					X						X	X	
Mitsubishi Electronics			X		X						X		
NEC Electronics USA					X						X	X	
OKI Semiconductor											X		
Sharp											X	X	
Toshiba Semiconductor					X						X	X	

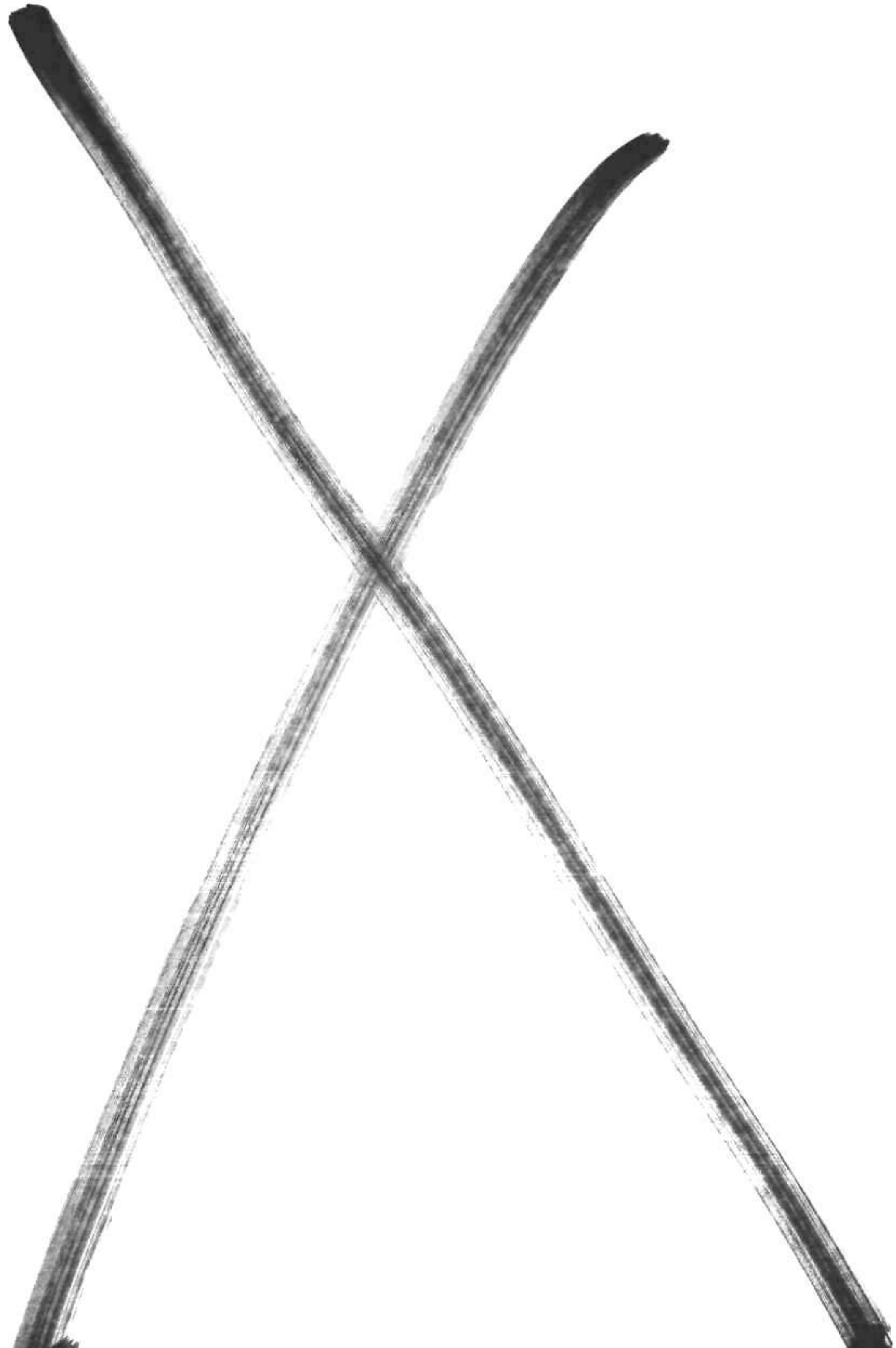
Source: DATAQUEST

Table 2

STANDARD LOGIC ESTIMATED CONSUMPTION
(Millions of Dollars)

	1983	1984	1985	1986	1987	1988	1989
Total Standard Logic	2,380.2	2,830.1	3,087.6	3,143.7	3,313.4	3,551.5	3,773.6
Bipolar Total	1,898.4	2,202.2	2,316.2	2,289.4	2,311.6	2,383.4	2,435.2
TTL Total	1,584.1	1,892.6	1,983.5	1,934.9	1,919.8	1,947.8	1,978.8
STD-TTL	167.3	120.5	92.3	66.6	47.7	29.7	22.1
Schottky TTL Total	1,416.8	1,772.2	1,891.2	1,868.3	1,872.1	1,918.0	1,956.7
S-TTL	226.1	211.4	192.8	158.5	128.4	100.1	64.6
AS	12.0	18.0	25.2	28.2	28.4	32.6	37.9
FAST	135.0	184.0	251.0	253.0	314.7	410.4	501.1
LS	1,003.7	1,293.8	1,345.5	1,345.5	1,305.2	1,266.0	1,228.0
ALS	40.0	65.0	76.7	83.1	95.5	108.9	125.1
ECL Total	210.0	226.4	261.8	293.2	336.2	387.7	451.0
10K	116.0	123.3	131.9	138.3	148.4	161.9	175.3
10KH, 100K	94.0	103.1	129.8	154.9	187.9	225.8	275.7
Other	104.3	83.1	71.0	61.3	55.6	48.0	5.4
MOS Total	481.8	628.0	771.4	854.3	1,001.8	1,168.0	1,338.4
74C/4000	387.4	416.1	449.4	470.0	526.9	605.4	684.1
Hi-Speed CMOS Total	94.4	211.9	322.1	384.3	474.9	562.6	654.3
HC	76.4	159.0	230.5	272.7	343.6	405.1	471.6
HCT	18.0	52.9	91.6	111.6	131.2	157.5	182.7

Source: DATAQUEST



February Newsletters

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

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: February

AMD TO BUILD WAFER FAB IN IRELAND

OVERVIEW

Advanced Micro Devices (AMD) has announced construction of a new wafer fab facility in Ireland starting October 1, 1985. The new factory will be located in Greystones, a suburb of Dublin, and will occupy approximately 80 acres. The first of two 22,000-square-foot wafer fabrication lines should be on-line for production in 1987. Total cost of the project is estimated at $186 million.

TECHNOLOGY

The new facility will house two state-of-the-art factories that are closely modeled after AMD's Austin, Texas, operation. The Irish plant will produce six-inch, fine-line, CMOS wafers, focused primarily on microprocessor, telecommunications, and memory integrated circuits. AMD has also indicated that it is considering additional facilities at the same site for product assembly/test and R&D.

STRATEGY

AMD has stated that it intends to be the number one supplier of integrated circuits to the telecommunications industry. European telecom suppliers are key players in that market, so the selection of Ireland as a site for AMD's capacity expansion is a logical choice. Access to the common market countries was undoubtedly an important factor in the decision. It is interesting to note that the Irish wafer fab will be AMD's first offshore wafer facility, and the $186 million investment indicates the level of commitment and strategic importance to the company.

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GEOGRAPHICAL ISSUES

Ireland has pursued an aggressive program to attract high-technology "clean" industries for several years now. Under the direction of the Irish Development Authority (IDA), Ireland has developed a very competitive system of government grants, tax incentives, training support, and construction aids. Companies such as Apple Computer, Analog Devices, Mostek, and now, AMD, have chosen Ireland as a key element in their expansion strategies. AMD has stated that the large and well-educated work force, an abundant supply of engineers, and the appropriate infrastruture were important factors in their decision.

Other countries such as Scotland, Spain, and Britain have also launched similar aggressive programs to attract high-tech companies, especially in the semiconductor and software industries. DATAQUEST believes that U.S.-based chip suppliers will increase their offshore expansion of high-tech facilities as the industry matures into a truly international business and the labor and infrastructure become available, supportive, and profitable.

DATAQUEST ANALYSIS

AMD is one of the fastest-growing semiconductor suppliers in the industry. DATAQUEST estimates that AMD moved upward from tenth position in 1983 to eighth position in 1984 in worldwide digital MOS sales, with 1984 revenues of $480 million (see the SIS newsletter dated January 8, 1985, entitled "Preliminary 1984 Market Share Results"). In the area of microprocessor components, DATAQUEST estimates that AMD's sales grew an incredible 244 percent from 1983 to 1984, and leaped from eleventh place to fourth place in worldwide market position for these important, strategic devices. The Irish wafer fab project gives a clear indication of AMD's continued confidence in the future of the semiconductor industry, the pervasiveness of CMOS process technology, and the recognition that the industry is maturing into a true, international business and must design its strategies to fit a worldwide market.

Ken McKenzie

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: February

ASIC TECHNOLOGY SWAP MEET--
BUY, SELL, OR TRADE

INTRODUCTION

In the application-specific IC (ASIC) marketplace, 32 different companies were involved in a total of 26 major announcements of joint ventures, licensing agreements, and second-source agreements during 1984. It almost seemed as if the entire ASIC industry had suddenly discovered the importance of forming key alliances. In fact, if the pace continues much longer, it would appear that a special "swap" conference, reminiscent of some of the early personal computer fairs, may be in order.

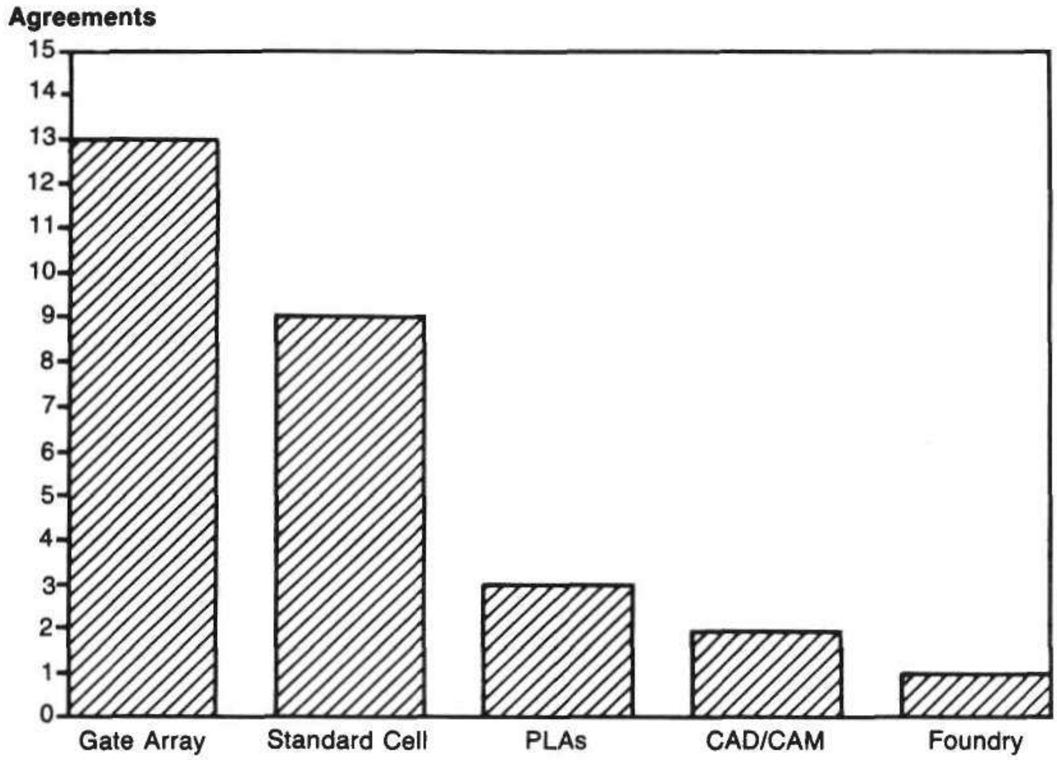
In the endless scramble for more market share, we believe that a few of the key reasons for the large number of agreements in 1984 are:

- To establish a standard in the marketplace
- To strengthen product portfolios and broaden product lines
- To increase presence in a worldwide marketplace
- To add design centers
- To increase capacity
- To fill customers' needs for alternate sources

A high percentage of these agreements involved gate arrays. As shown in Figure 1, gate array agreements accounted for half of the 26 announcements. (The totals shown in the figure add up to more than 26 since some companies had more than one agreement.) With 98 companies participating in gate arrays, it is the ASIC market that is closest to entering a mature phase and one where firms must become more cost- and service-oriented to ensure good market share.

Figure 1

NUMBER OF ASIC AGREEMENTS
1984



Source: DATAQUEST
February 1985

AGREEMENTS

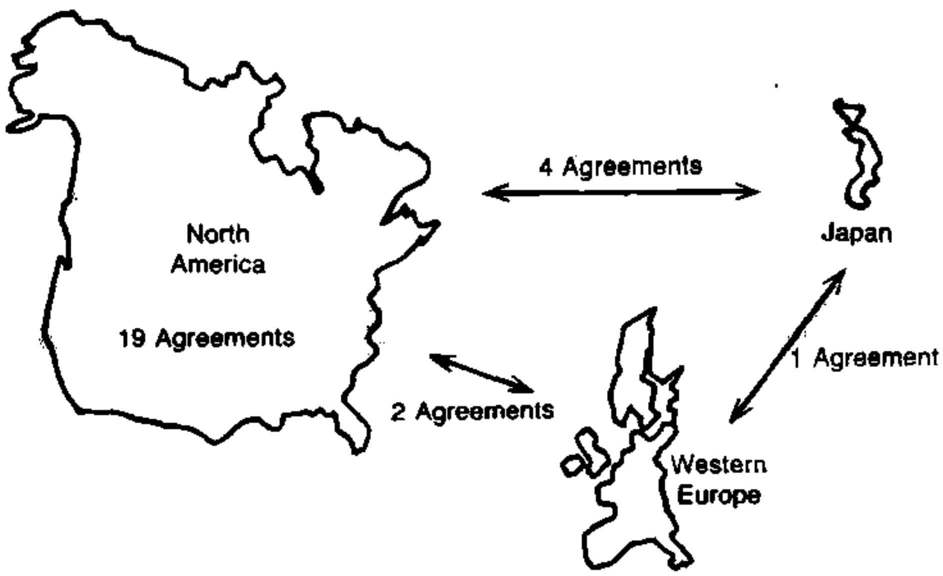
The overwhelming majority of the agreements were between North American companies. Figure 2 breaks down the number of agreements by regions; only seven of the 26 agreements were between different regions, and all of the agreements were for gate arrays.

In studying DATAQUEST's 1984 semiconductor industry data base, we found that there were 13 joint venture announcements and 18 second-source agreements (see Table 1 at the end of this newsletter). This list may not be all-inclusive, but we believe that it is representative of the trend of the ASIC market's agreements. The top five companies in numbers of agreements last year were:

- VLSI Technology--five agreements
- Texas Instruments and LSI Logic--four agreements each
- Fairchild and International Microelectronic Products--three agreements each

Figure 2

AGREEMENTS BETWEEN NORTH AMERICA, EUROPE, and JAPAN



Source: DATAQUEST
February 1985

Joint Ventures

The 13 joint ventures announced during 1984 were:

- VLSI Technology and Lattice Semiconductor
  - Second-sourcing and joint product development for programmable logic devices, EEPROMs, and static RAMs
- Plessey and GTE Microcircuits
  - A six-year agreement to work jointly on process development, in addition to exchanging process technology and future products. Both companies have also signed second-source agreements for each other's CMOS gate arrays
- Texas Instruments and Signetics (and parent company Philips)
  - An agreement to combine cell libraries, adapt the cells to a 2.3-micron process, and extend the combined libraries to include more complex functions. The companies' cell libraries will now be available to users at 31 design centers

- AMD and LSI Logic
  - Development of a CMOS standard cell library for designing large-scale integrated circuits. The companies also plan to cooperate on joint definitions of the CMOS standard cells, with AMD providing the 1.6-micron technology and LSI Logic responsible for software development
- VLSI Technology and Fairchild (gate array division)
  - An agreement providing for joint product specifications and development, product and software exchanges, and process cooperation. In addition, VLSI will be the second source for Fairchild's 2-micron CMOS gate array
- Ricoh and Custom MOS Array
  - A partnership in which Ricoh will provide CMOS wafer processing technology in exchange for Custom MOS Arrays' gate array technology
- Mostek and AMI
  - An agreement to develop and support semicustom product families. This five-year agreement includes technology exchange for CMOS gate arrays and standard cell library products, second sourcing, and development of compatible CAD tools
- Western Micro Technology and AMI
  - An agreement offering AMI's CMOS standard cell and CMOS gate array libraries through Western Micro Technology's design center
- VLSI Technology and Western Digital
  - A three-year agreement to jointly develop VLSI's Megacell standard cells based on Western Digital's product architectures for both companies' use in custom IC designs
- National Semi. and International Microelectronic Products (IMP)
  - A five-year technology exchange transferring IMP's standard cell design methodology to National. In turn, National is transferring its multiple-layer metal silicon gate CMOS process to IMP, as well as future CMOS process offerings to the standard cell market
- Harris and Texas Instruments
  - An agreement exchanging design software and circuits for gate array products. Harris has also adopted TI's circuit description language and application software for new customers' circuit designs

- Zymos and Intel
  - An extension of their technology exchange agreement covering joint development of custom VLSI circuits. This agreement also includes second sourcing of each other's products
- California Devices and Olympus Optical
  - An agreement to transfer California Devices' CMOS gate array technology and new product developments to Olympus. This is a nonexclusive one-year agreement

<u>**Second-Source Agreements**</u>

Second-source agreements during 1984 included:

- Oki Semiconductor and Thomson CSF
  - An agreement by which Thomson CSF is manufacturing Oki's 3-micron gate array family, and Oki is manufacturing Thomson CSF's recently announced gate arrays
- Honeywell and Applied Micro Circuit Corporation (AMCC)
  - Second-sourcing of AMCC's Q700 series gate arrays. Honeywell's Digital Product Division also has become the alternate second source for AMCC's bipolar logic arrays
- Fujitsu and Monolithic Memories (MMI)
  - A five-year agreement for MMI to second-source Fujitsu's TTL gate arrays
- Fujitsu and Texas Instruments
  - An agreement by which Texas Instruments will be the second source of Fujitsu's CMOS gate array and bipolar TTL arrays
- International Microcircuits Inc. (IMI) and S-MOS Systems Inc.
  - A two-year second-source agreement covering both companies' 2-micron CMOS gate arrays. Additionally, the companies will share each other's standard cell libraries
- International Microelectronic Products and GTE Microcircuits
  - An agreement to second-source each other's respective 3-micron CMOS processes

- Intersil and LSI Logic

  - A five-year second-source agreement covering LSI Logic's HCMOS process logic arrays and Intersil's CMOS gate array family

- Altera and Intel

  - A second-source agreement giving Intel the option to manufacture the Altera family of electrically programmable logic devices

- Philips and Fairchild

  - A second-sourcing agreement for each other's families of gate arrays

- National Semiconductor and Monolithic Memories

  - National's new high-speed PLAs are being second-sourced by Monolithic Memories in accordance with a previous agreement

- VLSI Technology and Silicon Compilers

  - A licensing agreement in which VTI will manufacture and market Silicon Compilers' RasterOp chip

AND IN 1985 . . .

Agreements in 1985 have already begun. VLSI Technology and Sierra Semiconductor, Texas Instruments and National Semiconductor, and Standard Microsystems and NCR are the first few companies to sign agreements this year. We expect that 1985 will have as many announcements as 1984, if not more.

Katy Guill
Andy Prophet

Table 1

JOINT VENTURES, LICENSING AGREEMENTS, AND SECOND-SOURCE AGREEMENTS
1984
(Reverse Chronological Order)

Date	Companies	Product	Joint	Lic.	Sec.*
11/27	VLSI Technology Silicon Compilers	Standard cells	x		
10/22	VLSI Technology Lattice Semi.	Programmable logic	x	x	x
10/10	Western Micro. AMI	Gate array/ standard cells	x		
10/8	GTE Micro. Plessey Semi.	CMOS gate arrays	x		x
9/30	Oki Thomson CSF	CMOS gate arrays			x
9/24	Texas Instruments Signetic/Philips	CMOS standard cells	x		x
8/13	Altera Intel	Programmable logic			x
8/8	AMD LSI Logic	CMOS standard cell library	x		

*Joint = joint venture
Lic. = licensing agreement
Sec. = second-source agreement

(Continued)

Table 1 (Continued)

JOINT VENTURES, LICENSING AGREEMENTS, AND SECOND-SOURCE AGREEMENTS
1984
(Reverse Chronological Order)

Date	Companies	Product	Joint	Lic.	Sec.*
8/6	AMCC Honeywell	AMCC's bipolar gate array			x
8/3	AMD LSI Logic	LSI's CMOS gate array			x
7/30	Zymos Intel	Standard cells			x
7/23	California Devices Olympus	CMOS gate array technology		x	
7/20	VLSI Tech Western Digital	Standard cells	x		
6/18	National Semi. IMP	Standard cells	x		
5/31	Philips Fairchild	Gate arrays			x
5/30	Fairchild VLSI Technology	CAD system	x		

*Joint = joint venture
Lic. = licensing agreement
Sec. = second-source agreement

(Continued)

Table 1 (Continued)

JOINT VENTURES, LICENSING AGREEMENTS, AND SECOND-SOURCE AGREEMENTS
1984
(Reverse Chronological Order)

Date	Companies	Product	Joint	Lic.	Sec.*
5/30	Fujitsu Monolithic Mem.	Fujitsu's TTL gate arrays			x
5/30	VLSI Technology Fairchild	Fairchild's gate arrays			x
5/14	S-MOS IMP	CMOS gate arrays and library			x
5/28	National Semi. Monolithic Mem.	NSC's program-mable logic			x
5/7	IMP GTE Micro.	CMOS standard cells			x
3/26	Ricoh Custom MOS	CMOS wafer production	x		
3/3	Harris Texas Instruments	Bipolar gate array and CAD	x		
	Texas Instruments Harris	TI's CMOS gate array	x		

*Joint = joint venture
Lic. = licensing agreement
Sec. = second-source agreement

(Continued)

Table 1 (Continued)

JOINT VENTURES, LICENSING AGREEMENTS, AND SECOND-SOURCE AGREEMENTS
1984
(Reverse Chronological Order)

1984 Date	Companies	Product	Joint	Lic.	Sec.*
3/1	AMI Mostek	Gate array and standard cells	x		x
2/20	LSI Logic Intersil	LSI's CMOS gate array			x
	Intersil LSI Logic	Intersil's CMOS gate array			x
1/9	Fujitsu Texas Instruments	Fujitsu's CMOS gate arrays Bipolar TTL			x

*Joint = joint venture
Lic. = licensing agreement
Sec. = second-source agreement

Source: DATAQUEST
February 1985

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters

MICROPROCESSOR MARKET TOPS $3.1 BILLION--
RECORDS PHENOMENAL 62.5 PERCENT GROWTH IN 1984

In 1984, one of the best years in the history of the semiconductor industry, the MCU, MPU, and MPR segment outpaced the rest of the industry and was characterized by the following:

- The microprocessor market exceeded $3.1 billion, more than the entire worldwide integrated circuit market was just ten years ago.
- Nine of the top ten companies had revenues of more than $100 million each in this segment.
- Advanced Micro Devices (AMD) grew a staggering 244.8 percent, and joined the top ten microprocessor companies by surging from eleventh to fourth place.
- Japanese manufacturers did not gain market share.
- Eight companies grew more than 100 percent.

TOP TEN RANKING CHANGES SLIGHTLY

The top ten companies shown in Table 1 accounted for more than 70 percent of the market, and nine of the ten had revenue of more than $100 million each in the microprocessor segment. In 1984, Intel, NEC, and Motorola remained number 1, 2, and 3, respectively, while AMD rose from number 11 in 1983 to the number 4 spot in 1984. Hitachi and Fujitsu changed ranking, with Hitachi moving from number 7 to number 6. Zilog moved to eleventh place and was replaced by Texas Instruments in the ninth position.

Table 1

TOP TEN 1984 MICROPROCESSOR MANUFACTURERS
(Millions of Dollars)

1983 Rank	1984 Rank	Company	Revenue 1983	Revenue 1984	Growth
1	1	Intel	$330	$653	97.9%
2	2	NEC	$237	$388	63.7%
3	3	Motorola	$190	$254	33.7%
11	4	Advanced Micro Devices	$ 58	$200	244.8%
5	5	Matsushita	$ 88	$139	58.0%
7	6	Hitachi	$ 85	$120	41.2%
6	7	Fujitsu	$ 85	$118	38.8%
8	8	National Semiconductor	$ 75	$115	53.3%
4	9	Texas Instruments	$135	$110	(18.5%)
10	10	Mitsubishi	$ 59	$ 97	64.4%

Source: DATAQUEST
February 1985

GEOGRAPHIC MARKET SHARE REMAINS STABLE

The geographic market share changed by less than one percentage point from 1983 to 1984, as shown in Table 2. Market share for West European companies rose from 3.1 to 3.8 percent, while the market share for Japanese companies slipped slightly. These comparatively stable 1984 market shares were a result of the capacity limitation in the industry, which prevented additional market penetration by any company. Microprocessor products are highly visible components and are frequently key elements in a manufacturer's account strategy. They are also high-margin or proprietary products and often receive highest priority in manufacturing allocation, thus allowing a company to protect its position with MPU support chips at the same account.

Table 2

GEOGRAPHIC MARKET SHARE FOR MICROPROCESSOR SEGMENT

	1983	1984
United States	60.8%	61.0%
Japan	35.7	34.9
Western Europe	3.1	3.8
Rest of World	0.4	0.3
	100.0%	100.0%

Source: DATAQUEST
February 1985

RECORD-SETTING GROWTH RATES

The ten manufacturers with the highest growth rates in the microprocessor segment are shown in Table 3. Eight companies grew 100 percent or more. Of these eight, four were U.S. companies, three were West European companies, and one, Oki, was a Japanese company.

Table 3

TOP GROWTH 1984 MICROPROCESSOR MANUFACTURERS
(Millions of Dollars)

	Revenue		
	1983	1984	Growth
Matra-Harris	1	11	1,000.0%
Advanced Micro Devices	58	200	244.8%
Siemens	6	19	216.7%
Signetics	30	75	150.0%
Oki	19	46	142.1%
Thomson	10	21	110.0%
Harris	26	53	103.8%
NCR	6	12	100.0%
Intel	330	653	97.9%
Sanyo	18	35	94.4%

Source: DATAQUEST
February 1985

ANALYSIS

DATAQUEST believes that 1984's unprecedented growth in this market segment will not be repeated soon. The 1984 growth was due to stable and high prices brought on by a supply-limited market; a rapid transition to the newer, high-integration devices, especially in the 16-bit MPU product group; and a tremendous surge in microcontrollers for automotive, industrial, and consumer applications.

DATAQUEST believes that this growth rate is somewhat misleading, however. Because of the frenzy of activity and acute fear of prolonged shortages during the first half of 1984, there was much overbuying both at the distributor level and at the OEM level. The market began to correct that excess in the final quarter of 1984, and we expect this trend to continue during the first few months of 1985. Consequently, DATAQUEST believes that microprocessor growth in 1985 will be 25 to 35 percent, considerably smaller than in 1984.

Mel Thomsen

March

March Newsletters

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

(Continued)

March Newsletters

- Table 4, Second-Generation 16-Bit Microprocessor Shipments Second Quarter 1984 through Third Quarter 1984, Page 3
- Table 5, Unit Market Share By Technology for 8-Bit Microcontrollers and 8-Bit Microprocessors Third Quarter 1983 through Third Quarter 1984, Page 4
- Table 6, Market Share by Region for Microcontrollers and Microprocessors Third Quarter 1983 through Third Quarter 1984, Page 5

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

EPROM MARKET SYNOPSIS--1984

SUMMARY

DATAQUEST has published its quarterly shipment estimates for 1984 for all densities of EPROMs. Detailed company data have been mailed to DATAQUEST notebook holders, and are located in the SIS Products and Markets notebook, behind the Memory tab under the "EPROMs-Data" heading.

During 1984, most U.S. manufacturers enjoyed a temporary respite from the intense Japanese competition they had experienced until late 1983. During the upswing, Japanese manufacturers concentrated their production capabilities on their home market, as well as on their dynamic and static RAM business. As a result, U.S. manufacturers were able to take best advantage of the growth opportunities in EPROMs. This situation resulted in stable pricing and steadily growing volumes until midsummer, at which time Japanese manufacturers returned to the marketplace. By the fourth quarter, many products that had been in short supply throughout the first nine months were readily available, and prices began a rapid decline.

Table 1 shows estimated 1984 revenues by leading suppliers of EPROMs. Eighteen companies generated revenues in the EPROMs market in 1984, although the market was very much dominated by the leading six producers, who supplied 78 percent of the total revenues. The total EPROM market was estimated to be $1169 million in 1984. As has been the case since the inception of the EPROM market, Intel was again the market leader, although its market share dropped considerably in the face of (1) its own capacity allocation problems, (2) leading-edge density competition, primarily from AMD, and (3) volume production in the more mature densities from Hitachi, Mitsubishi, and Texas Instruments. AMD and Mitsubishi were able to increase their production dramatically in the course of the year, and only a late rush by Hitachi in the fourth quarter kept them from taking the number two and number three slots. Texas Instruments, which was a longtime competitor of Intel for earlier generations of EPROMs in 1980 and 1981, moved back up in the ranks in 1984 with high volume shipments of 16K, 32K, and 64K devices.

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Table 1

ESTIMATED 1984 EPROM REVENUES FOR TOP 10 SUPPLIERS
(Millions of Dollars)

	1984
Intel	$200
Hitachi	165
AMD	163
Mitsubishi	155
Texas Instruments	128
Fujitsu	127
NEC	70
National	45
Toshiba	38
Seeq	35
Others*	43
Total	$1169

*Includes Matra-Harris, Mostek, Oki, Ricoh, Rockwell, SGS-Ates, Signetics, and Thomsen (Eurotechnique)

Source: DATAQUEST
March 1985

The market as a whole showed steady revenue growth and slowly declining prices through the early fall. At that time, the Japanese manufacturers, whose penetration of the EPROM market had been slowed during most of 1984, emerged again to bring supply into excess and drive prices down dramatically. While Japanese manufacturers as a whole lost market share to U.S. manufacturers during 1984, we expect that in the supply excess market of 1985, we will see them again gaining market share as they did in 1982 and 1983.

Table 2 shows the estimated mix of EPROMs by density, as well as estimated unit shipments and average selling prices for each density. More than 75 percent of the EPROM revenues were generated at the 64K and 128K densities, but 16K, 32K, and 256K densities also were good markets. CMOS EPROM revenues made up about $112 million of the total EPROM market in 1984. Shipments of one-time programmable plastic-packaged EPROMs (OTPs) were also slowed by a variety of technical and marketing problems, and probably totaled only about $30 million in 1984.

Table 2

ESTIMATED 1984 EPROM REVENUES, UNITS, AND PRICES BY DENSITY

Density	Revenues ($M)	Units (Million)	Worldwide ASP
2K	$ 4	0.5	$ 8.00
8K	2	0.4	$ 4.00
16K	115	36.0	$ 3.20
32K	187	55.0	$ 3.40
64K	448	95.0	$ 4.85
128K	327	27.0	$ 12.00
256K	85	2.1	$ 40.00
512K	1	0.01	$100.00
Total	$1169	216.01	

Source: DATAQUEST
March 1985

Despite some significant instances of production capacity being allocated away from the EPROMs, the market grew steadily from the third quarter of 1983 through the third quarter of 1984. Although several U.S. manufacturers are shipping high volumes at 256K densities, and are beginning to ship at 512K densities, most of the 1984 market growth resulted from increased unit shipments of the more mature products--32K, 64K, and 128K devices.

Because of the tight capacity situation and a variety of technical, manufacturing, and market development problems, it was extremely difficult for manufacturers to introduce the newer technologies, such as OTP EPROMs and CMOS EPROMs.

PRODUCT MARKET SUMMARIES

Principal market developments in each of the product areas are discussed briefly in the paragraphs below. Details of each vendor's shipments can be found in the notebooks.

8K EPROMs

Estimated shipments of 8K EPROMs were 360,000 units in 1984. Prices were usually in the $4.00 to $4.50 range, for a total revenue base of about $2 million.

16K EPROMs

Estimated shipments of 16K EPROMs were about 36 million units. Because of the strong market of 1984 and the tight capacity, many manufacturers are extricating themselves from the 16K market. Prices, which were steady at about $3.25 in the first two quarters, resumed their decline in the third quarter and accelerated in the fourth quarter. Unit shipments are expected to drop quickly during 1985, although prices should remain in the $2.75 to $3.00 range.

32K EPROMs

Shipments of 32K EPROMs were about 55 million units in 1984. Different manufacturers have approached this market differently: some have continued to stay in it and ship stable or increasing volumes, while others, which had different capacity constraints, backed out entirely. However, the market continues to generate good total revenues that were estimated to be $187 million for 1984. Though Japanese manufacturers gave up some ground in higher density EPROMs in 1984, they continued to maintain an extremely large market share in the 32K EPROMs.

64K EPROMs

At present, 64K EPROMs are the highest revenue generating density EEPROM, totaling an estimated $448 in 1984. At year end, there were 15 suppliers of the part, including six manufacturers shipping CMOS parts. In 64Ks, AMD, Hitachi, and Mitsubishi picked up a significant market share during 1984. During the year, Mitsubishi shipped an estimated 22 million 64Ks to become the market leader (in units) compared with Hitachi's 21 million, AMD's 5.7 million, and Intel's 8.0 million.

In the U.S. market, 64K EPROMs tended to be priced in the $5.50 range for both the first and second quarters, but resumed their competitive price decline in the third quarter. Prices in Japan, Europe, and the Far East have consistently been lower than they have been in the United States, and probably were about $4.25 to $4.50 during the first half of the year. The overall ASP for the year for 64Ks was estimated to be about $4.85.

128K EPROMs

The 128K EPROMs grew steadily through the first three quarters of 1984, and exploded in the fourth quarter to total about 27 million units for the year. As in the lower density EPROM markets, 128K prices declined into the fall of 1983, then backed up, and new business was in the $16 to $18 range during the first two quarters of 1984. However, with the emergence of new production capacity and new vendors at the 128K density, billing prices in the third quarter of 1984 dropped to about $12 to $14, and to about $10 to $11 in the fourth quarter as much additional product became available from Japanese vendors.

256K EPROMs

Shipment estimates for 256K EPROMs were an estimated 2.1 million units in 1984. Even at the end of the year, only three vendors were truly in volume production on this part. Prices came down steadily throughout the year, and were about $80 in the first quarter, $45 in the second quarter, and $38 in the third quarter. It is at the 256K level that AMD is really pounding on the door of the market leader, Intel. However, over the coming months we expect to see all U.S. manufacturers of 256K EPROMs increase their production significantly, and also a marked increase in availability from Fujitsu and Hitachi.

At present, 256K EPROMs in CMOS are available from Fujitsu, Hitachi, Intel, Seeq, and Toshiba, although with the exception of Fujitsu, the volumes delivered are still quite small.

512K EPROMs

At the 512K density, AMD was the first manufacturer to ship product, sampling some accounts in the first quarter of 1984 and shipping a few thousand units in the second quarter. Intel followed suit, sampling accounts in the second quarter, and began to increase its production in the third quarter. Intel has also offered a page-addressed 512K EPROM variant, the 27513, which is organized as four 16Kx8 pages. Total shipments for the year were about 12,000 units, at an average selling price of about $95.00.

EMERGING EPROM TECHNOLOGIES

Although a number of EPROM technology directions surfaced in 1983 and 1984, most had very limited success in becoming established in the market. Three of these are discussed below.

High Speed EPROMs

Although none of these products have yet hit the market, several manufacturers have developed high speed EPROMs. These products have access times in the range of 55ns to 70ns, and are usually targeted as bipolar PROM replacements. Some of these are very impressive devices, using state-of-the-art NMOS or CMOS technologies with die sizes nearly as small as Intel's technology-leading 2764A (about 11,000 square mils). We expect to see samples coming out of a number of manufacturers in early 1985, with production volumes slated for later in the year.

One-Time Programmable EPROMs

During 1983, many manufacturers attempted to develop technologies to enable them to be price competitive in the emerging OTP market for 1984, 1985, and 1986. During 1984, a variety of developments conspired to keep OTP penetration at a minimum, temporarily.

First, the EPROM market was extremely strong, thereby lessening the economic pressure to have OTPS in order to remain price competitive. With the strong market, users had been able to get adequate margins using a traditional CERDIP package with quartz lid, without having to address the troublesome reliability problems that have plagued OTP since its inception.

Second, the declining video games market made the ROM market much more competitive in applications where users had a choice between mask ROM or EPROM. During the last part of 1983 and the first half of 1984, the long lead times and continuing high prices of EPROMs may have halted, or perhaps even reversed, some of the gains made by EPROM manufacturers in the overall MOS nonvolatile memory market from 1981 through 1983.

Now that supply has caught up with demand and a price-competitive market has been restored, DATAQUEST expects EPROMs and OTPs to resume their encroachment into the ROM market.

DATAQUEST continues to believe in the long-term potential of the OTP market, although volume production has suffered from some technical setbacks at certain manufacturers. We still expect that during the period from 1985 through 1988, we will see significant replacement of traditional CERDIP EPROMs by plastic OTPs.

CMOS EPROMs

Many manufacturers are active in the CMOS EPROMs area, but the penetration of CMOS as a cost-effective, low power NMOS replacement was extremely slow during 1984. We attribute this primarily to the difficulty in mastering the CMOS EPROM process, as well as the strong market environment that dictated against bringing up low-yielding, silicon-intensive products in a tight capacity market.

Even in the third quarter of 1984, production of CMOS EPROMs at 64K densities and greater was modest. In the 16K to 32K levels, however, National Semiconductor continued to ship significant volumes.

OUTLOOK

Over the last decade among all MOS memory products, EPROMs have consistently shown the greatest ability to improve the price/performance to the user, to overcome technical barriers involved in scaling, and to improve ease of use by virtue of improved programming algorithms and lower programming voltages. In addition to device improvements themselves, the EPROM programming equipment has offered users the ability to use EPROMs in a true cost-oriented, high volume production environment, thereby making them extremely competitive with mask ROMs.

In the competitive marketplace, the resurgence of the Japanese manufacturers that began late in 1984 will undoubtedly make it difficult for most U.S. suppliers during 1985. Prices have dropped drastically in just the last three or four months, and give every indication that it will become increasingly difficult to hold onto market share, even at high densities.

Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

EEPROM AND NVRAM MARKET SYNOPSIS--1984

SUMMARY

DATAQUEST has published its estimates of 1984 unit shipments of several EEPROM and NVRAM products. Quarterly shipment estimates for 1984 by companies participating in the NVRAM, low density (<2K) EEPROM, and 16K, 32K, and 64K EEPROM markets have been mailed to DATAQUEST notebook holders, and are located in the SIS Products and Markets notebook, behind the Memory tab under "EEPROMs/NVRAMs--Data."

Table 1 shows estimated 1984 total revenues by leading suppliers of NVRAM and EEPROMs. Twenty-two companies generated revenues in these product areas in 1984, but many are captive-only, or local market only, and most are only small players. The total market in 1984 was estimated to be $153 million. Xicor, whose sole revenue sources are EEPROMs and NVRAMs, and which has done much of the market making, was the number one supplier with 1984 revenues of $39 million. It was followed by General Instrument and Intel, with estimated revenues of $27 million and $22 million, respectively. National Semiconductor, which generates most of its revenue at lower densities, and Seeq Technology, which offers 16K and 64K EEPROMs, followed with an estimated $15 million and $14 million, respectively.

Much of the technological innovation and market leadership has come from smaller manufacturers dedicated to achieving high market shares in these emerging technologies. There is no doubt, however, that as the market settles down, becomes more production-oriented, and poses a larger revenue opportunity, many established U.S. and Japanese manufacturers will pay more attention to these markets.

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Table 1

ESTIMATED 1983 AND 1984 EEPROM AND NVRAM REVENUES
(Millions of Dollars)

	1983	1984
Xicor	$ 15	$ 39
General Instrument	22	27
Intel	16	22
National Semiconductor	5	15
Seeq Technology	5	14
Motorola	5	6
NCR	7	6
Others*	28	24
Total Market	$103	$153

*Includes AMD, Exel, Hitachi, Hughes, Inmos, Matsushita, Mitsubishi, NEC, Philips, Rockwell, SGS-Ates, Siemens, Synertek, Toshiba, and Tristar, all of which generated EEPROM or NVRAM revenues in 1984.

Source: Dataquest
March 1985

Table 2 shows the estimated EEPROM revenue mix by density, and also breaks out NVRAMs. The market growth in low density EEPROMs was greatest in 1984, with revenues up nearly 50 percent from 1983. However, with more activity now at the 16K to 64K level, DATAQUEST expects the major growth for the next few years to be in the higher densities.

Table 2

ESTIMATED 1983 AND 1984 EEPROM AND NVRAM REVENUES BY DENSITY

	1983	1984
NVRAM--all densities	$ 15	$ 21
EEPROM--<2K	40	57
2K-8K	10	12
16K	37	52
32K	1	4
64K	0	7
Total	$103	$153

Source: DATAQUEST
March 1985

PRODUCT MARKET SUMMARIES

Principal market developments in each of the product areas are discussed briefly in the paragraphs below. Details of each vendor's shipments can be found in the notebooks.

Nonvolatile RAMs (NVRAMs)

Xicor has done much of the pioneering work here and is the market leader in terms of both revenue and diversity of products offered. Though most of the revenues continue to be generated at or below the 1K level, three manufacturers have shipped 4K devices--General Instrument, Intel, and NCR.

Low Density EEPROMs

Shipments for a variety of low density EEPROMs (less than 2K bits) totaled an estimated 39 million units in 1984. Although there is some second sourcing or pin compatibility among products offered into this market, users very often face sole-source decisions.

Long-time supplier General Instrument appears to be the volume leader, but National Semiconductor and NCR are seen with increasing frequency.

Many of the devices offered into this market are 256-bits, which may sell anywhere from $0.90 in a loose die form, up to $1.35 to $1.80 packaged in a MINIDIP. There are also a number of 512-bit, 1K, and 2K parts organized either x4 or x8. With the exception of Hughes Aircraft, which has shipped modest quantities of a CMOS part, all of the current products on the market either utilize a metal or a silicon nitrox technology, or an NMOS floating-gate technology. In 1985, we expect to see low density CMOS EEPROMs available from several of the new start-ups.

16K EEPROMs

During 1984, Xicor emerged as the 16K EEPROM market leader in terms of unit shipments, and the company's X2816A part type has emerged as the de facto standard in this market. At the end of 1984, Exel, SEEQ, Tristar, and Xicor were all shipping functionally compatible 16K products. Market-initiator Intel's most advanced product, the 2817A, is also targeted for second-sourcing by several manufacturers. We expect to see these two parts squeeze most of the earlier versions out of the market in the coming year or so.

Estimated shipments of 16K EEPROMs during 1984 were about 4.3 million units for $52 million. Unit prices in the first half generally ran in the $14 to $17 range, with occasional lower pricing. By the end of the third quarter, unit pricing had moved down to the $10.50 to $12.00 range. At year end, considerable business was less than $10.

In addition to the standard, fully functional, fully tested parts on the market, there appears to be a substantial 16K EEPROM market for users whose endurance, data retention, and write speed requirements are not as demanding as the standard data sheet product would indicate. As a result, some of the low-end pricing in the market at the end of the third quarter had drifted down as far as $6 to $8, and brokered 16Ks with just 100 write cycles guaranteed were offered in early 1985 for less than $6.

During 1985, with at least four or five manufacturers in production with the 2816A and several making the 2817A, we expect prices to come down significantly in a much more competitive market.

32K EEPROMs

Estimated shipments of 32K EEPROMs in 1984 were 95,000 units, generating about $4 million in revenue. The 32K EEPROM market's future must be viewed as quite tentative because of the simultaneous presence of higher density 64K products on the market from several vendors. Furthermore, at the 64K density, there is higher manufacturer interest, there is more agreement on product standards, and there are several manufacturers poised to go into volume production in 1985. As a result, the 32K EEPROM market is likely to be a very temporary and low-volume market.

Exel's XL46C32 high speed (55ns to 70ns) 32K EPROM marks a departure from the traditional 150ns to 250ns devices now available. Targeted as a bipolar PROM replacement, it is one of several high speed EEPROMs expected out in the next 9 to 12 months.

64K EEPROMs

During 1984, five vendors shipped 64K EEPROMs--AMD, Inmos, NCR, SEEQ, and Xicor. Although the market is still very small, SEEQ is considered the volume leader. Shipments of 64K EEPROMs for 1984 were estimated to be 135,000 units, generating revenues of about $7 million. Pricing in the first half was generally in the $50 to $70 range, although sample quantities sold into the military market could be four to six times that high. High density EEPROMs are getting a lot of interest from the military and automotive markets, although several technical and economic issues remain to be resolved. During 1985, we expect at least two or three vendors to ship several hundred thousand 64Ks each.

At the 64K density, several manufacturers are also looking at bipolar PROM replacement type, high speed EEPROMs, which should appear on the market during 1985. Foremost among these is a 35ns part from Lattice Semiconductor in Portland, Oregon.

OUTLOOK

Both the NVRAM and EEPROM markets experienced strong growth during 1984, but like all MOS memory products, entered 1985 facing a slowing of demand and much more competitive markets. With the emergence of second-sourcing and device standards, the market has begun to settle down somewhat. Prices, relative to EPROM or SRAM with battery back-up, remain high. Heretofore, this has been a big limiter to EEPROM market growth, and with tremendous price erosion in those competitive markets, promises to remain a constraint on market growth.

During 1985, we expect to see more participation in the EEPROM market from larger, more established producers such as AMD and Hitachi. While this will likely be tough on EEPROM suppliers with lesser financial resources, narrower product lines or manufacturing skills, it will undoubtedly also give the EEPROM market some added credibility and improved price/performance.

Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: March

INTERNATIONAL SOLID STATE CIRCUITS CONFERENCE--1985
CONFERENCE OVERVIEW AND MEMORY SESSIONS

SUMMARY

The 32nd annual meeting of the International Solid State Circuits Conference (ISSCC) was held at the New York Hilton, February 13, 14, and 15. Seventeen formal sessions focused on the key circuit and process issues that are certain to be a part of tomorrow's state-of-the-art semiconductor components, and authors from nine countries presented 108 papers. Additionally, 11 less formal (off-the-record) evening sessions offered the opportunity for panel discussions centering on several emerging technical issues. Table 1 summarizes session titles.

Dr. Raj Reddy of Carnegie-Mellon University delivered the keynote address on Wednesday afternoon, discussing "Superchips for Artificial Intelligence."

For the first time, papers by authors from Japanese companies outnumbered those from U.S. companies; there were 49 from Japan and 41 from the United States, compared with 44 from Japan and 53 from the United States at last year's ISSCC. European authors contributed 13 papers and 5 were authored by Canadians. As recently as five years ago, U.S. authors outnumbered Japanese by as much as 2-1/2 to 1, but they have steadily lost ground since then.

More than half the devices described employed CMOS technology (57 papers), again capturing a shift in technology that has been accelerating rapidly in recent years. As in each ISSCC since 1980, papers discussing semiconductor memory constituted the largest single area of discussion, thus acknowledging the importance of the memory area, both as a leading-edge process development vehicle and as an important part of the industry's revenue base.

Table 1

ISSCC SESSION SUMMARY

Session Number	Topic	Number of Papers	Authorship: U.S. or Canada Merch.	Authorship: U.S. or Canada Captive	Authorship: Japan	Authorship: Europe	Technology Employed: MOS CMOS	Technology Employed: MOS NMOS	Technology Employed: CCD	Technology Employed: GaAs	Technology Employed: Bipolar	Technology Employed: Other
I.	MPUs & Floating Point Processors	4		2*	2		4					
II.	Consumer ICs	7			5	2*	2	1		1	3	
III.	Special Application Memories	7	3	1	3		3	2			2	
VI.	High Density SRAMs	6	1		5		5			1		
VII.	Data Converters	5	3		1	1	4				1	
VIII.	Signal Processing	5	2	1	1	1		5				
IX.	Image Sensors	5		1*	4		1		4			
X.	Flexible Digital Arrays	5	1		4		5					
XI.	Op Amps and Voltage Regulators	7	4	1		2	2**	1			4**	
XII.	Communication Links	5	1*	2*		2	4				1	
XIII.	Nonvolatile Memories	8	4		4		6	2				
XIV.	Processors for Specific Applications	7	4	1*	2		4**	3			1**	
XV.	High Speed Arrays	6	1		4	1	1			2	3	
XVI.	High Speed Technology and Design	7	1		4	2	2			2	3	1
XVII.	Megabit DRAMs	10	1	2	7		5	5				
XVIII.	Modeling and Technology	7	2	2	2	1	4**		1	1	2**	
XIX.	Monolithic Analog Filters	7	1	4*	1	1	5	1	-	-	1	-
	Totals	108	29	17	49	13	57	20	5	7	21	1

*Joint authorship involving different companies or schools
**Includes devices employing two separate technologies

Wednesday Evening Sessions

- Computing for Artificial Intelligence
- Video Signal Processing
- The Effect of Scaling Up on Future Analog/Digital Systems
- System Applications and Limitations of Submicron MOS
- Nonvolatile Circuits as Building Blocks
- CAE Workstations

Thursday Evening Sessions:

- Custom and Semicustom Design Approaches for the Future
- A/D Architectures of the Future
- Fault Tolerant Techniques for Memory Components
- Using Optical Links to Interconnect Digital Equipment
- High Speed LSI Technologies Challenging the CMOS VLSI Era

Source: 1985 ISSCC Digest of Technical Papers
DATAQUEST
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CONFERENCE OVERVIEW

As always, the ISSCC foretells the pressures of tomorrow's market. This year's program was no exception. Full sessions devoted to special

application memories and special application microprocessors addressed a trend toward dedicating fundamental memory or microprocessor architectures to specific applications through optimizing device parameters or adapting device features to the appropriate application. Communication chips, in the form of echo-cancellers, coder-decoders, and network controllers, all underscored the explosive activity in the office networking and digital telecommunications areas.

Sessions on image sensors, high-performance A-to-D converters, signal processors, and floating-point processors all addressed the growing efforts underway in the areas of capturing, converting, and processing analog information. This thread, running throughout many of the sessions, tied in well with the keynote address on artificial intelligence (AI), and was accompanied by related evening sessions on AI and signal processing.

Apart from the substantive technical issues discussed in the sessions themselves, broad trends in the semiconductor industry at the technical, corporate, and overall industry levels could be discerned. Authorship of the papers and the gradual substitution of CMOS for the older bipolar and NMOS technologies as the primary growth vehicle, reflected similar trends in the components marketplace.

Authorship

To some degree, paper authorship is a measure of the level of technical ability within a school, lab, company, or country. The emphasis on publishing may vary from one institution to another, or from one country to another, but, there is a good correlation between authorship of the technical papers delivered at ISSCC and current or subsequent success in the component marketplace. Japan's dominance of the merchant RAM market has closely paralleled its previous high level of representation in authorship of RAM papers at earlier ISSCC sessions.

Table 1 and Table 2 look at paper authorship from two viewpoints. Table 1 shows authorship based on the locations of the authors' companies. Table 2 lists the leading companies providing papers this year and the number of papers from each. It shows that Hitachi was the leader, with 14 papers spread out over 10 of the 17 technical sessions. Toshiba with 9, and NEC with 8, took the next two slots. Among U.S. suppliers, only the combined forces of ATT-Bell Labs (6 papers) were able to break into the top six. This could either mean that Japanese companies are technically superior to U.S. companies or merely that Japanese companies place more emphasis on having their work recognized at ISSCC. However, the large representation by large vertically integrated companies, captive or not, as shown in both Tables 1 and 2, probably does indicate some advantage of size or captive demand, compared to operations that are completely merchant-market driven.

Table 2

LEADING SOURCES OF ISSCC PAPERS

Company	Number of Papers
Hitachi	14
Toshiba	9
NEC	8
ATT-Bell Labs	6
Mitsubishi	4
Fujitsu	4
Texas Instruments	3
Bell Northern	3
Matsushita	3
Fairchild	3

Source: DATAQUEST
March 1985

Device Technology

CMOS technology was employed in more than half the devices described. The strongest remaining areas of NMOS design were signal processing (which is still 100 percent NMOS) and 1Mb DRAMs, where half of this year's session papers were NMOS. Bipolar technologies (usually ECL) were used in 19 percent of the devices described, principally in high-speed memories and logic arrays, as well as in operational amps and voltage regulators (Session XI). In addition, an increasing number of devices mixed bipolar and MOS processes on a single chip.

CCDs and GaAs technology retained their five percent shares of papers delivered, which they have had for several years. GaAs appeared in five sessions concerned with high performance technologies. CCDs are almost alone now as the technology of choice for image sensors.

SESSION HIGHLIGHTS

Technical developments over a wide range of circuit applications were covered in all the sessions listed in Table 1. Several of the well-attended sessions are reviewed briefly below.

Signal Processing

The rapid growth in interest in speech recognition, image processing, and other digital signal processing applications has directed considerable design resources to this broad area. In many ways, much of the entire ISSCC program was pointed toward this trend: AI, floating point processors, image sensors, and data converters. Session VIII focused specifically on the digital processing core of such systems.

Two papers discussed image processing and recognition. Both were university papers, one from Tohoku University in Japan and one from Catholic University/Ackermans Van Haaren NV in Belgium. Other papers in this session included one from Texas Instruments (a leader in today's commercial market) describing a digital signal processor with multiprocessing capability, and a paper on a programmable processor with 32-bit floating-point arithmetic from ATT.

Flexible Digital Arrays

In this session, the emphasis was on logic arrays in which RAM, ROM, shift registers and linear circuity could be implemented efficiently. Such devices have enabled gate array manufacturers to compete successfully against standard cell manufacturers, who could offer more fully optimized versions of these circuit elements.

All five devices described in the session were implemented in CMOS, and four of the five papers were delivered by authors from Japanese companies. Toshiba's 24,000-gate array used triple-level wiring to build a signal processor with RAM and ALU on a chip 12.85mm on a side. Though this implementation used 3.3 times as much silicon as the handcrafted version of the same processor, performance was about equal, and from design to implementation took only 25 man-months compared with 100 for the handcrafted version.

Signetics described an interesting 48-term electrically programmable logic device (EPLD). This CMOS device utilizes an EPROM cell, and was speced at 50ns propagation delay and 200mW active power. Several manufacturers are developing CMOS EPROM or EEPROM user-programmable arrays. Altera Corporation of Santa Clara, California, is now producing 300-gate and 1200-gate CMOS EPLDs.

Communication Links

Captive telephone companies in Europe and Canada were the principal contributors to this session of five papers. Increased use of digital circuits in office networks and subscriber telephone links has created opportunities and new technical challenges for LSI current designers. Increasingly high digital data rates for mixed voice-data communication and optical fiber networks have led to great efforts to solve a new set of technical problems.

Plessey Research has developed an optical fiber interface circuit to perform the coder/decoder and signal multiplex functions in such an optical network system. Bell Northern of Canada had two papers, one describing a 2.6Mb/sec local loop transmitter/receiver, and the second describing a line card for intra-office voice-data communications. Mitel Corporation described a full-duplex echo cancelling transceiver that addresses the difficulty of increasing data transceiver rates over existing twisted-pair cables.

High Speed Arrays

Six papers (four from Japan, one from the United States, one from Europe) described new advances and directions in high-speed semicustom arrays. Fujitsu's 20,000-gate array was the sole CMOS device, and has 12K of configurable SRAM on board. This 2.0um design rule chip is 240,000 $mils^2$ (12.1x12.7mm) and claims a 1ns propagation delay. Siemens AG used emitter-coupled logic to achieve a 150ps propagation delay on the most recent implementation of a 9000-gate masterslice. National Semiconductor's ECL implementation of a programmable logic array achieved a 3.6ns (typ.) propagation delay from input to output. Finally, GaAs was used by Oki Electric and Toshiba to achieve arrays of 1000 and 2000 gates with propagation delays of 390ps and 42ps, respectively.

Processors for Special Applications

Judging from this session, communications applications are the first place to look for dedicated processors. Six of the seven papers described devices targeting the communications market, either for telephoning, facsimile, or LAN applications. These devices often employed mixed analog/digital circuitry on the same chip. Texas Instruments described both a LAN controller with on-chip ROM and a LAN system interface chip.

Memories for the Future

Four sessions totaling 32 papers were devoted to semiconductor memories. Session III, Special Application Memories, highlighted the trend toward feature memories that are dedicated to specific system applications. Session VI, High Density SRAMs, Session XIII, Nonvolatile Memories, and Session XVII, Megabit DRAMs, focused on the traditional directions of memory technology: higher performance and increases in density toward 256K SRAMs, megabit EPROMs, and 1Mb DRAMs. The selection of the papers was a good representation of both present design activities and likely new memory product introductions expected over the next 12 to 18 months.

Special Application Memories Session

The three most common digressions that manufacturers have made from general-purpose RAMs have been in the areas of (1) video RAMs, to support the special needs of the explosive graphics display market; (2) dual port RAMs, to enhance system performance in multiprocessor systems; and (3) content-addressable memories.

This session showed some good examples of manufacturers' efforts to address these special applications. NEC's 256K dual port RAM is built using the company's 256K NMOS DRAM technology. The chip circuitry has been changed to allow continuous serial readout from the serial port, making the device especially suitable for high speed graphics applications. In today's market, only Texas Instruments' TMS 4161 video RAM is commercially available, but several companies are looking at the video RAM market. Other companies, such as Intel with its ripple mode[R] CMOS 256K DRAM, have designed devices that are somewhat less application-specific than true video RAMs, but still recognize and are designed to the special needs of graphics systems.

In a different session, Inmos' 20ns color lookup table for color graphics applications is a useful adaptation of what is primarily a memory technology to a fast-growth special application area. Inmos' device uses the company's sub-2um CMOS technology that is also used in its new 16K and 64K SRAMs, and will be utilized in all of Inmos' subsequent product introductions. Here again, several other manufacturers are looking to address this market using different technologies and circuit designs.

Matsushita described an 8K Content-Addressable and Reentrant Memory (CARM), which can be useful in dynamic data flow computer applications. Activity in the CAM area has heretofore been limited to custom designs done by or for large system houses, and as yet, no commercial market exists.

ATT Technologies described a CMOS 2Kx9 dual port RAM, which will be available to the merchant market by mid-1985. Today, only IDT offers a dual port RAM commercially, though now-defunct Synertek has reportedly licensed some alternate sources for its SY21D1 that it produced for some time.

While there is a clear trend in the industry toward offering more and more special-application memories, DATAQUEST believes that market development will be slowed by a lack of standards and second sources, and a lack of full agreement on these devices' feature content. Nevertheless, applications-oriented manufacturers like AMD, IDT, Intel, and Texas Instruments can certainly do a good business in these emerging areas, even if market sizes are relatively small compared with the markets for maintstream memory products. In many ways, we expect that the characteristics of the markets for special-application memories will be much more like microprocessor peripheral markets than like traditional semiconductor memory markets. Specifically, we expect that these markets will be circuit design intensive, use standard parts that are not widely sourced, have relatively low production volumes, have a potential for high profits, lack the price volatility of commodity devices, and will highlight feature content and performance as keys to market success.

High Density SRAMs

The High Density SRAMs Session featured 256K CMOS SRAMs from Hitachi, Mitsubishi, and NEC which now join Toshiba's device offered at the 1984 ISSCC. Like Toshiba's part from a year earlier, these devices typically employ 1.2um or 1.3um design rules, and have die sizes of about 5x9mm (or 70,000 mils^2). Typical address access times are 45ns to 55ns, which are also comparable to Toshiba's. Since Hitachi and Toshiba are already market leaders in the 64K SRAM market, and have now been shipping these devices for three years, we expect to see at least these two vendors sample 256Ks by mid-year 1985, and perhaps Mitsubishi and NEC by year-end 1985.

High Speed SRAMs

Only three RAM papers specifically emphasized the high-speed aspects of the devices discussed. Two of these were ECL 64Kx1 RAMs from Fairchild and Fujitsu, having typical address access times of 15ns. NEC described a new GaAs 4K RAM, using current mode logic (CML) circuit techniques to allow compatibility with today's drive and output levels of the ECL cores of existing large computers. If the relationship between the announcement at ISSCC and commercial sampling remains the same as for the prior generation of ECL RAMs, we may see external samples of these parts by year end. However, Fujitsu's own computer operations often have a significant advantage over outsiders in early availability of state-of-the-art roducts from its components group.

Aside from these three papers, most of the shift to higher speed RAMs was captured in the improved performance of higher density dynamic and static RAMs. This trend, too, parallels that of the marketplace. As microprocessor-based systems use a larger fraction of the total semiconductor memory markets, we believe that higher density parts will be emphasized rather than higher performance parts. While no manufacturer will decline the opportunity to produce higher performance devices, the growth in the market is greater at the high density, modest speed area than in speed-optimized applications.

Nonvolatile Memories

Nine papers (one CMOS PROM, three EEPROMs, one ROM, and four EPROMs) described new levels of density, speed, and special features in MOS nonvolatile memories. There were no papers delivered describing bipolar nonvolatile memories.

Subjects of the papers and the companies presenting them included:

1Mb CMOS ROM with ECC	Mostek
256K CMOS EPROM--100ns	Intel
256K CMOS EPROM--95ns	Hitachi
1Mb CMOS EPROM--Page Mode	Hitachi
1Mb CMOS EPROM--80ns	Toshiba
64K EEPROM--Page Mode Write	AMD
64K CMOS EEPROM--35ns	Lattice
256K Flash EEPROM	Toshiba
25ns CMOS 16K PROM--4TX Cell	Cypress Semiconductor

The encroachment of CMOS on what has been the exclusive province of bipolar, i.e., high-speed read-only memory, is becoming increasingly evident with the development of 64K density EEPROMs with 35ns access times by Lattice Semiconductor. Another example is Exel's 32K EEPROM introduced at 1984's ISSCC. For Cypress Semiconductor, a 1983 start-up, aggressive scaling and process technology and an innovative 4 transistor cell have opened the door to a 16K CMOS PROM with speeds as fast as 25ns, at about half the power of traditional bipolar PROMs. In addition, this year's 256K and 1Mb EPROMs potentially offer significant improvements in speed over earlier generations, and though the EPROM marketplace is still overwhelmingly NMOS at all densities, we expect a good increase in CMOS products from 64K through 256K, from both new and established vendors during 1985.

One of the most interesting devices was a 256K Flash EEPROM from Toshiba. This "featureless" EEPROM uses a triple poly process and has a one-transistor cell of $62um^2$, using 2um design rules. This compares well with Intel's $36um^2$ cell with its HMOS II-E process, using 1.75um design rules. Depending on where Toshiba takes the technology, and whether the devices are viable in a high-volume manufacturing environment, this device could have significant impact on parts of the traditional EPROM market. Likewise, the small cell size, if proven to be sufficiently reliable and high-endurance, could be embedded in typical EEPROM (5-volt, latched and timed, page mode) peripheral circuitry to cause an impact on EEPROM makers, who are still using multitransistor cells of much larger size (and accordingly, higher cost). Apparently, commercial introduction of this device or technology is at least a year away.

Fault Tolerant Techniques for Memory Components

An informal Thursday evening session was held to discuss the pros and cons of using various fault-tolerant techniques in semiconductor memories to enhance chip yield and/or improve device reliability as device densities increase. On-chip error correction circuitry (ECC) has been experimented with occasionally, (e.g., Hitachi's 1Mb ROM at the 1983 ISSCC) but was not offered commercially until SEEQ Technology's 64K EEPROM and Micron Technology's 256K DRAM were introduced during 1984. Redundancy, in its various forms (electrical fuse, OPROM cell, laser zap to connect or disconnect), had received some initial resistance (in 1981 and 1982) in 64K DRAM (16K SRAM) from systems houses and Japanese vendors. In less than two years, however, those concerns were laid to rest and redundancy is now, by and large, an accepted yield enhancement technique. All nine megabit RAMs had redundant rows and/or columns.

The question under discussion was at what density, if any, would on-chip ECC be the most economical method of continuing the rate of bit density growth in the generations of dynamic RAMs. Finer line geometries may make it difficult for circuit designers to keep target fuses separated enough for lasers to cleanly implement redundant elements. Also, increasing bit density generally requires reducing the cell DRAM capacitance, thereby increasing susceptibility to alpha particle-induced soft errors. On-chip ECC can address both of these trends.

Full on-chip error correction can correct for soft errors at the chip level, thereby offering improved chip reliability that can be valuable in smaller systems that do not use system error checking. DATAQUEST believes that systems without error checking and correction now constitute the larger part of the dynamic RAM market, and that chips with ECC may be an economic way of improving system reliability for these users.

The arguments about ECC, pro and con, sounded suspiciously like those voiced four years ago at the ISSCC redundancy evening session...virtually all of which have been put to rest. Micron Technology's 256K may be a very early harbinger of things to come, since most vendors plan to produce even their 1Mb RAMs using only redundancy without full error correction circuitry on-chip. But it is clear that discussions are under way to determine what the industry will have to consider to go to the 4Mb device level and beyond.

Megabit DRAMs

Nine papers described megabit DRAMs, plus an additional paper describing a novel 16-level dynamic memory cell suitable for slower semiconductor file memory (50us to 100us). Key device parameters are summarized in Table 3.

Table 3

1985 ISSCC MEGABIT DRAMS SESSION
PRODUCT SYNOPSIS

	Session Number/Author									
	17.1/ NEC	17.2/ Mitsubishi	17.3/ Mostek	17.4/ Toshiba	17.6/ IBM	17.7/ Fujitsu	17.8/ Toshiba	17.9/ Hitachi	17.10/ ATT	17.5/ Hitachi
Process	NMOS	NMOS	N-well CMOS	NMOS	NMOS	NMOS	N-well CMOS	N-well CMOS	Twin well CMOS	P-well CMOS
Design Rule	1.0um	1.2um	1.2um	1.2um	(1.0um) 1.5um	1.4um	1.2um		1.3um	1.3um
Organization	1Mx1	1Mx1	256Kx4	1Mx1	x1, x2 or x4	1Mx1	1Mx1	1Mx1	1Mx1 (256Kx4)	N/A
Package	300 mil, 18 pin DIP	300 mil, 18 pin DIP	PLCC or SOJ	300 mil, 18 pin DIP	PGA or SOJ	SOJ or 300 mil DIP	300 mil, 18 pin DIP	300 mil, 18 pin DIP	300 mil, 18 pin DIP	N/A
Cell (um)	3.4x6.0	3.8x9.4	4.0x9.0	5.0x6.4	4.1x8.8	3.15x8.4	3.8x9.0	3.35x7.2	3.5x10.5	N/A
Die (mm) Aspect Ratio	4.6x9.4 2.04	5.0x13.0 2.60	5.97x11.4 1.91	4.78x13.23 2.77	5.5x10.5 1.91	4.44x12.32 2.77	5.0x12.5 2.50	4.68x10.1 2.16	4.8x14.5 3.02	N/A
Capacitor	Trench	Planar	Planar	Folded Capac.	Planar	Stacked Capac.	Planar	Corrugated Capac.	Planar	
Capacitance	60fF	45fF		70fF	37fF	55fF	40fF			60fF
Functions	Nibble/ page	Nibble/ page	Static column	Nibble/ page	Fast page		Fast page, stat col.	Static column	Page or fast col.	N/A
Poly Levels	2	2		2	2	3	3	2	2	2
Metal	1	1	2	2	1			2	1	2
Redundancy Implementation	1R/1C Laser	8R/1C Laser	16R/8C Laser	4R/4C	2/quad =8	2R/2C Electric	4R/4C Laser		32C/16R Laser	
Trac	85ns	90ns		70ns	80ns	90ns	56ns	74ns	80ns	
Other	Cas b.Ras	Epi Cas b.Ras		BOX Cas b.Ras						

N/A = Not applicable

Source: DATAQUEST
March 1985

Last year's 1Mb papers from Fujitsu, Hitachi, and NEC all employed NMOS technology. This year's were split nearly evenly, with five NMOS and four CMOS. Toshiba described both an NMOS and a CMOS device. Despite some concern as to the direction of megabit DRAM packaging, virtually every 1Mbx1 design has been intended for an 18-pin, 300 mil DIP from initial layout. (In order to fit into such a narrow package, half the devices described have aspect ratios of 2.5 or greater.) All employ redundancy (usually laser implemented), and many devices now incorporate either a fast page mode or static column mode of operation, which is understandably more common in CMOS than in NMOS devices.

Engineering samples of 1Mb DRAMs are now available internally at each of the large vertically integrated chip manufacturers, and at a few external customers. We expect that full sampling from as many as six or eight makers will be in progress by year-end 1985, even as the 256K is still in the early part of its life cycle.

As shown by Table 3, however, some divisions remain as to the specific technology approach employed. DATAQUEST sees this diversity reflecting both a tendency of the applications base to fragment and several unsettled technical questions for circuit designers and process engineers.

Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

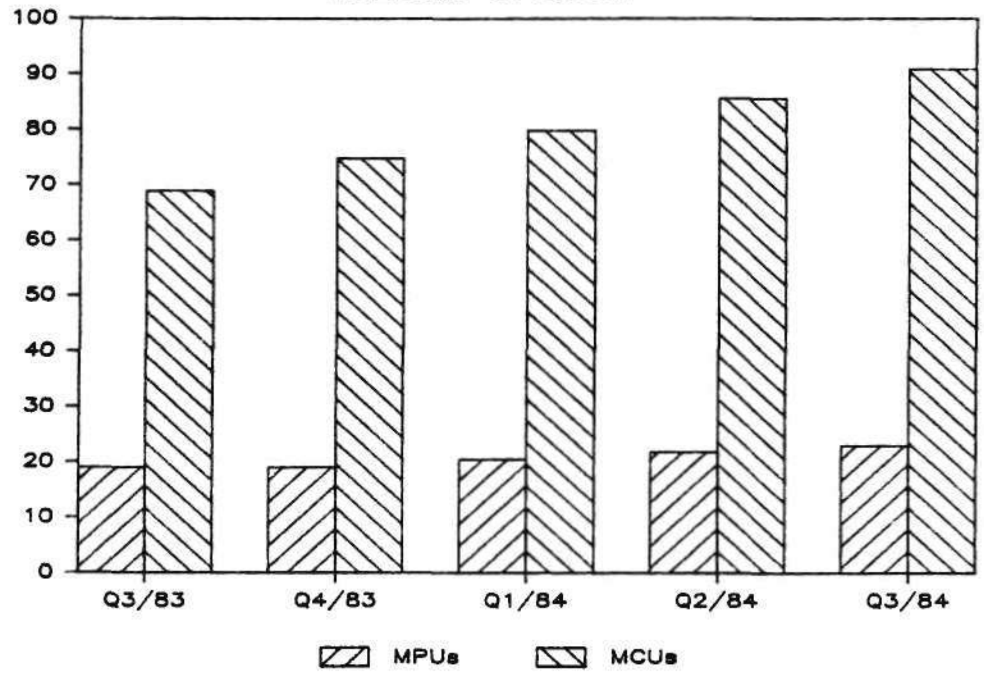
SIS Code: 1984-1985 Newsletters: March

THIRD QUARTER 1984 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the third quarter of 1984, worldwide microprocessor and microcontroller unit shipments increased approximately 6.5 million units or 6.02 percent from second quarter 1984. Estimated shipments of all microcontroller devices totaled approximately 90.9 million units. Shipments of 4-bit MCUs remained relatively flat, while 8-bit MCU shipments increased 15.16 percent. Estimated shipments of all microprocessor devices totaled approximately 23.0 million units. Shipments of 16-bit MPU shipments were up approximately 7.63 percent, while 8-bit MPU shipments increased only 5.15 percent. Figure 1 shows MCU and MPU unit shipments from third quarter 1983 through third quarter 1984.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS THIRD QUARTER 1983 THROUGH THIRD QUARTER 1984 (Millions of Units)



Source: DATAQUEST
March 1985

Table 1 shows the change in total microcontroller unit shipments from the second quarter of 1984 through the third quarter of 1984.

Table 1

TOTAL MICROCONTROLLER UNIT SHIPMENTS
SECOND QUARTER 1984 THROUGH THIRD QUARTER 1984
(Thousands of Units)

	Q2/1984		Q3/1984		Percent
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
4-Bit	47,604	55.60%	47,136	51.85%	(0.99%)
8-Bit	36,987	44.37	43,747	48.12	15.16%
16-Bit	30	0.03	30	0.03	0.00%
Total	85,621	100.00%	90,913	100.00%	6.18%

Table 2 shows the change in total microprocessor unit shipments from the second quarter of 1984 through the third quarter of 1984.

Table 2

TOTAL MICROPROCESSOR UNIT SHIPMENTS
SECOND QUARTER 1984 THROUGH THIRD QUARTER 1984
(Thousands of Units)

	Q2/1984		Q3/1984		Percent
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
8-Bit	19,377	88.58%	20,376	88.38%	5.15%
16-Bit	2,450	11.20	2,637	11.44	7.63%
Others	48	0.22	41	0.18	(14.58%)
Total	21,875	100.00%	23,054	100.00%	5.38%

Source: DATAQUEST
March 1985

Table 3 shows the change in shipments of the leading 8-bit MPUs from the second quarter of 1984 through the third quarter of 1984.

Table 3

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
SECOND QUARTER 1984 THROUGH THIRD QUARTER 1984
(Thousands of Units)

	Q2/1984		Q3/1984		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
Z80	6,950	35.86%	6,550	32.15%	(5.76%)
8085	3,728	19.24	4.180	20.15	12.12%
8088	2,179	11.25	2,930	14.38	34.45%
650X	2,291	11.82	2,445	12.00	6.72%
6802	1,180	6.09	1,261	6.19	6.86%
Others	3,049	15.74	3,010	14.77	(1.28%)
Total	19,377	100.00%	20,376	100.00%	5.15%

Table 4 shows the percent changes in estimated shipments of second-generation 16-bit microprocessors from the second quarter 1984 through the third quarter of 1984.

Table 4

SECOND-GENERATION 16-BIT MICROPROCESSOR SHIPMENTS
SECOND QUARTER 1984 THROUGH THIRD QUARTER 1984
(Thousands of Units)

	Q2/1984		Q3/1984		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q2 to Q3
8086	987	46.51%	1,104	46.80%	11.85%
68000	438	20.64	489	20.73	11.65%
80186	385	18.14	475	20.14	23.38%
Z8000	203	9.57	166	7.03	(18.23%)
80286	70	3.30	85	3.60	21.42%
32016	39	1.84	40	1.70	11.16%
Total	2,122	100.00%	2,359	100.00%	11.16%

Source: DATAQUEST
March 1985

Table 5 shows market share by technology for 8-bit microcontroller and microprocessor devices from the third quarter of 1983 through the third quarter of 1984, and indicates little CMOS growth during this period.

During the third quarter of 1984, 8-bit CMOS microcontroller unit shipments increased slightly, while 8-bit CMOS microprocessor unit shipments decreased slightly.

During third quarter 1984, approximately 90 percent of all 8-bit CMOS MCU unit shipments and approximately 68 percent of all 8-bit CMOS MPU unit shipments were U.S. manufactured. Japanese companies are still behind the United States in 8-bit CMOS technology, so second-source agreements with Intel, Motorola, and Zilog predominated in 1984.

Toshiba shipped the 8-bit CMOS MPU Z80C making Toshiba the first Japanese company to second-source the CMOS version of Z80 from Zilog. Matsushita and Oki second-source MPU CMOS technology from Intel and Motorola. NEC, Oki, and Toshiba also second-sourced 8-bit CMOS MCUs from U.S. manufacturers in 1984.

New chip designs with smaller features will make the 8-bit CMOS market surge. Telephone, automobile, keyboard, and consumer goods (such as an intelligent blender) are expected to be big markets for 8-bit CMOS devices. Pacific Asia may dominate in manufacturing the CMOS consumer products due to the high volume and low cost of this huge market.

Table 5

UNIT MARKET SHARE BY TECHNOLOGY FOR
8-BIT MICROCONTROLLERS AND 8-BIT MICROPROCESSORS
THIRD QUARTER 1983 THROUGH THIRD QUARTER 1984

Device	Tech	Q3/83	Q4/83	Q1/84	Q2/84	Q3/84
8-Bit MCU	CMOS	7.97%	9.68%	10.07%	9.95%	9.96%
8-Bit MCU	NMOS	92.03	90.32	89.93	90.05	90.04
Total		100.00%	100.00%	100.00%	100.00%	100.00%
8-Bit MPU	CMOS	7.13%	8.49%	10.29%	10.67%	9.92%
8-Bit MPU	NMOS	92.87	91.51	89.71	89.33	90.08
Total		100.00%	100.00%	100.00%	100.00%	100.00%

Source: DATAQUEST
March 1985

Table 6 shows the market share changes in shipments by geographical region for microcontrollers and microprocessors, from third quarter of 1983 through third quarter of 1984.

Japanese manufacturers gained market share in both microcontroller and microprocessor markets during the past five quarters. European manufacturers gained market share in both 8-bit markets during the same period.

Table 6

MARKET SHARE BY REGION FOR MICROCONTROLLERS AND MICROPROCESSORS THIRD QUARTER 1983 THROUGH THIRD QUARTER 1984

Device	Region	Q3/83	Q4/83	Q1/84	Q2/84	Q3/84
4-Bit MCUs	United States	19.10%	18.00%	19.10%	18.05%	17.98%
	Japan	80.30	81.40	80.90	81.95	82.02
	Europe	0.60	0.60	0.00	0.00	0.00
Total		100.00%	100.00%	100.00%	100.00%	100.00%
8-Bit MCUs	United States	60.00%	58.90%	55.20%	56.88%	52.15%
	Japan	31.20	32.10	36.10	33.55	36.49
	Europe	8.80	8.70	8.70	9.77	11.36
Total		100.00%	100.00%	100.00%	100.00%	100.00%
8-Bit MPUs	United States	66.00%	62.20%	60.30%	59.73%	59.76%
	Japan	28.00	31.40	33.40	32.49	32.34
	Europe	6.00	6.40	6.30	7.78	7.90
Total		100.00%	100.00%	100.00%	100.00%	100.00%
16-Bit MPUs	United States	83.20%	81.50%	73.80%	78.69%	76.45%
	Japan	12.80	15.10	21.00	13.88	16.38
	Europe	4.00	3.40	5.20	7.43	7.17
Total		100.00%	100.00%	100.00%	100.00%	100.00%

Source: DATAQUEST
March 1985

ANALYSIS

Despite the slow growth in the semiconductor industry, the unit volume growth rate for all microprocessor and microcontroller markets grew approximately 6.02 percent from second quarter to third quarter 1984. Inventories are expected to straighten out by the second quarter of 1985.

Janet Rey

April

April Newsletters

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

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: April

DYNAMIC RAM MARKET SYNOPSIS--1984

SUMMARY

DATAQUEST has published its estimates for 1984 unit shipments of several densities of DRAMs. Quarterly shipment estimates for 1984 by companies participating in the DRAM market have been mailed to DATAQUEST notebook holders and are located in the SIS Products and Markets notebook behind the Memory tab under "MOS Dynamic RAMs--Data."

Fueled by a strong worldwide economy, an insatiable demand for personal computers, and only slowly declining prices, the 1984 DRAM market grew 94 percent over the 1983 market, to an estimated $3.6 billion. Twenty-two vendors participated in the market, in a year that probably saw more DRAM profits brought to the bottom line than in all other previous years of DRAM production combined. While 64K DRAMs constituted about 70 percent of the total DRAM revenue dollars in 1984, there were still substantial markets in 3-power supply and 5-volt 16K DRAMs, and a surprisingly large amount of revenue in the emerging 256K market.

Explosive demand, panic buying, and double ordering drove some prices even higher than their year-end 1983 levels as manufacturers added tremendous capacity to catch up with demand. Prices for 64Ks remained very stable in the first half of the year and only began to decline at all in the third quarter, while prices for 256Ks declined steadily throughout the year. However, in the fourth quarter, when supply finally caught up with demand and considerable excess supply appeared on the market, prices for both 64Ks and 256Ks dropped sharply.

In 1984, U.S. manufacturers took advantage of the strong 64K market and high prices in the U.S. market to pick up 64K DRAM market share from the Japanese. Japanese manufacturers, facing the same capacity constraints as U.S. vendors, turned their attention and increased production more to the Japanese market, and it was not until late in the summer that Japanese manufacturers were again visible in the U.S. market competing for new business. Several manufacturers came into production in the course of the year, including some, such as Tristar, Sharp, and Vitelic, that had never before participated in the DRAM market. Although

U.S. manufacturers had an estimated 42 percent share of the 64K market, their nearly complete absence in the 256K market resulted in a strong tilt toward the Japanese, who garnered 62 percent of the overall world market for DRAMs in 1984.

Persistent and significant price differentials existed throughout the year between product sold in the United States and that sold in Japan. Generally, the differential was in the neighborhood of $0.75 to $1.20 per unit of 64K, although it was reduced somewhat at year end. For 256Ks, the price difference typically was 15 percent to 25 percent, which encouraged many users to set up local buying locations in Japan. Throughout the year, Europe and Rest of World prices remained between these two extremes although they tended to be closer to Japanese prices than to U.S. prices.

An early indication of the current supply glut in the DRAM market was given in the fourth quarter of 1984, when Micron Technology lowered its 64K price to less than $2.00, which was at that time $0.60 to $1.20 less than the world price. In a short three-month period, however, almost all prices were renegotiated downward. So, after a slight decline in the third quarter, prices dropped markedly in the fourth quarter and entered 1985 in a virtual free fall. Only prior commitments and the more stable contract business kept the average selling price as high as it was, as the increasing amount of business moving on the spot market was frequently discounted by as much as $1.00 by the fourth quarter of 1984.

Table 1 shows estimated DRAM revenues for the top ten producers in 1984. Japanese manufacturers get the first three places, distinguishing themselves by their presence primarily in the 256K DRAM market. Fourth position goes to Texas Instruments, which was the number one supplier of 64K DRAMs, as well as the market maker and number one supplier of the submarket for 16Kx4 DRAMs. These ten manufacturers each generated in excess of $100 million in DRAM revenues in 1984. (In the total market estimate, we have included all production from AT&T Technologies--approximately $70 million of its 256K DRAMs--although during the year only very small amounts reached the merchant market.)

Table 2 shows the worldwide DRAM market composition for 1984, including average selling prices, units, and revenues for each of the different product groups selling into the market. Several new DRAMs were introduced in 1984, including CMOS DRAMs from Intel, NEC, and start-up Vitelic, and video RAMs from Texas Instruments. All of these promise to be substantial markets in the 256K generation of devices.

Table 1

ESTIMATED 1984 DYNAMIC RAM REVENUES
(Millions of Dollars)

	1983	1984
NEC	$ 261	$ 574
Hitachi	305	516
Fujitsu	208	452
Texas Instruments	205	405
Mostek	218	284
Mitsubishi	112	236
Motorola	168	228
Oki Electric	73	184
Toshiba	38	125
Micron Technology	24	120
Others	232	450
Total	$1,844	$3,574

Table 2

ESTIMATED 1984 WORLDWIDE DRAM MARKET COMPOSITION

Technology	Density	Average Selling Price	Units (M)	Revenue ($M)
	4K	$ 3.00	2.3	$ 7
	16K 3ps	$ 0.90	120.7	109
	16K 5V	$ 1.95	40.6	79
NMOS	64Kx1	$ 3.05	796.4	2,429
NMOS	16Kx4	$ 3.35	51.7	173
NMOS	8Kx8	$ 4.25	1.7	7
CMOS	All	$ 5.00	2.9	15
NMOS	256Kx1	$17.00	41.2	700
NMOS	64Kx4	$20.00	2.7	53
CMOS	All	$40.00	0.1	2
			Total	$3,574

Source: DATAQUEST
April 1985

PRODUCT MARKET SUMMARY

Shipments of 64K DRAMs constituted the mainstay of the DRAM market in 1984, although substantial markets continued to exist for the older 3-power supply and 5-volt only 16K devices. The following describes each of the individual product areas.

4K DRAMs

Four vendors continued to ship 4K DRAMs at year end: Mostek, Motorola, SGS-Ates, and Standard Telecom and Cable. The market for 1984, however, totaled only about $7 million and 2.3 million units.

16K 3-power Supply Parts

Shipments of 16K 3-power supply DRAMs totaled an estimated 120 million units in 1984. Few vendors are actively pursuing the market, although eleven manufacturers continue to ship to old accounts. Production dropped off sharply in the first half of the year. Contract pricing through the year was reasonably stable in the $1.10 to $1.25 range, although the spot market price oscillated wildly from a high of about $1.00, to some products being sold at fire sale prices as low as $0.40 in large quantities. The leading suppliers for the 3-power supply part in 1984 were NEC and Texas Instruments, each of which shipped an estimated 21 million units.

16K 5-Volt Only DRAMs

Six vendors continue to ship 16K 5-volt only DRAMs, although the units shipped dropped from an estimated 54 million in 1983 to 40 million in 1984. Most vendors were able to achieve prices of about $1.65 to $2.25 throughout most of the year, thereby getting a substantial premium over the older 3-power supply part. The leading manufacturer of the 5-volt only part is now Motorola, which continued to ship about 1 million per month at year end. The total market for 16K 5-volt only DRAMs was about $79 million.

64K DRAMs

Shipments of 64K DRAMs totaled an estimated 852 million units valued at about $2.6 billion. The mainstream part, NMOS 64Kx1, constituted about 93 percent of the total revenue, but there were also significant revenue contributions from the 16Kx4 part (6.5 percent of the market, or $173 million), and the 8Kx8s part, as well as small quantities of CMOS 64Ks from several suppliers.

Estimated quarterly regional pricing for the 64K DRAMs is shown below:

Consumption Location	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1984 Year
United States	$3.80	$3.70	$3.40	$3.05	$3.43
Japan	$3.00	$2.80	$2.30	$2.15	$2.50
Europe	$3.20	$3.10	$2.80	$2.30	$2.79
ROW	$3.20	$3.10	$2.60	$2.20	$2.70
Worldwide	$3.50	$3.37	$3.00	$2.69	$3.08

CMOS 64Ks had been available from Intel since late 1983, and production shipments began early 1984. However, the design-in window for the CMOS part was cut short when Intel's CMOS 256K became available in midyear, and high-volume shipments of the 64K were curtailed. NEC also introduced a CMOS 64K in 1984 and shipped an estimated 2.2 million units, the overwhelming majority of which stayed in the Japanese market. Overall, the estimated price for the CMOS DRAM was probably in the vicinity of $5.00 for the year--a modest price premium compared with the NMOS counterparts. Vitelic Corporation, a new start-up company, began sampling its 64K CMOS part late in 1984 and will follow that up with the introduction of a 256K device during 1985.

Although the PC market was the principal contributor to demand for DRAMs throughout 1984, the fraction of 64Ks going into the personal computer market probably declined from between 40 and 45 percent in the early part of the year, to 35 percent by the end of the year.

256K DRAMs

Shipments of 256K DRAMs totaled an estimated 43.9 million units in 1984. (This includes shipments by AT&T of about 3.0 million units, most of which remained inside the parent company.) NEC led a string of Japanese suppliers that took the first six places as bona fide merchant market suppliers, shipping an estimated 13.9 million units. Hitachi and Fujitsu followed closely with an estimated 10.9 million and 9.4 million units, respectively. Toshiba, which has had very little experience in the DRAM market in the past, moved up strongly into a fourth position, shipping an estimated 3.9 million units. Mitsubishi and Oki Electric rounded out the top six, with about 1.2 million units apiece.

Prices for 256Ks entered the year in the $40 to $50 range but by midyear were selling in the low $20 range in Japan. Second quarter prices in the United States, by comparison, were in the $30 to $32 range. By year-end 1984, pricing was in the $14 to $16 range for the mainstream part (256K NMOS 150ns), and the price differential between the United States and Japan had been compressed significantly.

Intel was the only supplier that shipped CMOS 256Ks during 1984, with modest volumes of its 256Kx1, and 64Kx4 samples late in the year. Intel's products were priced at $120 to $170 per unit when introduced in midyear, but by year end, quotes for the CMOS 256Kx1 were running $30 to $40 and have since tracked the rapid decline of NMOS parts, although Intel is still maintaining a significant price premium in this market.

Texas Instruments and NEC began shipments of the 64Kx4 NMOS DRAM in the first quarter, but NEC has emerged as the leader shipping an estimated 2.7 million units of this part. At year end, NEC was still the only supplier widely visible with a 64Kx4 configuration. In addition, both Mostek and NEC shipped 32Kx8 devices during the year. Mostek shipped an estimated 150,000 units of its high-performance part.

Due to production ramp-up glitches or choice of initial product offerings, U.S. manufacturers have given up the broad center of the 256K DRAM market to the Japanese. Bona fide U.S. merchant suppliers captured only about 3 percent of the unit shipments during 1984. All the leading U.S. suppliers at the 64K density--Texas Instruments, Mostek, Motorola, National Semiconductor, Micron Technology, and Intel--either chose to avoid the mainstream with their first product offering at 256K or had product ramp-up troubles. With plummeting prices at 64K densities, this will undoubtedly cause significant consequences for the U.S. suppliers' position in the 1985 and 1986 DRAM market.

CONCLUSIONS

Dynamic RAM suppliers benefited from a strong market in 1984 and reaped tremendous revenue growth and outstanding profits during the year. However, the production excesses that emerged at year end, and some manufacturers' failure to position themselves in the newer generation of products have caused many suppliers to be in trouble in the present period of adjustment in the market. The DRAM market, which grew from $1.8 billion in 1983 to $3.6 billion in 1984, is likely to decline as much as 20 to 25 percent in 1985 as a result of unit price drops on the order of 60 to 75 percent for the mainstay 64K and 256K densities.

In 1984, the homogenous market began to splinter into products serving different submarkets. This was made possible through the introduction of new technologies such as CMOS products from Intel, NEC, and Vitelic; x4 and x8 configurations from a number of suppliers; and application-specific memories such as Texas Instruments' video RAM. All of these alternatives will undoubtedly increase as a share of the total DRAM market in the coming years, although in 1984 these combined splinter markets constituted less than 8 percent of the total revenue base of the DRAM market.

Lane Mason

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: April

"FUTURE DIRECTIONS IN MICROELECTRONICS"-- A SYMPOSIUM

INTRODUCTION

A significant one-day technical symposium entitled "Future Directions in Microelectronics," was held on March 15 at Stanford University. Sponsored by Cornell University, the symposium focused on the impact of integrated circuit technology in the 1990s. It was the first of six symposia that Cornell is holding nationwide to celebrate the 100th anniversary of Electrical Engineering at the university.

The key issues and topics facing the semiconductor industry were discussed in eight presentations by leaders from industry, government, and academia. Charles E. Sporck, President and Chief Executive Officer of National Semiconductor Corporation, introduced and chaired the event. The eight discussion leaders were:

- Dr. Alec N. Broers, Professor of Electrical Engineering and head of the Electrical Division at Cambridge University
- Dr. Lester F. Eastman, Given Foundation Professor of Engineering at Cornell University
- Dr. James D. Meindl, John M. Fluke Professor of Electrical Engineering at Stanford University, director of the Stanford Electronics Laboratory, co-director of the Center for Integrated Systems, and Associate Dean for Research in the School of Engineering
- Dr. David A. Hodges, Professor of Electrical Engineering and Computer Sciences at the University of California at Berkeley
- Dr. Robert N. Noyce, Vice Chairman of the Board of Intel Corporation
- Dr. William G. Howard, Jr., Senior Vice President and Director of Research and Development at Motorola Inc.

- Dr. Joel S. Birnbaum, Vice President and Director of Hewlett-Packard Laboratories

- E. D. Maynard, Jr., Director of VHSIC/Electronic Devices in the Office of the Under-Secretary of Defense for Research and Engineering

THE PRESENTATIONS

The symposium began with highly technical presentations that were very narrowly focused. As the day progressed, the presentations became larger in scope and dealt with macro issues that will face decision makers. The following is a brief account of each presentation.

VLSI Lithography and Nanolithography

Dr. Broers gave a survey of trends in VLSI lithography and discussed today's optical lithography methods.

He believes that 1/2-micron linewidths will be the norm and fabrication will be done on 8-inch wafers as we approach the 1990s. Dr. Broers stated that today's step-and-repeat technology provides adequate resolution down to as low as 3/4 micron, but step-and-scan technology, which uses mirror optics and covers a subset of a wafer at a time, will allow better resolution in the 1/2-micron range. However, as numerical apertures increase and smaller wavelengths are required, there will be depth of field limitations. These limitations will reduce the use of optics altogether, and lead the move toward electron beam technology where he cited drawbacks of low throughput and prohibitive costs. Here though, he favored variable-shaped beams because throughput is not as dependent on addressing.

Dr. Broers believes that ion beams will be used mainly for mask repair, diagnostics, testing, and microanalysis. He expects X-ray lithography will be strong in the future. He mentioned problems with runout and discussed the benefits of high throughput as more sensitive photoresists are developed.

Compound Semiconductor High-Speed Electron Devices

Dr. Eastman discussed gallium arsenide. He stated that more than 100 labs are working on gallium arsenide in the United States, and that more than 30 percent of these labs are university programs. He then discussed specific programs currently under development at Cornell University.

These programs have achieved amplifiers with a gain of 6db at 60 GHz. He predicts similar gains at 250 GHz in 15 years, and expects to see ring oscillators with propagation delays of 1.5 picoseconds in the same time frame. He noted that switching times have increased by a factor of ten every ten years.

Limits on Ultra-Large Scale Integration

Dr. Meindl discussed the future of Ultra-Large Scale Integration (ULSI), which he defined as having 10^7 to 10^9 transistors per chip. He believes that the historical growth rate of components per chip (a factor of four every three years since 1972) will reach a break point around 1990. He conservatively estimated that by the year 2000 there may be a billion transistors per chip.

Dr. Meindl presented a matrix for viewing the limits of and analyzing ULSI. There is a hierarchy of limitations to ULSI at five levels: system, circuit, device, material, and fundamental. For each of these levels there are particular theoretical, practical, and analogical limits. He had a particularly interesting view of material analogies that created an excellent perspective from which to view the evolution of semiconductor materials.

Material Analogies

Structure	Electronic
Stone	Vacuum Tube
Iron	Silicon
Aluminum	Gallium Arsenide
Titanium	Superconductive Niobium (J2)
Plastics	Polycrystalline SOI
Composite Materials	Multimaterial ICs

As he filled in the matrix with examples such as the one above, Dr. Meindl proposed a viewpoint to examine the evolution of ULSI.

Future of Microelectronic Systems

Dr. Hodges expanded on the presentations that preceded him--with the emergence of submicron technology, a billion transistors per chip, and 8-inch wafers, what will the world do with all this technology? Dr. Hodges discussed the future of microelectronic systems. He said that silicon VLSI, magnetic disks, and CRTs will be the dominant technology for information processing, storage, and display for many years to come. He discussed several areas in which system level chip design has been, or should be, an objective:

- Microprocessors and controllers
- Telephone codec-filters
- Data modems
- Touch Tone* receivers
- Artificial intelligence

- High-resolution TV

- Speech recognition

Dr. Hodges said that without a great deal of effort, we will not take advantage of the technology available to us. Progress is slower in system application areas than in technology development. In closing he said: "We haven't exploited technology. We need imaginative thinking about useful applications and intelligent ways of breaking them down and implementing technology."

<u>Yankee Ingenuity Revisited</u>

Immediately after lunch, Dr. Noyce addressed the group. His presentation, entitled "Yankee Ingenuity Revisited," was a highlight of the symposium and discussed limitations to the future of microelectronics that are not technological, but rather economic and competitive. He cited startling statistics that very clearly indicate the challenges facing the United States as an industrial producer.

Dr. Noyce said that manufacturing is essential to a service economy and that the steady decline in the U.S. trade balance is not merely a result of the strong dollar. He called for government emphasis on science and technology, and discussed the results of the Presidential Committee on Industrial Competitiveness of which he is a member.

Dr. Noyce criticized the U.S. ethic that minimizes the importance of manufacturing technology, saying that it does very little good to create things if the Japanese beat us to the production line. Other key areas that need addressing, according to Dr. Noyce, are:

- Patent laws

- Abuses of the Freedom of Information Act

- Research and development tax laws

- A reestablishing and strengthening of U.S. trade policy

He also called for a stable monetary policy, saying that the differences in capital costs are hurting the U.S. ability to compete. High capital costs force a detrimental short-term view. In conclusion, he mentioned the following goals:

- Technology--Create, apply, and protect U.S. technology

- Capital--Increase the supply of capital at a reduced cost

- People--Develop a more skilled, flexible, and motivated work force

- Trade--Define trade rules and priorities both domestically and internationally

International Competitiveness in Electronics

Dr. Howard spoke on "International Competitiveness in Electronics." His ideas clearly paralleled those of Dr. Noyce. Both of these speakers addressed a topic that acted as a thread throughout the entire symposium--Japanese and other foreign competition. Dr. Howard also cited statistics that indicate the trade deficit is not solely linked to the strong U.S. dollar. He said it is clear that the United States has a problem in this area and presented supporting graphs that show percentages of international business between 1979 and 1983. All the U.S. companies (except for one) showed declines and all the Japanese companies showed strong increases. The percentage of U.S. Information Technology patents coming from the United States is declining while those from the Japanese are increasing. To look at the Japanese economy as "me too" producers--taking existing technology and perfecting its production--is no longer accurate. The Japanese have been quite innovative. Dr. Howard called for alliances and said that they are essential for focusing on and solving problems. He stated that decision makers must be open to new and different approaches.

Toward the Domestication of Instruments

Dr. Birnbaum spoke of the impact of microelectronics on computer systems and instrumentation. He said that issues for the future are use and usability, while old issues of price and performance are losing importance.

Dr. Birnbaum spoke of "domesticating" computer technology and compared computer systems with many older technologies (i.e., the telephone and automobile). He said there are four steps to pervasiveness:

- Laboratory curiosity
- Using the technology as an exotic tool
- Manufacturing for direct use by only a small percentage of the population
- Manufacturing for direct use by a large percentage of the population (i.e., the phone, TV, or automobile)

He said that personal computers were clearly in stage three and that they are primitive when compared to their counterparts of tomorrow. He believes that user idiosyncrasies need to be absorbed and that software must be adaptive and hide operational details. This, he said, computer scientists have not yet done. As an example for comparison, he pointed out that people no longer have to go through detailed steps, and button-pushing to fine-tune a TV. Similarly, one can start a car's engine and drive off without knowing the whys and hows and whats that are taking place under the hood. These analogies served very clearly to highlight Dr. Birnbaum's contention that "computer technology must mask the complexity of internal operations and raise the level of abstractions." Dr. Birnbaum underscored the difficulty of forecasting system pervasiveness by asking "Did Shockley foresee the Walkman?" and "Did Gutenberg predict the greeting card?".

The Role of Government

The last presentation of the day was from Mr. Maynard. He spoke of the reasons for the government's VHSIC program and gave an update. Originally the program was established because DoD needs were not being met and the lead in military ICs was eroding. It was not started to counter Japanese efforts in VLSI. To date all major technologies are being represented and the program is considered successful. Participants are developing their products and there are approximately 40 systems signed up to use VHSIC parts.

The project's second-phase goals include submicron linewidths, expanded fault tolerance and built-in test capability, and broad chip set applicability. Major players include Honeywell, TRW, and IBM. Motorola is also part of this phase; it is working with TRW in support of CMOS processes and with Honeywell in the bipolar area.

Phase two applications include:

- Honeywell--Radar and EO systems
- IBM--Sonar, EW, and Radar systems
- TRW--Cruise Missile, Sat Com, and Avionics

Mr. Maynard concluded that the program is spurring advances in IC design, architecture, and related tools. He said that technology diffusion is rapid in the IC industry and this program will catalyze technology through feasibility demonstrations and the establishment of small but viable markets.

CONCLUSION

DATAQUEST analysts agreed that the symposium provided an excellent opportunity for decision makers and technologists to meet and discuss crucial trends in microelectronics. The impressive lineup of speakers offered a rare insight into issues that will define the future of the semiconductor industry.

Anthea Stratigos

SIS Code: 1984-1985 Newsletters: April

COMPUTER-AIDED MANUFACTURING SYSTEMS UPDATE

DATAQUEST believes that computer-aided manufacturing (CAM) is of strategic importance to semiconductor manufacturers. CAM systems are the glue that holds the semiconductor manufacturing operation together. Reliably accessible and analyzable data on lot location, equipment performance, and engineering parameters can be used to detect line balance or yield problems before they become catastrophic, thus improving the output of good products. The leaders of the semiconductor industry are likely to be those that are the most skilled in the use of CAM systems.

A number of commercial vendors of CAM systems now exist, though some semiconductor companies have developed their own systems internally. The sales of these commercial vendors are shown in Table 1. All sales dollars are combined for hardware and software. Bruce, Consilium, and IP Sharp are third-party houses and do not vend the hardware. In 1984, sales increased dramatically due to the number of new fabs constructed that employ these systems.

Table 1

CAM SYSTEMS SALES
(Millions of Dollars)

Company	1981	1982	1983	1984
Bruce			$ 1.0	$ 2.0
Consilium		$ 2.0	4.0	18.0
CTX		0.5	1.0	4.0
Hewlett-Packard	$ 4.0	4.0	5.0	15.0
IP Sharp		2.0	2.0	10.0
Total	$ 4.0	$ 8.5	$13.0	$49.0

Source: DATAQUEST

Table 2 represents DATAQUEST's estimate of U.S. and European sales of CAM systems.

Table 2

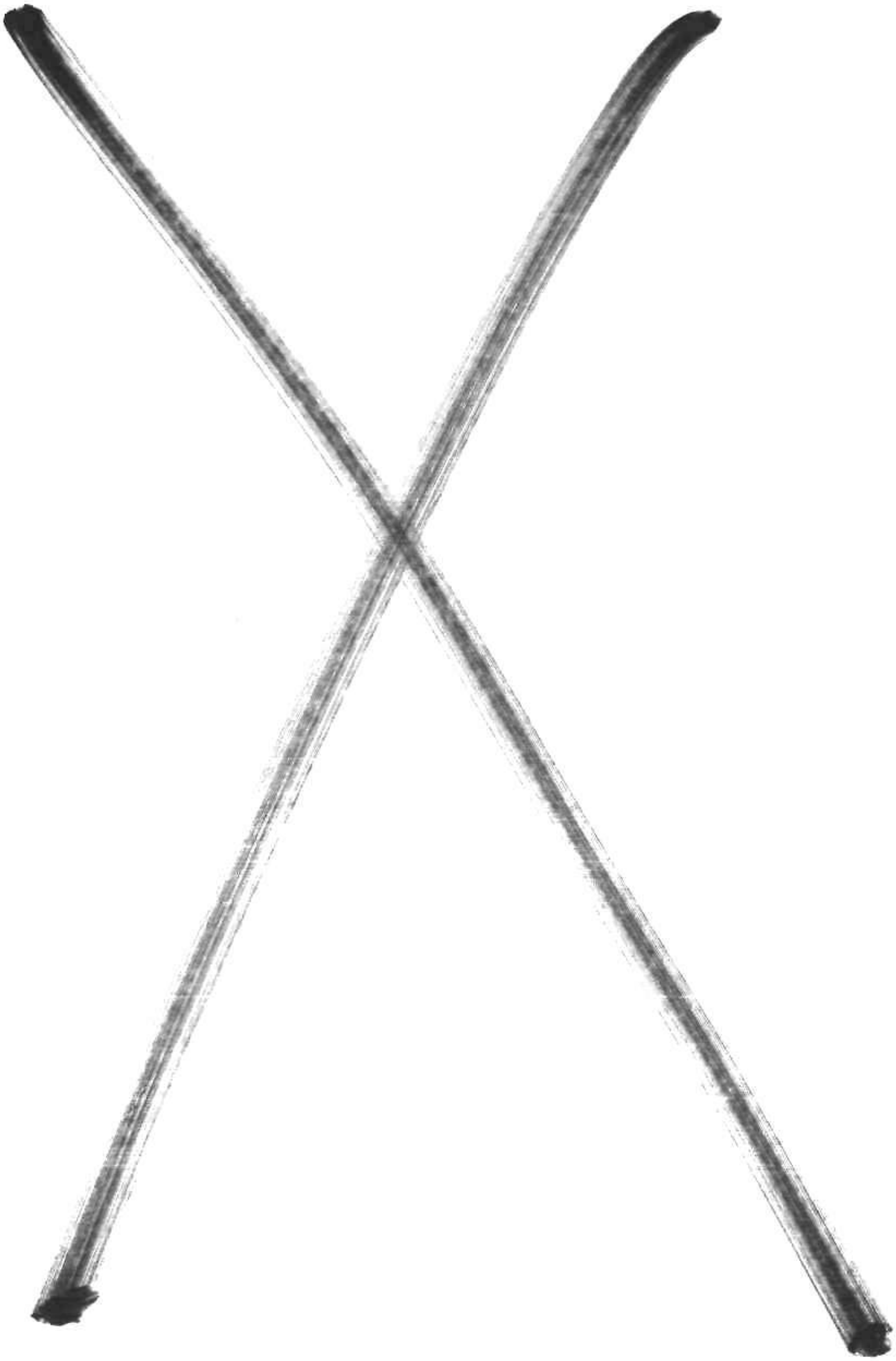
ESTIMATED U.S. AND EUROPEAN SALES OF CAM SYSTEMS
(Millions of Dollars)

	1983	1984	1985	1986	1987	1988	CAGR (1984-1988)
Sales	$13.0	$49.0	$60.0	$82.0	$115.0	$165.0	36.9%

Source: DATAQUEST

This information updates information that originally appeared in the DATAQUEST Research Newsletter, "Computer Managagement of Wafer Fabrication: The Competitive Edge," August 1984. The notebook section entitled "Computer Management of the Wafer Fabrication Process" has also been republished.

Howard Bogert



May Newsletters

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

(Continued)

May Newsletters

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: June

THE SEMICONDUCTOR START-UP BOOM CONTINUES

Despite the industry downturn, semiconductor start-ups are alive and well. As shown in Table 1, DATAQUEST has recorded 48 semiconductor start-ups since late 1983--a record for the industry. This figure tops the 29 start-up companies recorded for the same period covered by our last newsletter on this subject ("The Boom in Semiconductor Start-ups," December 19, 1983). Twenty-eight of the start-ups are located in Silicon Valley. Moreover, DATAQUEST believes that at least 10 more companies have not yet been publicly announced, since they are maintaining their secrecy while seeking first-round financing and developing their products.

Since 1977, 98 start-up companies have entered the industry, while only a handful have gone bankrupt. We believe that this continuing start-up boom and high survival rate reflects the emergence of new market niches in application-specific ICs (ASICs), CMOS memory and logic, gallium arsenide (GaAs), linear, digital signal processing (DSP), and silicon compilers. Major developments include the following:

- Emergence of nine GaAs start-ups
- Proliferation of ASIC vendors due to the availability of improved CAD systems and excess plant capacity
- Shift to silicon compilation (Cirrus Logic, Seattle Silicon, and Silicon Design Labs)
- Appearance of specialized CMOS memory and logic manufacturers (application-specific standard circuits)
- Growth in linear products for telecommunications, consumer, and military markets
- Initial companies offering DSP, graphics chips, sensors, and DMOS discrete chips

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During the summer, DATAQUEST will survey these start-up companies and issue an industry update newsletter. We would appreciate hearing news of any other start-ups.

Table 1

SEMICONDUCTOR START-UPS (1983 to 1985)

Company	Location	Products
Anadigics	Morristown, NJ	GaAs A/D converters
Array Logic	Melbourne, England	CMOS and bipolar ASICs
Barvon Research	Milpitas, CA	ASICs
Calmos	Kanata, Ontario	ASICs
Calogic	Fremont, CA	ASICs
Celeritek	San Jose, CA	GaAs FETs
China Micro	China	MOS ICs
Chips & Technologies	Milpitas, CA	ASICs
Cirrus Logic	Milpitas, CA	Silicon compilers
Crystal Semiconductor	Austin, TX	Telecom ICs
Custom Silicon	Lowell, MA	ASICs
Dallas Semiconductor	Dallas, TC	CMOS memories
Electronic Technology	Cedar Rapids, IA	ASICs
Inova Microelectronics	Campbell, CA	SRAMs
Integrated Logic Systems	Colorado Springs, CO	ASICs
Integrated Power Semiconductor	Santa Clara, CA Livingston, Scotland	Linear
Isocom	Campbell, CA	GaAs couplers
Ixys Corporation	Santa Clara, CA	Power monolithics
Logic Devices	Sunnyvale, CA	CMOS multipliers
Micro MOS	Santa Clara, CA	EPROMS
Microwave Technology	Fremont, CA	GaAs amplifiers
Modular Semiconductor	Santa Clara, CA	CMOS memories
Mosel	Sunnyvale, CA	EPROMs, SRAMs
NMB Semiconductor	Tokyo, Japan	CMOS memories
Pacific Monolithics	Sunnyvale, CA	GaAs monolithic ICs
Panatech Semiconductor	Santa Clara, CA	CMOS memories
Performance Semiconductor	Sunnyvale, CA	CMOS SRAMs, MPUs
Pivot III-V Corp.	Unknown	GaAs digital ICs
Quasel	Santa Clara, CA	CMOS memories
Seattle Silicon	Bellevue, WA	Silicon compilers
Sensym	Sunnyvale, CA	Pressure sensors
SID Microelectronica SA	Sao Paulo, Brazil	MOS ICs
Sierra Semiconductor	Sunnyvale, CA	Reconfigurable MPUs
Silicon Design Labs	Liberty Corner, NJ	Silicon compilers
Silicon Macrosystems	Santa Clara, CA	Static ROMs
Teledyne Microwave	Mountain View, CA	GaAs analog
Topaz Semiconductor	Santa Clara, CA	DMOS discretes
Triquint Semiconductor	Beaverton, OR	GaAs analog and digitizer
Unicorn Microelectronics	San Jose, CA	ASICs
Vatic Systems	Mesa, AZ	ASICs
VTC Inc.	Eagan, MN	CMOS logic
VISIC	San Jose, CA	CMOS RAMs
Vitelic	San Jose, CA	CMOS memories
Vitesse Electronics	Camarillo, CA	GaAs digital ICs
Xilinx	San Jose, CA	CMOS logic arrays
Xtar Electronics	Elk Grove, IL	Graphics chips
Zoran	Sunnyvale, CA	DSP

Source: DATAQUEST

Barbara Van
Sheridan Tatsuno

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

THE GENERATION GAP-- AN UPDATE ON 32-BIT MICROPROCESSORS

SUMMARY

The 32-bit generation of microprocessors is now emerging. Three devices are already on the market, and there are more to come. The decision to move to a new generation of semiconductor devices is complex, and timing can be critical to the company making that decision. This newsletter gives an update on the 32-bit microprocessor, its applications, and its current and future manufacturers.

INTRODUCTION

Users look to the 32-bit microprocessor to provide increased speed and functional enhancements. Engineering and CAD workstations represent the most visible market segment to adopt the 32-bit MPU. Other important design-ins are in robotics, computer-aided manufacturing, and telecommunications.

DATAQUEST anticipates three phases in the adoption of the 32-bit microprocessor:

1. The replacement of 16-bit devices by 32-bit devices will be the first phase as new versions of existing systems are designed. We see this occurring initially with engineering workstations as growing systems complexity demands greater performance from the microprocessor. The important issue in this phase will be upward compatibility. The Motorola 68020 and the National 32032 are expected to be important players here because many of the existing workstations have been designed with the 16-bit predecessors to these 32-bit MPUs. In both cases, the conversion to the new MPU can easily be accomplished. This phase is already beginning.

2. In the second phase of the market development, we will see the use of 32-bit microprocessors in minicomputers and small business systems. Designers will use these products to improve the cost/performance ratio of their machines. A significant factor in this market will be the captive manufacturers of 32-bit devices, such as Data General, Digital Equipment Corporation, Hewlett-Packard, and NCR. The potential exists for any of these companies to offer its devices on the merchant market. NCR's entry into the merchant market marks the beginning of this phase.

3. The third phase of the development of the 32-bit market will occur when the devices are well understood and accepted and become the basic design elements of many microprocessor-based systems. Rapid growth in consumption of 8-bit and 16-bit microprocessors occurred about five years after they were first introduced. We expect 32-bit microprocessors to follow the same trend, with rapid growth beginning in 1989.

MICROPROCESSOR PRODUCT ACCEPTANCE

If 32-bit microprocessors follow the trends we have observed, they will exhibit slow to moderate growth in the first two or three years after introduction, followed by a period of extremely rapid growth in the fourth and fifth years. There are, however, arguments for either faster or slower growth than this experience suggests.

The arguments for slower acceptance revolve to some extent around the fact that the full capabilities of existing 16-bit devices have not yet been exploited. Another argument is that there are more design alternatives than ever before. Many systems designs are being done with multiple 8- or 16-bit microprocessors.

With the evolution of application-specific ICs, we are seeing the development of intelligent microperipherals. A number of coprocessors for 16-bit devices are also coming to the market. All these devices make the design of higher-performance systems possible without resorting to the use of a 32-bit microprocessor.

Faster acceptance of the 32-bit microprocessor could come about simply because the market is much larger than it was when the 8-bit and 16-bit devices were introduced. Some 32-bit microprocessors offer upward compatibility with existing 16-bit devices, making the transition from a 16- to 32-bit device much easier than previous generation switches.

The 32-bit device will appeal to manufacturers of minicomputers and superminicomputers as a means of reducing cost. These manufacturers will not have the same commitment to previous generations of microprocessors as microcomputer manufacturers, so they may accept the devices more readily, thus accelerating the rate of acceptance.

MANUFACTURERS--PRESENT

Motorola

The Motorola 68020 was introduced in the third quarter of 1984. The company is now ramping up to full production. The 12MHz version will be in volume production by mid-1985 and the 16MHz version in the Fall. Motorola has entered into a second-source agreement with Thomson-CSF, contingent upon certain technology exchange agreements. If these agreements are met, Thomson-CSF is expected to start production of the 68020 by the end of 1985. Hitachi, Rockwell International, and Signetics also second-source Motorola's 16-bit devices and may be regarded as potential second sources for the 32-bit family.

National Semiconductor Corporation

National Semiconductor Corporation is currently the leading supplier of 32-bit MPUs with its 32032. The device has been in production for more than a year. Texas Instruments, which is second-sourcing the family, is expected to start sampling around mid-1985.

NCR Corporation

NCR is offering its 32-bit chip set, originally developed for internal use, on the merchant market. The device, which features external microcode, can emulate existing microcomputers. Honeywell, Inc., has signed an agreement with NCR to use the NCR/32 chip set for a future small- to medium-scale computer system.

MANUFACTURERS--FUTURE

This section of the newsletter will cover the announced plans of future participants in the 32-bit microprocessor market. Table 1 lists those companies believed to be currently involved in 32-bit microprocessor development.

Advanced Micro Devices

The Advanced Micro Devices (AMD) 29300 family of bipolar devices includes the Am29323 Multiprecision Multiplier, the Am29325 Floating Point Processor, the Am29332 16-bit Micro-Interruptible Sequencer, the Am29332 32-bit Arithmetic Logic Unit, and the Am29334 Four-Port Dual-Access Register File. Each device can function alone or act as a building block for a 32-bit system. The products are intended for use in high-performance applications, for intelligent peripherals control, and in digital-signal and array processors. The 29325 arithmetic unit will be sampling within two months, and all five devices will be sampled by the end of 1985.

AT&T Technologies

AT&T's WE32100 is a CMOS microprocessor originally developed for in-house use. The company recently announced commercial availability of the family. The WE32100 is now in production, together with the WE32101 memory management unit and the WE32105 system interface unit. The 32106 math acceleration unit is now being sampled, and the 32103 DRAM access controller and the 32104 DMA controller will complete the chip-set early next year.

Hitachi Ltd.

Hitachi Ltd. announced the development of a CMOS 32-bit microprocessor at the end of 1984. Sample quantities are expected at the end of 1986, with full production beginning in mid-1987. The device is expected to be upwardly compatible with Motorola's 68000 family. Hitachi had been regarded as a potential second source for the Motorola 68020 and it is not yet clear what effect the announcement of a proprietary 32-bit device will have on the situation.

Inmos

Inmos is in the final development stages of a family of devices based on its unique, high-performance architecture. The family includes both a 16-bit and a 32-bit transputer as well as some intelligent microperipherals. Inmos will begin sampling the first parts of this family by the end of 1985 or early 1986.

Intel

Intel announced early this month that it plans to ship samples of its 80386 32-bit microprocessor in about six months. The device will be offered in 12- and 16-MHz versions, and Intel will also offer a 32-MHz clock generator and a floating-point coprocessor chip.

NEC

NEC's V series family of microprocessors will include 32-bit devices. The V-60 is scheduled for introduction in 1986 and the V-70, described by NEC as a second-generation 32-bit device, is planned for 1987. NEC has licensed both Sony Corporation and Zilog, Inc., as second sources. NEC is also licensed as a second source for Zilog's Z80,000.

Zilog

The Zilog Z80,000 is now expected to be sampled by the end of 1985. NEC is a licensed second source for the part.

Other Manufacturers

Data General, Digital Equipment Corporation, and Hewlett-Packard have all introduced 32-bit microprocessors for internal use, but it is not yet known whether they will offer these devices on the merchant market. The other companies listed in Table 1 are believed to be developing 32-bit devices for the merchant market.

SELECTING A 32-BIT MICROPROCESSOR

As Table 1 shows, 17 companies already produce or are planning to produce 32-bit microprocessors. How do you pick a winner from such a range of alternatives? The market is still too young to predict who the big winners will be, but there are several points worth considering.

For the first time, the computing power of a minicomputer will be available in a microprocessor. This means that the 32-bit device can be approached from two directions: it can provide an upward migration path for current users of 16-bit devices, and it can offer a lower-cost option to manufacturers of mini- and superminicomputers. These two categories of users make different demands on 32-bit devices. Those taking the upward migration path are looking for upward compatibility from existing 16-bit devices so that they can continue to exploit the existing software base. Those taking the downward path from the minicomputer environment are more concerned with getting the architectural capabilities available with advanced technology. In the long term, this diversity could set the stage for a larger number of suppliers to enter the market.

There are two new factors in the 32-bit market that could change the market pattern. The first is the presence of the captive manufacturers. Captive manufacturers were ahead of the merchants in their development of the 32-bit device. There has been an increasing trend for captive semiconductor manufacturers to offer their products on the merchant market. NCR's device, the NCR/32, is the first of such products to be offered, but others could follow. Such a development could herald the growth of a 32-bit niche market for those users who are looking for minicomputer capability in a microprocessor. Captive manufacturers have the advantage of a protected internal market to help them weather the vicissitudes of market introduction. However, the ability of captive manufacturers to market their products effectively will obviously be an important factor in the growth of this niche market.

The second factor to be considered in the 32-bit market is the development of proprietary devices by Japanese companies. In previous generations, Japanese manufacturers have second-sourced U.S. products.

The most important issue to consider in selecting a 32-bit microprocessor is whether you really need the added capabilities that the device can offer. Have you fully exploited the 16-bit options available? If your application requires 32-bit capability, then the next areas of consideration are similar to those for any microprocessor:

- Does the device match your application?
- Will it be available in sufficient quantities when you need it?
- Are the appropriate microperipherals and coprocessors also available?
- Are there adequate development tools?
- Is there a viable second source?

The point of divergence that you reach when selecting a 32-bit device is the decision about which category of 32-bit devices you should be considering. Is upward compatibility an issue? If so, you should be considering those devices that offer a migration path from earlier generations. Are you looking for minicomputer-like architecture? Devices developed initially for captive use will fit into this category. National Semiconductor's 32032 offers a VAX-like architecture, and Fairchild is promising to take a minicomputer-like approach to its 32-bit offering. Japanese companies will also be entering the market with devices that are not upwardly compatible with existing products. There is yet another segment, represented by AMD's 29300 family and also, perhaps, by the Inmos transputer. These devices offer alternatives for high-performance applications that do not fit into either of the other categories.

The ultimate success of 32-bit microprocessors may rest on the rate at which the market develops. If market acceptance of the 32-bit device is delayed, the winners could be those companies that gained an early share of the market, those companies with upward compatibility to a substantial installed base of 16-bit devices, or those companies with protected internal markets. Early acceptance of the 32-bit devices, on the other hand, may permit market growth adequate to support a wider range of successful products than we have seen in any previous generation.

Future newsletters on the 32-bit microprocessor will examine the growth of the market and the development of new devices. This information will help you to implement a selection strategy that will satisfy your product's requirements.

Mel Thomsen
Jean Page

Table 1

COMPANIES INVOLVED IN 32-BIT MICROPROCESSOR DEVELOPMENT

Advanced Micro Devices (Bipolar)	Matsushita
AT&T Technologies	Motorola
Data General	National Semiconductor
Digital Equipment Corporation	NCR
Fairchild Semiconductor	NEC
Hewlett-Packard	Texas Instruments
Hitachi	Toshiba
Inmos	Zilog
Intel	

Source: DATAQUEST
May 1985

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

AT&T INTRODUCES 32-BIT MICROPROCESSOR FAMILY TO THE MERCHANT MARKET

The long-awaited battle between traditional semiconductor makers and large captive minicomputer makers in the microprocessor arena has begun in earnest. Since the first microprocessor was introduced over a decade ago, semiconductor manufacturers have been offering successive generations of higher-performance microprocessors. Migration from 8-bit to 16-bit microprocessors led to object code compatibility problems that semiconductor manufacturers learned to overcome but which initially hindered the growth of 16-bit MPUs. Migration from 16-bit to 32-bit MPUs is expected to be less painless for microprocessor manufacturers due to the installed software base. A mainframe on a chip has been envisioned by semiconductor manufacturers since the first microprocessor was created, and it is closer to reality with the emergence of the 32-bit microprocessor.

The 32-bit architecture on a single chip offers many opportunities due to its hardware and software enhancements. CAE, certain CAD applications, and high-accuracy robotics were not possible without a full 32-bit microprocessor. Needs met only with a 32-bit MPU are now a reality, and many so far unknown high-performance applications will become realities. While semiconductor manufacturers have been offering upward migration paths for microprocessors, minicomputer manufacturers have turned to manufacturing proprietary circuits to maintain economic and technological advantages within their industry. The upward migration of 8- and 16-bit microprocessors and the downward migration from system level architecture have collided in the 32-bit market arena.

AT&T has announced commercial availability of its 32-bit microprocessor family, and has announced sampling of its 16-bit microprocessor in fourth quarter 1985. Its 16-bit MPU is fully upward object code compatible with its 32-bit MPU. AT&T's strategy is a combination of upward and downward migration to enter the 32-bit market. AT&T believes that both approaches are essential to capture market share. The 16-bit microprocessor market only has 12 percent of the market today but is expected to take off in 1985, according to DATAQUEST. We believe that AT&T's introduction of its 16-bit

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microprocessor has not missed the market. However, AT&T's marketing must be strong to capture designs at this time. The 16-bit microprocessor, WE32116, will sample late in 1985 and will make upgrading easier for users not quite ready for 32-bit cost or performance. The complete family is part of an integrated UNIX microsystem that includes the microprocessor, support chips, and software. Other available products are a development system that supports in-circuit-emulation for the memory management unit as well as the microprocessor, development software, and an evaluation board.

The following components make up the AT&T family:

- WE32100, 32-bit Microprocessor
- WE32101, Memory Management Unit
- WE32102, System Clock Chip
- WE32103, Dynamic RAM Controller
- WE32104, Direct Memory Access Controller
- WE32105, System Interface Unit
- WE32106, Math Acceleration Unit
- WE32116, 16-bit Microprocessor

The microprocessor, memory management unit, and system clock chip are in full production now; the other units are presently available for sampling, and will be in full production by the end of 1985.

The UNIX operating system, which was originally developed by AT&T, is a strong feature and AT&T plans to capitalize on it. The UNIX System V has been licensed to all of the major semiconductor manufacturers and has become a de facto standard in the industry. Because of AT&T's experience with UNIX, the WE32100 microprocessor family has been optimized to achieve outstanding performance with this software. DATAQUEST believes that although AT&T is a newcomer to the microprocessor market, its relationship with UNIX will provide it with the distinctive competency necessary to penetrate the market.

ANALYSIS

AT&T is the second captive manufacturer to announce commercial availability of its microprocessor family. (The first was NCR with the NCR/32 family.) We expect other minicomputer manufacturers to follow this trend. Other major minicomputer makers (Hewlett-Packard, Digital Equipment Corporation, and Data General), also are generally ahead of the semiconductor manufacturers in the development of the 32-bit microprocessor families. AT&T has been in production with the WE32100 since last year and prior to that with its predecessor, the WE32000. In fact, AT&T has manufactured several tens of thousands of the 32-bit microprocessor for use in its own terminals, workstations, and telecommunications equipment. Minicomputer manufacturers have the advantages of generally superior architecture for high-performance systems, more extensive software for both development and application, and a large installed base of development systems. They also have an advantage because their internal consumption helps to increase the production volume.

AT&T's WE32100 family fits the 32-bit market well, but can AT&T market the product effectively without previous experience in the merchant market? The company's strategy is a good one combining upward and downward migration paths for its users. The strength of UNIX and the fact that the product should run smoother than any other product on UNIX is key to its success. The development of an effective sales and marketing force for this new market area is the most important factor in launching a product designed and manufactured by a captive manufacturer.

Two major semiconductor manufacturers National Semiconductor and Motorola) with experience in effective sales and marketing throughout the semiconductor industry are already in the 32-bit microprocessor market. These companies have an advantage over other merchant manufacturers in the 32-bit arena due to their early entry into the market. DATAQUEST believes that AT&T's entry into this dynamic and challenging marketplace adds merit to the 32-bit market and offers great opportunities for industry.

Mel Thomsen
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FAST MOS STATIC RAMS

SUMMARY

Fast MOS static RAMs constitute the largest performance-optimized product market in the entire MOS memory portfolio. Having speeds comparable to most TTL RAMs and some of the slower ECL devices, fast MOS static RAMs are more and more often becoming the device of choice in many high-performance systems because of their high density, low power, or low cost. In addition, with device performance being the principal driving force in the chip circuit design and system application (more than price per bit, for example), fast MOS static RAMs are used in a unique set of applications at a relatively concentrated set of customers and well-defined set of systems.

As a result, the fast MOS static RAM market behavior is different from that of slow static RAMs, EPROMs, ROMs, and most dynamic RAMs. Product life cycles are prolonged, and healthy markets continue to exist for higher-speed, low-density devices long after the next generation becomes available. New high-performance CMOS technologies are adding momentum to the penetration of MOS in speed-optimized applications.

Shipments of fast MOS static RAMs from 20 participating vendors were estimated to have been $315 million during 1984. Table 1 shows the estimated market composition by density and technology of device. In 1984, the fast MOS static RAM market size exceeded that of bipolar RAMs (TTL and ECL combined) for the first time.

Fast MOS SRAMs constituted approximately 20 percent of the total MOS static RAM units shipped in 1984, accounted for 15 percent of the total MOS SRAM bits, and generated 28 percent of the total SRAM dollars.

This newsletter summarizes data collected through a survey that was followed by interviews with all major fast MOS static RAM manufacturers, as well as a number of prospective entrants to the market. The comments of 14 vendors and several users and industry observers were incorporated into the data summarized below.

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Table 1

ESTIMATED FAST MOS SRAM REVENUES
(Millions of Dollars)

Device	1984	1985
1K NMOS	$ 3	$ 2
1K CMOS	1	3
4K NMOS	47	36
4K CMOS	9	6
16K NMOS	191	163
16K CMOS	58	86
64K NMOS	2	9
64K CMOS	4	35
Total	$315	$340

Source: DATAQUEST
May 1985

Worldwide Regional Markets

The United States constitutes approximately 65 percent of the worldwide total available market (TAM), with a number of vendors selling close to 80 percent of their fast SRAMs into the U.S. market. Japan was 22 percent of the world market, Europe was 13 percent, and Rest of World (ROW) made up less than 1 percent of the worldwide TAM. More than half of Japan's 22 percent was used internally at three of the major Japanese suppliers--Fujitsu, Hitachi, and NEC.

Vendors' Market Shares

Japanese vendors, led by the three vertically integrated semiconductor-computer suppliers, had the largest market share in 1984, with 51 percent of the total revenues, followed by the European vendors (principally Inmos Corp.) with 28 percent and U.S. vendors with 21 percent.

Speed Mix

The speed mix is still a strong function of device density. Fast 4K MOS SRAMs, introduced in 1977, average close to 35ns. Fast 16Ks, introduced in 1980/1981, averaged between 45ns and 55ns, with volumes of 35ns devices just beginning late in 1984. Fast 64Ks, which were introduced in 1984, were mostly 45ns and 55ns. Second-generation 16Ks using newer 64K technologies are expected to yield significantly to 25ns and 35ns in 1985 and 1986.

Architecture

Initially only x1 devices were available, but healthy markets now exist for 1Kx4, 4Kx4, and 2Kx8, and the outlook for 16Kx4 and 8Kx8, at the 64K density, is promising. About 30 to 35 percent of 4K revenues are generated by the 2148/2149/6148-type parts; about 25 percent of the 16K dollars are 4Kx4 or 2Kx8. However, as the 16K market matures, the 4Kx4 and 2Kx8 devices are expected to increase their shares significantly. In the mature 64K market, all three organizations (64Kx1, 16Kx4, and 8Kx8) should be represented in nearly equal proportions.

Technology

Scaled NMOS has traditionally been the mainstay technology of fast SRAMs, but is increasingly being challenged by CMOS. Hitachi's HiCMOS 6147 (4Kx1) and 6148 (1Kx4) followed pioneer Intel's 2147 into the market by about 18 months in 1977 to 1978. The technology is shifting rapidly, however, and NMOS may nearly be squeezed out of the 64K market. The CMOS devices are both 4Tx and 6Tx cells, and either P-well or twin-tub. Leading-edge devices, such as the emerging 64K densities, typically use 1.5 μm design rules, and are mostly CMOS.

End Use--Equipment

In 1984, an estimated 50 percent of the fast MOS static RAM market was in EDP equipment, 2 percent was in consumer products, 20 percent was in communications, 11 percent was in industrial equipment, and 17 percent was in government and military.

End Use--Applications

In 1984, cache memory made up an estimated 33 percent of the fast static RAM market, main memory (principally for mainframes or supercomputers) made up 22 percent, buffer memory made up 17 percent, video applications made up 5 percent, MOS microprocessor-associated applications made up 2 percent, writable control store applications made up 19 percent, and 2 percent were made up by the other applications.

Package Mix

In 1984, an estimated 70 percent of units were shipped in plastic DIPs, 20 percent were in ceramic DIPs or CERDIP, 8 percent were in leaded or leadless chip carriers, and 2 percent were in flatpak or other packages At the 4K level, CERDIP was more strongly represented than 16K or 64K. Surface Mounted Devices (SMDs) may constitute up to 30 to 40 percent of packages by 1988, and fewer than 10 percent of packages are expected to be ceramic or CERDIP by that time.

Specialty Parts

Several manufacturers are looking at variants of the standard fast static RAM that can further enhance system performance. Examples on the market include innovative high-density packages, resettable RAMs for cache memories, dual-port RAMs for multiprocessor systems, and devices with separate input and output pins to enhance performance in systems using several high-speed devices.

Fast Static RAMs--Definitions

The static RAM market can be divided into two submarkets based not only on speed, but also to a large degree on application:

- The "fast" static RAM market is that portion of the market where the fastest device available can be used to improve the system performance. These systems may have bit-slice processors, standard logic, or gate arrays as the associated processor or logic.

- The "slow" static RAM market consists primarily of local store in MOS microprocessor-based applications. In these applications, the microprocessor usually limits the speed of the system; getting a faster part than is required by the MPU does not enhance system performance.

Therefore, for the purposes of this survey, we have used the following definition:

Fast 4K parts have access speeds of less than 70ns, and include the 2147, 2148, 2149, 6147, and 6148, or equivalents. Fast 16K and 64K static RAMs include all 16Kx1, 4Kx4, 64Kx1, and 16Kx4 devices, regardless of speed. All the devices are sub-100ns and almost all are sub-70ns. Also included as fast devices are those x8s that have access speeds of less than or equal to 55ns. This latter group now includes only Cypress, Motorola, and Toshiba, but several fast 8Kx8s are expected during 1985 or 1986.

MARKET BREAKDOWN, DISCUSSION, AND FORECAST

In each of the sections below, we have included a fuller discussion of the fast MOS SRAM market breakdown, describing expected shifts in market makeup for the coming years.

Market Characteristics

The applications of fast MOS SRAMs and the consequent market behavior differ from those of other MOS memory devices in a number of important respects:

- More big system usage; less low-end equipment; end equipment has longer life cycles
- Less price volatility than DRAMs, slow SRAMs, or EPROMs, but still steady price erosion (albeit more slowly)
- Device manufacturers' design emphasis skewed more toward speed improvement than density increases or cost reduction
- Steadier market at lower densities; new entrants may begin with fastest available part at a lower, older, density
- Less motivation for systems makers to roll over to higher density devices; longer-lived markets for older products
- Market introduction of a given fast static RAM density may lag the slow part of the same density by 12 to 18 months
- Production ramp-up of fast SRAMs is gradual because of their systems applications--large systems with extended design cycles and in need of performance more than density

Market Growth

Fast SRAM units were about 20 percent of the total MOS static RAM units shipped in 1984, and made up 28 percent of the total SRAM dollars. DATAQUEST expects the percentage of revenues generated by fast parts shipped to continue to increase over the next several years, and perhaps reach as high as 40 to 45 percent of total SRAM revenues by 1988 or 1990. By 1990, the fast SRAM market is expected to be more than $920 million, with 64Ks and 256Ks being the principal contributors. The fast static RAM increase as a percentage of the total is expected to occur since CMOS DRAMs will be able to displace some of the slow CMOS static RAMs, and fast static RAMs are expected to encroach further on the bipolar RAM market, especially TTL RAMs.

By 1990, the percentage of units may rise to perhaps 30 to 35 percent of the SRAM total, and fast SRAM bits will be about 20 to 25 percent of total bits, up from 15 percent in 1984. These differences--revenues, units shipped, and bits--are because the life cycles of fast parts seem to be longer than those of slow parts, so the average bits per package is less. In addition, since the most desirable characteristic in this market is speed rather than high density, users will stay with a lower density part longer than with a slow part. Thus, although fast parts are increasing as a percentage of units, the percentage of bits is not expected to increase as quickly.

Worldwide Regional Markets

Worldwide regional market estimates, as a percentage of the total world market, are shown below (note that a sale to a U.S. company is defined as U.S. consumption, regardless of the destination to which the part is shipped):

	1984	1985	1988
North America	65%	63%	57%
Japan	22	24	27
Europe	13	13	14
ROW	0	0	2
Total	100%	100%	100%

The U.S. percentage of the worldwide merchant TAM was 65 percent in 1984. This percentage is significantly larger than for overall MOS memory, which averages about 55 percent of the worldwide TAM in the United States. The primary reason for this difference is that fast static RAMs are high-performance parts, many of which go into large computers and are used by the U.S. military.

In 1984, Japan accounted for 22 percent of the worldwide merchant TAM, and Europe had 13 percent. These percentages are expected to shift over the next few years, with Japan increasing to 27 percent of the TAM by 1988, and the United States dropping to 57 percent.

North American Regional Markets

This was the one area of the survey where we were unable to get good data. Specific data on regional distribution was not obtained, since each vendor divides the United States into regions differently. We do know, however, that Minneapolis is one of the largest regional markets, as is the Northeast.

Vendors' Market Shares

As shown in Table 2, Inmos was the top supplier of fast static RAMs last year, and at $85 million, constituted the major portion of the European market share of 28 percent. Fujitsu, Hitachi, and Toshiba were the next three biggest suppliers, with $70 million, $41 million, and $22 million, respectively. They contributed to the Japanese market share of 51 percent. The U.S. suppliers had 21 percent of the market, with the leading suppliers being AMD, IDT, and Intel.

Table 2

LEADING SUPPLIERS OF FAST MOS SRAMs
(Millions of Dollars)

	1983	1984
Inmos	$ 34	$ 85
Fujitsu	41	70
Hitachi	38	41
Toshiba	4	22
Intel	22	20
IDT	7	18
AMD	12	17
Mitsubishi	4	14
NEC	10	12
Others	17	16
Total	$189	$315

Source: DATAQUEST
May 1985

Table 3 shows the range of production or announced fast SRAMs. Almost all of those of 16K density or below are in production; only a few of the 64Ks are.

Table 3

FAST SRAM PRODUCT OFFERINGS

	Density and Organization									
	1K		4K		16K			64K		
Company	1Kx1	256x4	4Kx1	1Kx4	16Kx1	4Kx4	2Kx8*	64Kx1	16Kx4	8Kx8**
AMD			N	N, N	N	C				C
Cypress		C	C	C			C			
Fairchild								C		
Fujitsu			N	N, N	N, C	N		N, C		C
Harris					C					
Hitachi			C	C	C	C		C		
IDT					C	C	C		C	
Inmos					N	N, C		C		
Intel	N		N	N, N	C	C		C		
Lattice									C	
Matra-Harris					C	C				
Mitsubishi					N	N				C
MOSel						C				
Motorola			C		N	C	N	C	C	C
NEC			N		N			C	C	
National			N	N						C
Oki Electric									C	
Ricoh						C				
STC			N	N	N	N				
Seiko										C
Sharp					C					C
Toshiba						N	N	C	C	N

C = CMOS
N = NMOS
*Includes 2Kx9
**Includes 8Kx9

Source: DATAQUEST
May 1985

Sales Channels

Distribution by sales channel for 1984, 1985, and 1988 are shown below:

	1984	1985	1988
OEM/Direct	71%	69%	66%
Distribution	16	17	18
Internal	13	14	16
	100%	100%	100%

Distribution by sales channel is quite different for the U.S. and European manufacturers, compared to the vertically integrated Japanese vendors. The average of 1984 fast MOS static RAM internal consumption for U.S. companies was less than 1 percent of sales, while internal consumption for the top three Japanese vendors was 23 percent of sales.

The U.S. and European companies rely more heavily on direct sales and distribution, with 79 percent of fast static RAM revenues coming from OEM or direct sales and 21 percent from distribution, compared to 66 percent OEM sales and 11 percent distribution for the Japanese companies.

Speed Distribution

The actual 16K and 64K speed mix for 1984 and estimated mix expected for 1985 and 1988 are as follows:

- 16K Devices (Percent of Units)

	1984	1985	1988
≤25ns	0.0%	0.5%	3.0%
26-35ns	1.2	6.2	16.0
36-45ns	16.3	28.8	42.0
46-55ns	50.0	45.2	30.0
≥56ns	32.5	19.3	9.0
Total	100.0%	100.0%	100.0%

- 64K Devices (Percent of Units)

	1984	1985	1988
≤25ns	0.0%	0.4%	6.0%
26-35ns	1.3	6.0	26.0
36-45ns	25.3	42.1	43.0
46-55ns	46.2	39.5	18.0
≥56ns	27.2	12.0	7.0
Total	100.0%	100.0%	100.0%

For 4K SRAMs, the speed mix for 1984 was approximately 80 percent with less than or equal to 35ns (with a substantial portion of 25ns) and 20 percent with 45ns or slower.

Some vendors offer a 20ns, 30ns, 40ns, or 50ns split, as well, though it is not common. Products may be 10ns slower to guarantee operation over the full military temperature range.

Architecture

Historically, the x1 parts have been the first device introduced by any manufacturer, but this is changing. Although the 4Kx1, 16Kx1, and 64Kx1 were the first available on the market by nearly a year (versus the 1Kx4, 4Kx4/2Kx8, or 16Kx4/8Kx8), many vendors will offer 16Kx4 or 8Kx8 as their initial product introduction. This is because:

- The x4 and x8 markets are better developed than formerly
- Later entrants to the market at a given density can be more timely if they start with a x4 or x8 device, which may be less competitive early in the product life cycle
- A larger fraction of the fast market at each new generation is going into the alternative architectures

Estimates of the fast SRAM market development by organization are provided in Table 4.

Table 4

ESTIMATED FAST MOS SRAM MARKET DEVELOPMENT BY ARCHITECTURE AND TECHNOLOGY (Millions of Units)

Organization	1983	1984	1985	1986	1987	1988	1989
4Kx1	11.7	10.8	7.4	5.6	3.5	2.5	1.5
1Kx4	5.1	6.2	4.1	3.2	2.0	1.5	1.0
16Kx1	7.8	21.2	28.0	40.0	52.0	33.0	23.0
4Kx4	3.3	13.2	20.0	36.0	45.0	30.0	20.0
2Kx8*	1.7	2.9	8.0	16.0	22.0	15.0	12.0
64Kx1	N/A	0.1	1.3	5.4	16.8	30.5	43.8
16Kx4	N/A	N/A	0.3	3.2	13.3	30.0	51.5
8Kx8*	N/A	N/A	0.3	3.1	11.9	25.5	39.7
256K (x1, x4, or x8)	N/A	N/A	N/A	0.2	1.2	10.5	21.5

*Includes 2Kx9 or 8Kx9, as appropriate.

Density	Percent CMOS						
	1983	1984	1985	1986	1987	1988	1989
4K	12%	16%	17%	11%	8%	5%	5%
16K	26%	22%	34%	39%	45%	69%	70%
64K	N/A	50%	79%	83%	88%	88%	93%
256K	N/A	N/A	N/A	100%	100%	100%	100%

Source: DATAQUEST
May 1985

Price Premium for Speed

Given the following 16K fast static RAM market speed distribution, which approximates the 1984 market mix for NMOS 16Kx1 devices, the following are estimates of the relative prices for various speeds:

	Percent of Total Units	Relative Price
≤35ns	0.5%	2.00
36-45ns	22.0	1.25
46-55ns	42.5	1.00
56-70ns	20.0	0.90
≥71ns	15.0	0.70
Total	100.0%	1.00

These price premiums give a general indication of pricing based on speed, but the market's supply-demand balance will affect this dramatically. Price is determined not only by the percentage of the market at a given speed, but also by the number of suppliers of that speed. Price premiums for the fastest speed part could range from 1.5 times to 5 times the average price, and at the slowest speeds some suppliers can find themselves practically giving away the parts.

Technology

NMOS parts still comprise about 80 percent of the market at 4K and 16K densities, but CMOS is expected to dominate the 64K market from 1985 forward. Only two NMOS 64Ks have been announced, while at least 22 CMOS 64Ks have either been announced or are in early production. This is an abrupt departure from the 16K density, where NMOS constituted 80 percent of the units shipped and 62 percent of the part types offered in 1984. Five vendors are shipping CMOS 64K parts now, and at least five more are expected to be shipping by the end of 1985.

End Use--Markets

Actual fast MOS static RAM usage in end equipment in 1984 and the expected usage in 1985 and 1988 are as follows:

	1984	1985	1988
EDP	50%	48%	44%
Consumer	2	2	4
Communications	20	22	20
Industrial	11	10	14
Government/Military	17	18	18
	100%	100%	100%

DATAQUEST defines EDP to include all computers and peripherals. Consumer includes radio, television, and other consumer electronics. Communications includes datacom and telephony applications, both central office and subscriber lines. Industrial includes automatic test equipment, medical, and instrumentation. The Government/Military market includes radar, sonar and related signal processing applications, for both commercial and military markets.

End Use--Applications

End use by application for 1984 and estimates for 1985 and 1988 are as follows:

	1984	1985	1988
Cache Memory	33%	31%	27%
Main Memory	22	23	18
Buffer Memory	17	16	16
Video	5	7	15
MOS MPU	2	2	3
Writable Control Store	19	19	17
Other	2	2	4
	100%	100%	100%

Main memory for supercomputers may reach 50MB to 100MB, and will typically use the x1 organization. Several supercomputer makers have begun to offer fast MOS SRAM as an alternative to faster, more expensive, and more power-consuming ECL RAMs. Smaller configurations, such as cache memories (often up to 32KB to 64KB) may use a significant amount of the x4 as well as the x1. The other applications will often use considerable amounts of x4 and x8 because their total memory requirements are considerably smaller and the x1 organization in high density is too deep.

One of the fastest-growing areas for fast static RAMs is in video applications, where they may be used in conjunction with the newer video DRAMs that are beginning to appear from Texas Instruments, NEC, and several others.

There is also the potential for fast EEPROMs to replace fast static RAMs now used in conjunction with PROMs or floppy disks in writable control store applications. The initial penetration would be in the military market, but the commercial market could also use these in large computer systems.

Some of the rapidly growing application areas for high-speed MOS SRAMs include workstations, array processors, and a variety of signal and image processing applications such as facsimile, radar and sonar, and speech recognition. These calculation-intensive applications often use modest amounts of high-speed memory, and are expected to contribute to the growth of the x4 and x8 configuration relative to the traditional x1 configuration.

The percentage of cache memory applications is expected to decline, since cache is generally found in larger systems, which are not growing as fast as smaller applications of fast SRAMs. There may be some new growth in that area, however, as the manufacturers of smaller systems begin to feel market pressures and add cache memories in order to speed up their systems. DATAQUEST expects the use of a high-speed cache to percolate down to smaller and smaller computer systems over the coming years.

Package Mix

Actual fast MOS static RAM packages, as a percent of total units shipped in 1984, and estimated for 1985 and 1988, are as follows:

	1984	1985	1988
Plastic DIP	70%	71%	53%
Ceramic DIP or CERDIP	20	16	12
Ceramic LLCC	8	8	13
Plastic SMDs	0	3	20
Flatpak or Other (module, dice, etc.)	2	2	2
	100%	100%	100%

The percentage of ceramic or CERDIP packages in 1984 was about 25 percent due to:

- Present chip carriers are mostly leadless and ceramic
- 4Ks continue to be shipped in volume, with a high fraction in ceramic DIPs or CERDIP
- Several of the 16K vendors have not shifted their package mix into plastic, but will do so in 1985

The shift to plastic is apparent, however, even from 1984 to 1985, as the percentage of plastic DIPs increases with a shift from ceramic to plastic at the 16K and 64K level, and then the percentages of both plastic and ceramic DIPs drop by 1988 as chip carriers increase their share of the total.

Plastic surface mounted devices (SMDs) will become much more significant in the next few years, growing to about 20 percent of units by 1988. There are strong forces pushing for both small outline ICs (SOICs), specifically SOJs, and plastic leadless chip carriers (PLCCs). Flatpaks will not be a very significant package for fast static RAMs, with only 2 percent of units by 1988.

There is a wide variation among vendors, both in present and anticipated package mix, with CMOS suppliers more strongly into plastic packages, and U.S. suppliers having a higher fraction of CERDIP and ceramic DIPs.

Speciality Parts

The fast SRAM market offers many opportunities to diversify features from the basic multisourced commodity parts.

There is a lot of interest in dual-port static RAMs, to be used initially as a communication link between coprocessors. IDT has both a CMOS 1Kx8 and a 2Kx8 dual-port static RAM, and AT&T announced a 2Kx9 dual-port RAM at ISSCC in February of 1985. Synertek shipped an NMOS 1Kx8 (P/N SY21D1) during 1984, but has since licensed Signetics to produce it, as a part of Synertek's withdrawal from the market. Several other companies are developing dual-port static RAMs, and a number of applications are possible.

The dual-port RAM can be used to speed up a coprocessor system such as a PC with a main CPU processor and a second processor in a peripheral. Acting as a buffer, the dual-port RAM allows two processors to communicate at their own speeds. It also allows reading and writing from two different locations at the same time, as in electronic mailbox or workstation applications.

Another specialty SRAM is a resettable 4K RAM offered by AMD. This device can have all bits zeroed automatically with a control signal, making it a useful device for cache or scratchpad memories where there is no need to retain the data after the operation is concluded. Resettable RAMs allow the entire memory to be cleared before the following operation's data are moved into the cache.

IDT's P/Ns 71681 and 71682 feature separate data inputs and outputs that can be used to enhance system speed and reduce board space in multichip systems. This device comes in a 24-pin ceramic, 300-mil skinny DIP or chip carrier.

Toshiba offers a 2Kx9 modified version of its NMOS 2018 2Kx8 fast SRAM into several accounts. Although there has been talk of commercially available x9 devices for some time, this may be the first instance of a x9 SRAM offered in the merchant market. We can expect 8Kx9 fast SRAMs from at least two vendors by mid-1985.

Finally, there is considerable opportunity for special value-added packages for dense SRAM configuration sold into military accounts. IDT, Harris Semiconductor, EDI, and others all serve this market with a variety of high-performance multichip modules. The applications in which these products are used place high value on improved system packing density and incremental system performance improvements.

256K SRAMs and Fast-Slow SRAMs

Sample quantities of monolithic 256K CMOS SRAMs will be available during 1985 from at least three to five suppliers. These devices, as described at ISSCC during 1984 and 1985, had typical access times in the 45ns to 70ns range. When production volumes are available, this should easily translate into 85ns to 120ns devices (maximum, not typical) over the full commercial temperature range. These devices, however, are probably targeted for high-speed MPU-based applications, and will be followed by speed-optimized 256Ks that may be as fast as the present fast 64Ks, either in the x1, x4, or x8 organization.

While there exists a rather clear distinction between "slow" and "fast" SRAMs (as described in the Definition, above), there has been a growing business in the mid-range (70ns to 100ns) being served by low-power NMOS 4Kx4s (e.g., Inmos Corp.), as well as in the fast end of the slow 2Kx8 speed distribution, which may reach down to 85ns to 90ns (e.g., IDT and Matra-Harris Semiconductors).

OUTLOOK

The fast static RAM market rides better over the ups and downs of the fluctuating markets than do the more commodity portions of the MOS memory market. As a result, fast static RAMs are expected to outperform the MOS memory market in 1985 and 1986 by a wide margin.

Inmos, Fujitsu, Hitachi, and NEC are the principal suppliers to the largest, most highly visible parts of the fast SRAM market, namely EDP. But AMD and its progeny, IDT and Cypress Semiconductor, are very much contributors to the state-of-the-art and diversity of products that exist in the market. Because these three companies are applications and performance driven, they have all introduced innovative features and brought outstanding technologies to bear on the high-speed MOS SRAM market.

With the tremendous price pressure in dynamic RAMs, EPROMs, and the more commodity SRAMs, many vendors are expected to look hard at more stable markets with higher ASPs. Several are looking to the fast SRAM market to preserve margins, since we expect this market also to come under pressure later in 1985.

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Nielsen Dataquest RESEARCH NEWSLETTER

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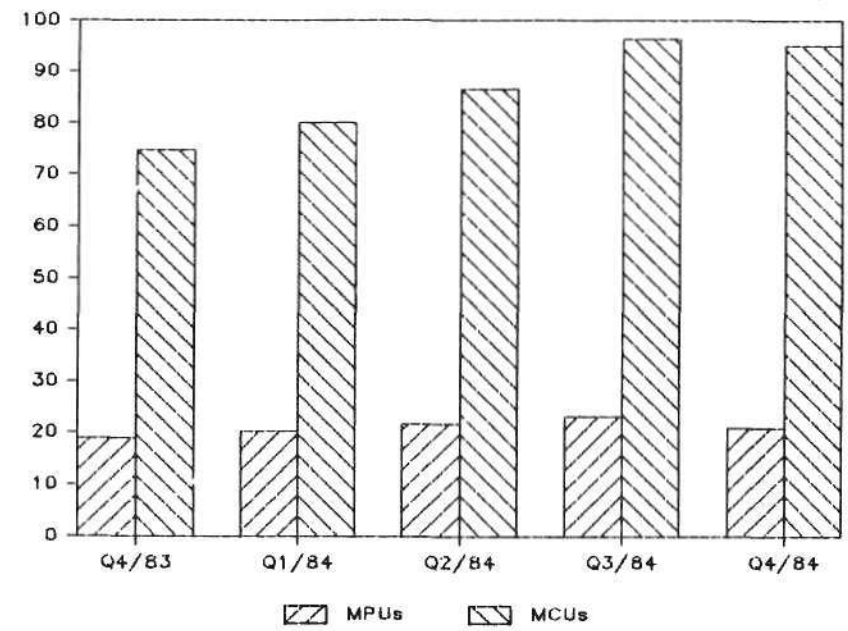
FOURTH QUARTER 1984 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the fourth quarter of 1984, worldwide microprocessor and microcontroller unit shipments decreased approximately 3.1 million units or 2.6 percent from third quarter 1984. Estimated shipments of all microcontroller devices totaled approximately 95.0 million units. Shipments of 4-bit MCUs decreased 1.9 percent and 8-bit MCU shipments decreased 0.7 percent. Estimated shipments of all microprocessor devices totaled approximately 21.3 million units. Shipments of 16-bit MPU shipments were down approximately 6.6 percent, while 8-bit MPU shipments decreased approximately 7.8 percent. Figure 1 shows MCU and MPU unit shipments from fourth quarter 1983 through fourth quarter 1984.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS
FOURTH QUARTER 1983 THROUGH FOURTH QUARTER 1984
(Millions of Units)



Source: DATAQUEST
May 1985

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

Table 1 shows the change in total microcontroller unit shipments from the third quarter of 1984 through the fourth quarter of 1984.

Table 1

TOTAL MICROCONTROLLER UNIT SHIPMENTS
THIRD QUARTER 1984 THROUGH FOURTH QUARTER 1984
(Thousands of Units)

	Q3/1984		Q4/1984		Percent
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
4-Bit	50,001	51.9%	49,065	51.6%	(1.9%)
8-Bit	46,272	48.0	45,928	48.3	(0.7%)
16-Bit	30	0.1	30	0.1	0.0%
Total	96,303	100.0%	95,023	100.0%	(1.3%)

Table 2 shows the change in total microprocessor unit shipments from the third quarter of 1984 through the fourth quarter of 1984.

Table 2

TOTAL MICROPROCESSOR UNIT SHIPMENTS
THIRD QUARTER 1984 THROUGH FOURTH QUARTER 1984
(Thousands of Units)

	Q3/1984		Q4/1984		Percent
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q3 to Q4
8-Bit	20,366	88.3%	18,771	88.2%	(7.8%)
16-Bit	2,652	11.5	2,476	11.6	(6.6%)
Others	44	0.2	36	0.2	(12.2%)
Total	23,062	100.0%	21,283	100.0%	(7.7%)

Source: DATAQUEST
May 1985

Table 3 shows the change in shipments of the leading 8-bit MPUs from the third quarter of 1984 through the fourth quarter of 1984.

Table 3

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1984 THROUGH FOURTH QUARTER 1984
(Thousands of Units)

	Q3/1984		Q4/1984		Percent Growth
Device	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
Z80	6,550	32.2%	5,855	31.2%	(10.6%)
8085	4,180	20.5	4,645	24.7	11.1%
8088	2,930	14.4	1,945	10.4	(33.6%)
6809	1,319	6.5	1,539	8.2	16.7%
6802	1,412	6.9	1,407	7.5	(0.4%)
Others	3,975	19.5	3,380	18.0	(15.0%)
Total	20,366	100.0%	18,771	100.0%	(7.8%)

Table 4 shows the percent changes in estimated shipments of second-generation 16-bit microprocessors from the third quarter of 1984 through the fourth quarter of 1984.

Table 4

SECOND-GENERATION 16-BIT MICROPROCESSOR SHIPMENTS
THIRD QUARTER 1984 THROUGH FOURTH QUARTER 1984
(Thousands of Units)

	Q3/1984		Q4/1984		Percent Growth
Device	Units	Percent of Shipments	Units	Percent of Shipments	Q3 to Q4
8086	1,104	46.4%	955	39.2%	(13.5%
68000	494	20.8	741	30.4	50.0%
80186	475	20.0	515	21.2	8.4%
Z8000	166	7.0	135	5.6	(18.7%)
32016	56	2.3	75	3.1	33.9%
80286	85	3.5	13	0.5	(84.7%)
Total	2,380	100.0%	2,434	100.0%	2.3%

Source: DATAQUEST
May 1985

Table 5 shows market share by technology for 8-bit microcontroller and microprocessor devices from the fourth quarter of 1983 through the fourth quarter of 1984, and indicates increased shipments of 8-bit CMOS microcontrollers and microprocessors.

Table 5

UNIT MARKET SHARE BY TECHNOLOGY FOR
8-BIT MICROCONTROLLERS AND 8-BIT MICROPROCESSORS
FOURTH QUARTER 1983 THROUGH FOURTH QUARTER 1984

Device	Tech	Q4/83	Q1/84	Q2/84	Q3/84	Q4/84
8-Bit MCU	CMOS	9.6%	10.1%	9.9%	9.4%	10.2%
8-Bit MCU	NMOS	90.3	89.9	90.1	90.6	89.8
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	8.4%	10.5%	10.7%	10.2%	11.5%
8-Bit MPU	NMOS	91.5	89.5	89.3	89.8	88.5
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Totals may not add due to rounding.

Source: DATAQUEST
May 1985

During fourth quarter 1984, approximately 66.0 percent of all 8-bit CMOS MCU unit shipments and approximately 29.0 percent of all 8-bit CMOS MPU unit shipments were Japanese manufactured and shipped. Even though U.S. manufacturers ship more 8-bit CMOS MPUs, approximately 1.5 million units, Japanese counterparts shipped twice as many or approximately 3 million 8-bit CMOS MCUs. DATAQUEST believes that as CMOS technology progresses, the Japanese position will become stronger in both MPU and MCU market segments.

We expect new chip designs with smaller features to make the 8-bit CMOS market surge. Telephone, automobile, keyboard, and consumer goods (such as intelligent blenders) are expected to be big markets for 8-bit CMOS devices. Pacific Asia may dominate in manufacturing the CMOS consumer products due to the high volume and low cost of this huge market.

Table 6 shows the market share changes in shipments by geographical region for microcontrollers and microprocessors, from fourth quarter of 1983 through fourth quarter of 1984.

Table 6

MARKET SHARE BY REGION FOR
MICROCONTROLLERS AND MICROPROCESSORS
FOURTH QUARTER 1983 THROUGH FOURTH QUARTER 1984

Device	Region	Q4/83	Q1/84	Q2/84	Q3/84	Q4/84
4-Bit MCUs	United States	18.0%	19.0%	17.8%	21.2%	18.9%
	Japan	81.4	80.4	81.0	77.3	78.7
	Europe	0.6	0.6	1.2	1.5	2.4
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MCUs	United States	58.9%	55.1%	57.0%	50.9%	48.2%
	Japan	32.1	36.1	33.1	38.2	37.3
	Europe	8.7	8.8	9.9	10.9	14.5
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPUs	United States	62.2%	61.4%	60.6%	60.7%	58.6%
	Japan	31.4	32.7	31.6	30.8	35.0
	Europe	6.4	6.5	7.8	8.5	6.4
Total		100.0%	100.0%	100.0%	100.0%	100.0%
16-Bit MPUs	United States	81.5%	78.6%	78.7%	76.6%	73.6%
	Japan	15.1	17.2	13.9	16.3	18.8
	Europe	3.4	4.2	7.4	7.1	7.6
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Totals may not add due to rounding.

Source: DATAQUEST
May 1985

ANALYSIS

Despite the decrease in unit shipments for microprocessors and microcontrollers from the third quarter to the fourth quarter of 1984, calendar year 1984 ended with record unit shipment growth in both microprocessor and microcontroller market segments.

Compared with 1983, 8-bit microprocessors were up approximately 11 percent, 16-bit microprocessors were up approximately 36 percent, 4-bit microcontrollers were up approximately 9 percent, and 8-bit microcontrollers were up approximately 80 percent in 1984.

We do not expect to see much growth during the first half of 1985; however, we do expect a pickup in demand during the second half. Microprocessors and microcontrollers are expected to grow faster than the total semiconductor industry. DATAQUEST believes that major growth areas will be 16-bit microprocessors and 8-bit microcontrollers with 37 percent and 33 percent unit growth rates respectively.

Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

DIGITAL SIGNAL PROCESSOR MARKET-- STC UNVEILS THE "CRISP" APPROACH

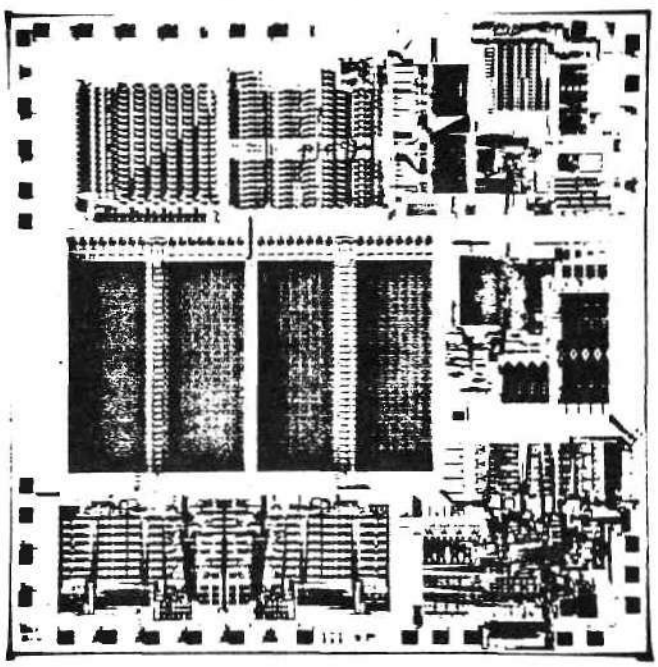
SUMMARY

With the increasing application of digital techniques in an analog world, the demand for VLSI ICs to manipulate digital words is accelerating. In order to help meet this demand, a British company, STC Components plc, has announced a new VLSI digital signal processor called the CRISP (cascadable real-time integrated signal processor).

Figure 1 shows STC Components' CRISP die.

Figure 1

STC'S CRISP CHIP



Source: STC Components plc

EUROPEAN DESIGN

Designed at Standard Telecommunication Laboratories (STL) in London with U.K. Ministry of Defense funding, the device will be fabricated in STC Components' new state-of-the-art 6-inch wafer fabrication facility in southern England. Fabrication will be done using the well-proven 3-micron NMOS process used for high-volume production of STC's static RAMs.

DATAQUEST notes that the size (almost 10mm on the side) and the complexity (90,000 transistors) make CRISP one of the most complex circuits to be designed and fabricated in Europe.

Prior to layout, the complete architecture of the chip was defined in Pascal. As well as helping the designers, this technique also benefits customers; i.e., the software simulator exists from the start and mirrors the device exactly, since it and the design specification are one and the same.

CASCADABLE ARCHITECTURE

Digital signal processors (DSPs) are stablemates of the general-purpose microprocessors. Therefore, one would expect to see the same type of architecture utilized in CRISP--i.e., either a single-bus system, which uses a standard bus for instruction and data transfers, or a Harvard architecture in which separate memory space and busses are used for programs and data. In fact, STL has gone one step further by adding a third system bus in order to maximize efficiency of bus usage. This third bus is dedicated to direct memory access (DMA) transfers and is under the control of an on-chip DMA controller. This way, DMA data transfers neither involve the CPU nor compete for the data bus, which improves the performance of the device and in particular, makes it easier to implement cascaded multiprocessor schemes.

DSP MARKET FORECAST

Definition

For the purpose of this newsletter, DATAQUEST has considered the DSP marketplace to be divided into two main categories of ICs that are used in DSP solutions:

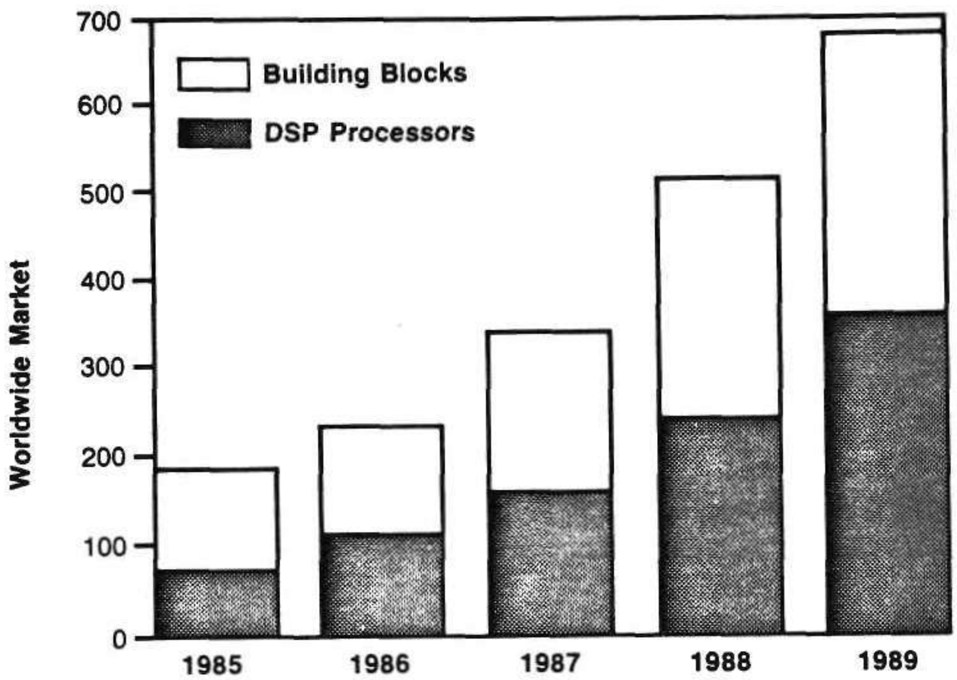
- Processors--General microprocessors and dedicated digital signal processors

- Building Blocks--Multipliers and accumulators, sequencers, address generators, algorithm-specific ICs, delay lines, ALUs, and systolic arrays

As shown in Figure 2, DATAQUEST estimates that the DSP marketplace will grow from $194 million in 1985 to $691 million in 1989.

Figure 2

DSP WORLDWIDE MARKET PROJECTION
(Millions of U.S. Dollars)



Source: DATAQUEST
May 1985

The processor portion of this marketplace will grow from $87 million in 1985 to $354 million by 1989, a compound growth rate (CAGR) of 42 percent. Included in this estimate is an increase in the usage of dedicated digital signal processors in DSP solutions. Dedicated signal processors such as the CRISP, TMS32020, and AMD 29500 series have been optimized in terms of architecture and instruction sets for fast signal processing. This allows a higher throughput and a more complex filtering capability than is available with their general-purpose stablemates. Consequently, DATAQUEST estimates that the general-purpose microprocessor portion will account for only 10 percent or $35 million of the processor marketplace by 1989.

DATAQUEST estimates that the building block portion of the worldwide marketplace will account for $107 million or 55 percent of the marketplace in 1985, increasing to $337 million by 1989. This represents a compound annual growth rate (CAGR) of 33.2 percent. (See Table 1.) As previously noted, the processor portion is projected to grow from $87 million in 1985 to $354 million by 1989, a CAGR of 42 percent. This high growth rate is due to a move within the dedicated processors field that favors cascadable or parallel processors. Cascading or paralleling up of processors allows complex algorithms to be divided into elements that are then processed simultaneously. It makes for phenomenal processor power, and is the reason that devices such as Inmos' Transputer and Weitek's fast floating-point processors are receiving so much attention from academic and commercial institutions that are looking into fifth-generation computer architecture.

Table 1

DSP WORLDWIDE MARKET FORECAST
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989
Processors	$ 87	$103	$154	$243	$354
Building Blocks	107	135	189	262	337
Total	$194	$238	$343	$505	$691

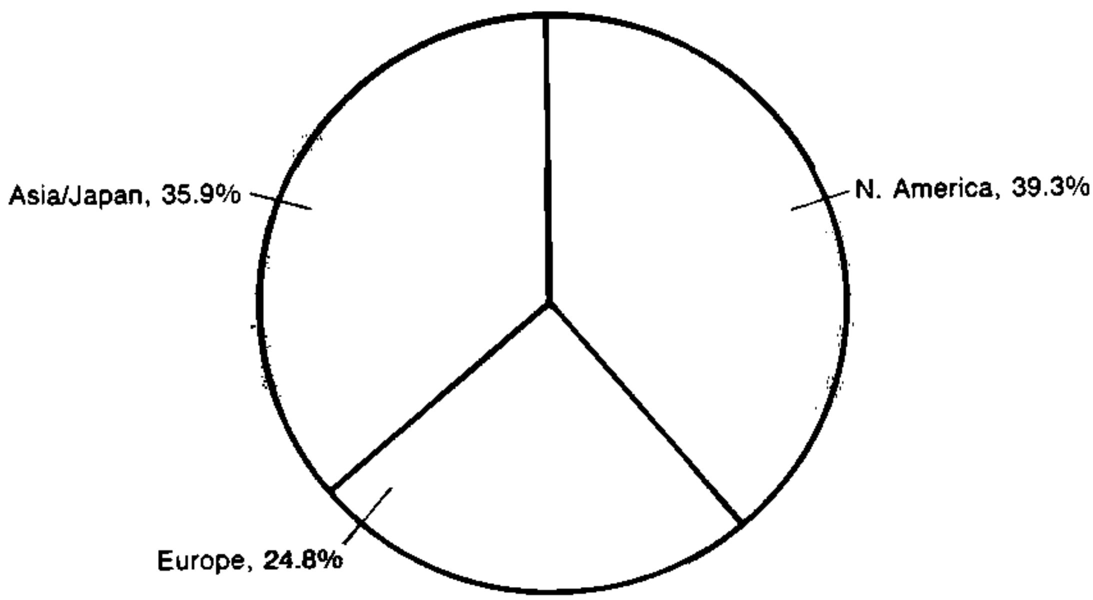
Source: DATAQUEST
May 1985

WORLD MARKET

DATAQUEST estimates that Europe will account for $36 million or 24.8 percent of the DSP world marketplace in 1985 (see Figure 3). This percentage is higher than expected, since Europe only accounted for 16.7 percent of the world semiconductor market in 1984. We believe that it reflects the leadership roles that European companies such as Philips, Ericsson, and Racal are playing in applying DSP solutions to the analog world.

Figure 3

DSP WORLD BY REGION



Source: DATAQUEST
May 1985

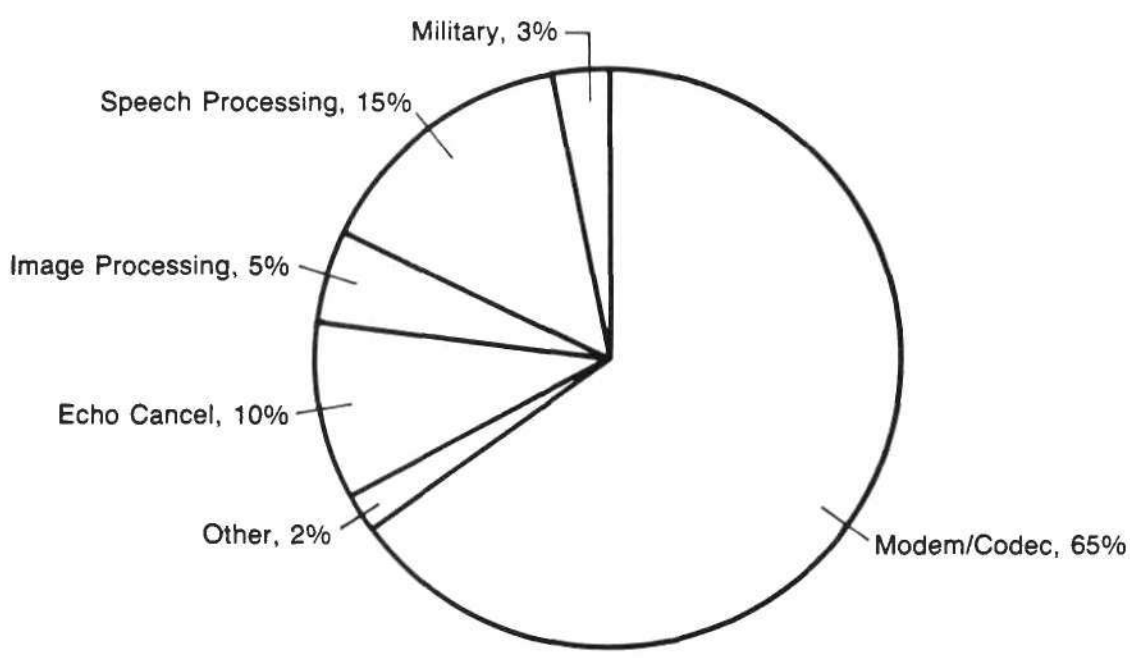
APPLICATIONS

Figures 4 and 5 show the DSP market broken out by application. Figure 4 depicts the situation in 1985; Figure 5 refers to 1989. The percentage split is based on unit consumption.

Figure 4 shows that in 1985, the majority of DSP consumption will occur in the telecommunications marketplace; modems, subscriber line cards, and echo canceling applications are expected to account for 75 percent of the market. However, speech processing, which is now mainly confined to production of speech compressor/expansion modules and accounts for 15 percent of the market, is expected to have expanded to include speech recognition applications and account for 23 percent of the market by 1989. (See Figure 5.) Electronic image processing is expected to increase from 5 percent of the market in 1985 to 11 percent by 1989. We believe that the government/military portion will represent 5 percent of the volume by 1989, but will account for approximately 12 percent of the dollar value due to the higher ASPs associated with the tighter specifications required for this sector.

Figure 4

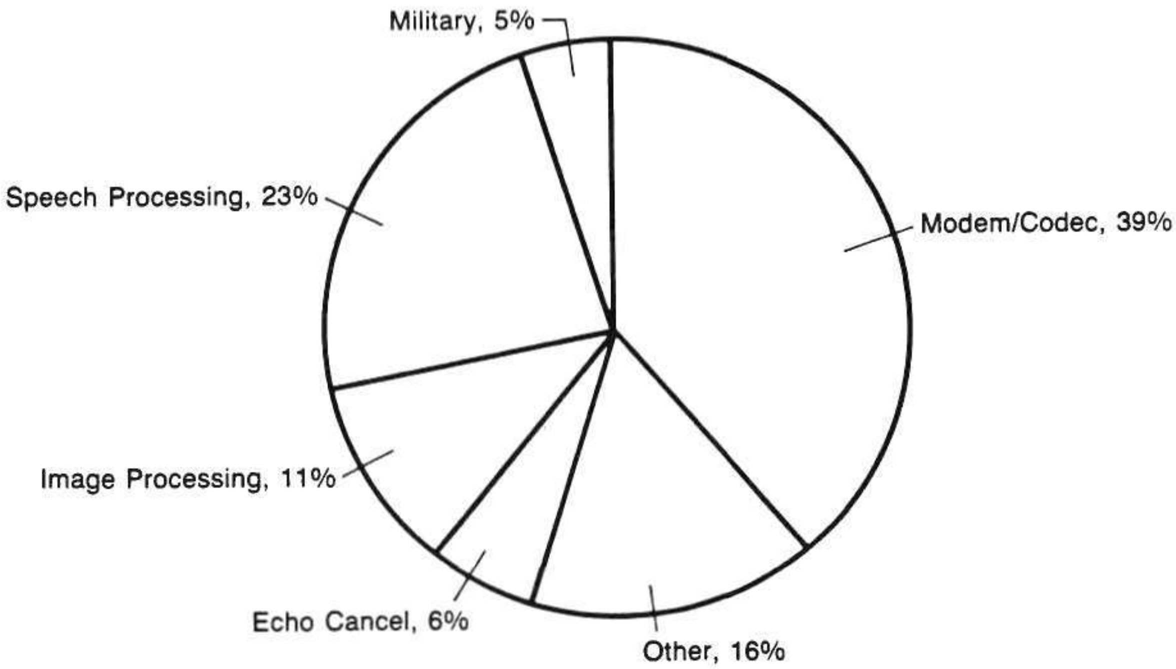
1985 DSP APPLICATIONS
(By Unit Volume)



Source: DATAQUEST
May 1985

Figure 5

1989 DSP APPLICATIONS
(By Unit Volume)



Source: DATAQUEST
May 1985

One of the more interesting features of this marketplace is that new applications are being discovered almost on a daily basis. The "other" category includes provision for these forthcoming ideas.

For the last few years, designers have steadily been lured away from the fickle analog world to the controllable digital domain. DATAQUEST believes that chips like the CRISP and its stablemates from AMD, Fujitsu, Hitachi, Inmos, NEC, TI, and Weitek ensure that this trend will accelerate. With the introduction of this device, STC has given itself an opportunity to make a significant impression in a marketplace that is about to come of age.

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Tom Holland, San Jose
Jim Beveridge, London

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

1984 8-BIT MICROCONTROLLER MARKET SHOWS HUGE INCREASE OVER 1983

The 8-bit microcontroller market showed substantial unit growth in 1984 considering the readjustment of inventories experienced throughout the industry during the final quarter. The market grew 81.5 percent over 1983. This is quite phenomenal compared with the overall 1984 semiconductor industry growth of 50 percent.

TOP TEN SUPPLIERS

The top ten companies shown in Table 1 accounted for approximately 86 percent of the total unit shipments of 8-bit microcontrollers in 1984. NEC remained the number 1 supplier of 8-bit microcontrollers for both 1983 and 1984, while Intel rose from number 3 in 1983 to the number 2 position in 1984, trading places with Motorola. In 1984, these three leading suppliers shipped more than 50 percent of all 8-bit microcontrollers. NEC's market share increased several percentage points during 1984, while Intel and Motorola lost market share.

Philips, Toshiba, and Signetics each jumped three ranking positions to 4, 5, and 7 from 7, 8, and 10, respectively. Unit shipments for each of these companies grew more than 175 percent from 1983 to 1984.

Regional Suppliers

American suppliers as a whole lost market share to both Japanese and European companies during 1984, as shown in Table 2, even though five of the top ten 8-bit microcontroller manufacturers are U.S. manufacturers.

Table 1

TOP TEN 1984 8-BIT MICROCONTROLLER MANUFACTURERS
(Millions of Units)

1983 Rank	1984 Rank	Company	Units Shipped 1983	Units Shipped 1984	Growth
1	1	NEC	17.5	36.7	110.1%
3	2	Intel	16.2	27.2	67.3%
2	3	Motorola	17.0	22.9	34.7%
7	4	Philips	3.6	10.3	186.2%
8	5	Toshiba	3.5	9.8	177.0%
4	6	General Instrument	6.6	9.5	43.3%
10	7	Signetics	2.1	7.7	262.3%
6	8	Hitachi	3.7	7.1	91.9%
5	9	National	4.3	7.0	61.8%
9	10	Siemens	2.8	3.9	37.8%
		Others	13.3	22.3	
		Total	90.6	164.4	81.5%

Table 2

REGIONAL MARKET SHARE UNIT SHIPMENTS
FOR 8-BIT MICROCONTROLLERS

Region	1983	1984
United States	59.6%	52.5%
Japan	31.4	36.3
Europe	9.0	11.2
Total	100.0%	100.0%

Source: DATAQUEST
May 1985

Growth Rates

Half of the 8-bit microcontroller suppliers had growth rates higher than the total overall growth of 81.5 percent during 1984. Thirteen of the 28 suppliers of 8-bit microcontrollers are shown in Table 3. Of the 13 manufacturers, six were U.S. companies, four were Japanese companies, and three were European companies.

Table 3

TOP GROWTH RATES OF 1984
8-BIT MICROCONTROLLER SUPPLIERS
(Millions of Units)

Company	Units Shipped 1983	Units Shipped 1984	Growth
Matra-Harris	0.05	0.60	1,108.3%
RCA	0.00	0.03	650.0%
AMI	0.30	1.60	376.5%
Signetics	2.10	7.70	262.3%
AMD	0.70	2.30	241.7%
Philips	3.60	10.30	186.2%
NCR	0.20	0.60	179.1%
Toshiba	3.50	9.80	177.0%
SGS	1.20	2.90	150.1%
Zilog	0.90	2.10	141.5%
OKI	1.00	2.30	121.4%
NEC	17.50	36.70	110.1%
Sharp	1.00	1.90	99.0%
Others	58.55	85.57	46.1%
Total	90.60	164.40	81.5%

Source: DATAQUEST
May 1985

ANALYSIS

The 8-bit microcontroller market experienced strong growth during 1984. However, entering 1985 there is a slowing of demand and a more competitive market due to price decreases in the past months, making it difficult to hold onto market share. We do not expect the 1984 growth rate of more than 80 percent in 1984 in this market segment to be repeated in 1985.

DATAQUEST expects 8-bit CMOS microcontrollers to greatly impact the market in 1985. In addition to CMOS, there will be many device improvements offered to users. We anticipate an increase in the variety of 8-bit microcontrollers and new applications to implement these devices.

We believe that Japanese and European suppliers will continue to be strong in the 8-bit microcontroller area due to a large increase in demand for automotive, industrial, and consumer applications.

Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

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16-BIT MICROPROCESSOR MARKET IN 1984

Growth of approximately 40 percent in 1984 for an exciting product area does not appear substantial when compared with its strong growth rates of previous years--73 percent in 1983 from 1982 and 133 percent in 1982 from 1981. The 1984 growth rate of 38.8 percent for all 16-bit microprocessors is a misleading indicator of the growth experienced by key products in this market segment. Six 16-bit devices made up 87 percent of all 16-bit MPUs shipped in 1984 and grew 140 percent from 1983. This is typical of a market segment reaching the rapid growth phase of its life cycle. Older 16-bit product shipments (CP-1600, 9900, 9980, and PACE) declined very rapidly in 1984. The product market share and growth for 16-bit microprocessors is shown in Table 1.

Table 1

PRODUCT MARKET SHARE AND GROWTH
FOR 16-BIT MICROPROCESSORS
(Thousands of Units)

	1983	Share	1984	Share	Growth
8086	2,150	30.1%	4,040	40.5%	87.9%
68000	773	10.8	2,036	20.4	163.4%
80186	130	1.8	1,570	15.9	1,107.7%
Z8000	409	5.7	628	6.3	53.6%
80286	13	0.2	208	2.1	1,500.0%
32016	109	1.6	202	2.0	85.3%
Others	3,554	49.8	1,280	12.8	(64.0)%
Total	7,138	100.0%	9,964	100.0%	39.6%

Source: DATAQUEST
May 1985

TOP TEN SUPPLIERS

Table 2 shows the top ten leading suppliers of 16-bit microprocessors in 1984. Intel and Motorola, the number 1 and number 2 suppliers, accounted for almost half of the total unit shipments in this market segment. Both of these U.S. manufacturers enjoyed high growth rates, but anticipate intense Japanese competition in the next few years. AMD, Hitachi, NEC, and Siemens, have all indicated strength in the 16-bit marketplace. Even though Texas Instruments showed a decrease in growth in the 16-bit market, it has second-sourced National's 32016 product line and is expected to get back in the race.

Table 2

TOP TEN 1984 16-BIT MICROPROCESSOR MANUFACTURERS
(Thousands of Units)

1983 Rank	1984 Rank	Company	Units Shipped 1983	Units Shipped 1984	Growth
2	1	Intel	1,448	3,663	153.0%
4	2	Motorola	465	1,266	172.3%
1	3	General Instrument	1,800	920	(48.9)%
6	4	NEC	255	660	158.8%
7	5	AMD	232	600	158.6%
9	6	Hitachi	220	445	102.3%
11	7	Siemens	135	430	218.5%
5	8	Fujitsu	305	340	11.5%
8	9	Zilog	221	319	44.3%
3	10	Texas Instruments	1,262	260	(79.4)%
		Others	795	1,061	
		Total	7,138	9,964	39.6

Source: DATAQUEST
May 1985

Regional Suppliers

U.S. suppliers of 16-bit microprocessors lost market share to Japanese and European manufacturers during 1984, as shown in Table 3. Six of the top ten 16-bit microprocessor suppliers were American manufacturers, three were Japanese, and one was European.

Table 3

REGIONAL MARKET SHARE UNIT SHIPMENTS
FOR 16-BIT MICROPROCESSORS

	1983	1984
United States	84.6%	77.1%
Japan	12.6	16.3
Europe	2.8	6.6
Total	100.0%	100.0%

Source: DATAQUEST
May 1985

Growth Rates

AMD, Intel, Motorola, NEC, and SGS all had similar growth rates during the past year--slightly more than 150 percent. (See Table 4.) Considerably more growth was shown by Harris, Mostek, Siemens, Signetics, and Thomson. Harris, Siemens, and Signetics shipped less than 1 percent of the total 8-bit microprocessor market segment in 1984. U.S. companies remain strong and viable in this market; however, second-source agreements have increased competition from Japanese and European manufacturers.

Table 4

TOP GROWTH RATES OF 1984
16-BIT MICROPROCESSOR SUPPLIERS
(Thousands of Units)

	Units Shipped		
	1983	1984	Growth
Harris	15	135	800.0%
Mostek	35	143	308.6%
Thomson	11	42	281.8%
Signetics	32	110	243.8%
Siemens	135	430	218.5%
Motorola	465	1,266	172.0%
NEC	255	660	158.8%
AMD	232	600	158.6%
Intel	1,448	3,663	153.0%
SGS	54	136	151.9%

Source: DATAQUEST
May 1985

ANALYSIS

The 16-bit microprocessor market segment is taking off, despite the slump in the semiconductor industry. DATAQUEST expects unit shipments of this market to grow approximately 34 percent in 1985, compared to an expected flat growth of total semiconductors. During 1984, 16-bit microprocessors grew approximately 38 percent, while 8-bit microprocessors grew only 13 percent. This is an indication that 16-bit microprocessors are replacing 8-bit microprocessors in computer-type applications. The high-integration chips provide cost-effective answers for cost-sensitive applications.

Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

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16-BIT MICROPROCESSOR MARKET IN 1984

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8086	2,150	30.1%	4,040	40.5%	87.9%
68000	773	10.8	2,036	20.4	163.4%
80186	130	1.8	1,570	15.9	1,107.7%
Z8000	409	5.7	628	6.3	53.6%
80286	13	0.2	208	2.1	1,500.0%
32016	109	1.6	202	2.0	85.3%
Others	3,554	49.8	1,280	12.8	(64.0)%
Total	7,138	100.0%	9,964	100.0%	39.6%

Source: DATAQUEST
May 1985

TOP TEN SUPPLIERS

Table 2 shows the top ten leading suppliers of 16-bit microprocessors in 1984. Intel and Motorola, the number 1 and number 2 suppliers, accounted for almost half of the total unit shipments in this market segment. Both of these U.S. manufacturers enjoyed high growth rates, but anticipate intense Japanese competition in the next few years. AMD, Hitachi, NEC, and Siemens, have all indicated strength in the 16-bit marketplace. Even though Texas Instruments showed a decrease in growth in the 16-bit market, it has second-sourced National's 32016 product line and is expected to get back in the race.

Table 2

TOP TEN 1984 16-BIT MICROPROCESSOR MANUFACTURERS
(Thousands of Units)

1983 Rank	1984 Rank	Company	Units Shipped 1983	Units Shipped 1984	Growth
2	1	Intel	1,448	3,663	153.0%
4	2	Motorola	465	1,266	172.3%
1	3	General Instrument	1,800	920	(48.9)%
6	4	NEC	255	660	158.8%
7	5	AMD	232	600	158.6%
9	6	Hitachi	220	445	102.3%
11	7	Siemens	135	430	218.5%
5	8	Fujitsu	305	340	11.5%
8	9	Zilog	221	319	44.3%
3	10	Texas Instruments	1,262	260	(79.4)%
		Others	795	1,061	
		Total	7,138	9,964	39.6

Source: DATAQUEST
May 1985

Regional Suppliers

U.S. suppliers of 16-bit microprocessors lost market share to Japanese and European manufacturers during 1984, as shown in Table 3. Six of the top ten 16-bit microprocessor suppliers were American manufacturers, three were Japanese, and one was European.

Table 3

REGIONAL MARKET SHARE UNIT SHIPMENTS
FOR 16-BIT MICROPROCESSORS

	1983	1984
United States	84.6%	77.1%
Japan	12.6	16.3
Europe	2.8	6.6
Total	100.0%	100.0%

Source: DATAQUEST
May 1985

Growth Rates

AMD, Intel, Motorola, NEC, and SGS all had similar growth rates during the past year--slightly more than 150 percent. (See Table 4.) Considerably more growth was shown by Harris, Mostek, Siemens, Signetics, and Thomson. Harris, Siemens, and Signetics shipped less than 1 percent of the total 8-bit microprocessor market segment in 1984. U.S. companies remain strong and viable in this market; however, second-source agreements have increased competition from Japanese and European manufacturers.

Table 4

TOP GROWTH RATES OF 1984
16-BIT MICROPROCESSOR SUPPLIERS
(Thousands of Units)

	Units Shipped		
	1983	1984	Growth
Harris	15	135	800.0%
Mostek	35	143	308.6%
Thomson	11	42	281.8%
Signetics	32	110	243.8%
Siemens	135	430	218.5%
Motorola	465	1,266	172.0%
NEC	255	660	158.8%
AMD	232	600	158.6%
Intel	1,448	3,663	153.0%
SGS	54	136	151.9%

Source: DATAQUEST
May 1985

ANALYSIS

The 16-bit microprocessor market segment is taking off, despite the slump in the semiconductor industry. DATAQUEST expects unit shipments of this market to grow approximately 34 percent in 1985, compared to an expected flat growth of total semiconductors. During 1984, 16-bit microprocessors grew approximately 38 percent, while 8-bit microprocessors grew only 13 percent. This is an indication that 16-bit microprocessors are replacing 8-bit microprocessors in computer-type applications. The high-integration chips provide cost-effective answers for cost-sensitive applications.

Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: May

THE GENERATION GAP-- AN UPDATE ON 32-BIT MICROPROCESSORS

SUMMARY

The 32-bit generation of microprocessors is now emerging. Three devices are already on the market, and there are more to come. The decision to move to a new generation of semiconductor devices is complex, and timing can be critical to the company making that decision. This newsletter gives an update on the 32-bit microprocessor, its applications, and its current and future manufacturers.

INTRODUCTION

Users look to the 32-bit microprocessor to provide increased speed and functional enhancements. Engineering and CAD workstations represent the most visible market segment to adopt the 32-bit MPU. Other important design-ins are in robotics, computer-aided manufacturing, and telecommunications.

DATAQUEST anticipates three phases in the adoption of the 32-bit microprocessor:

1. The replacement of 16-bit devices by 32-bit devices will be the first phase as new versions of existing systems are designed. We see this occurring initially with engineering workstations as growing systems complexity demands greater performance from the microprocessor. The important issue in this phase will be upward compatibility. The Motorola 68020 and the National 32032 are expected to be important players here because many of the existing workstations have been designed with the 16-bit predecessors to these 32-bit MPUs. In both cases, the conversion to the new MPU can easily be accomplished. This phase is already beginning.

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2. In the second phase of the market development, we will see the use of 32-bit microprocessors in minicomputers and small business systems. Designers will use these products to improve the cost/performance ratio of their machines. A significant factor in this market will be the captive manufacturers of 32-bit devices, such as Data General, Digital Equipment Corporation, Hewlett-Packard, and NCR. The potential exists for any of these companies to offer its devices on the merchant market. NCR's entry into the merchant market marks the beginning of this phase.

3. The third phase of the development of the 32-bit market will occur when the devices are well understood and accepted and become the basic design elements of many microprocessor-based systems. Rapid growth in consumption of 8-bit and 16-bit microprocessors occurred about five years after they were first introduced. We expect 32-bit microprocessors to follow the same trend, with rapid growth beginning in 1989.

MICROPROCESSOR PRODUCT ACCEPTANCE

If 32-bit microprocessors follow the trends we have observed, they will exhibit slow to moderate growth in the first two or three years after introduction, followed by a period of extremely rapid growth in the fourth and fifth years. There are, however, arguments for either faster or slower growth than this experience suggests.

The arguments for slower acceptance revolve to some extent around the fact that the full capabilities of existing 16-bit devices have not yet been exploited. Another argument is that there are more design alternatives than ever before. Many systems designs are being done with multiple 8- or 16-bit microprocessors.

With the evolution of application-specific ICs, we are seeing the development of intelligent microperipherals. A number of coprocessors for 16-bit devices are also coming to the market. All these devices make the design of higher-performance systems possible without resorting to the use of a 32-bit microprocessor.

Faster acceptance of the 32-bit microprocessor could come about simply because the market is much larger than it was when the 8-bit and 16-bit devices were introduced. Some 32-bit microprocessors offer upward compatibility with existing 16-bit devices, making the transition from a 16- to 32-bit device much easier than previous generation switches.

The 32-bit device will appeal to manufacturers of minicomputers and superminicomputers as a means of reducing cost. These manufacturers will not have the same commitment to previous generations of microprocessors as microcomputer manufacturers, so they may accept the devices more readily, thus accelerating the rate of acceptance.

MANUFACTURERS--PRESENT

Motorola

The Motorola 68020 was introduced in the third quarter of 1984. The company is now ramping up to full production. The 12MHz version will be in volume production by mid-1985 and the 16MHz version in the Fall. Motorola has entered into a second-source agreement with Thomson-CSF, contingent upon certain technology exchange agreements. If these agreements are met, Thomson-CSF is expected to start production of the 68020 by the end of 1985. Hitachi, Rockwell International, and Signetics also second-source Motorola's 16-bit devices and may be regarded as potential second sources for the 32-bit family.

National Semiconductor Corporation

National Semiconductor Corporation is currently the leading supplier of 32-bit MPUs with its 32032. The device has been in production for more than a year. Texas Instruments, which is second-sourcing the family, is expected to start sampling around mid-1985.

NCR Corporation

NCR is offering its 32-bit chip set, originally developed for internal use, on the merchant market. The device, which features external microcode, can emulate existing microcomputers. Honeywell, Inc., has signed an agreement with NCR to use the NCR/32 chip set for a future small- to medium-scale computer system.

MANUFACTURERS--FUTURE

This section of the newsletter will cover the announced plans of future participants in the 32-bit microprocessor market. Table 1 lists those companies believed to be currently involved in 32-bit microprocessor development.

Advanced Micro Devices

The Advanced Micro Devices (AMD) 29300 family of bipolar devices includes the Am29323 Multiprecision Multiplier, the Am29325 Floating Point Processor, the Am29332 16-bit Micro-Interruptible Sequencer, the Am29332 32-bit Arithmetic Logic Unit, and the Am29334 Four-Port Dual-Access Register File. Each device can function alone or act as a building block for a 32-bit system. The products are intended for use in high-performance applications, for intelligent peripherals control, and in digital-signal and array processors. The 29325 arithmetic unit will be sampling within two months, and all five devices will be sampled by the end of 1985.

AT&T Technologies

AT&T's WE32100 is a CMOS microprocessor originally developed for in-house use. The company recently announced commercial availability of the family. The WE32100 is now in production, together with the WE32101 memory management unit and the WE32105 system interface unit. The 32106 math acceleration unit is now being sampled, and the 32103 DRAM access controller and the 32104 DMA controller will complete the chip-set early next year.

Hitachi Ltd.

Hitachi Ltd. announced the development of a CMOS 32-bit microprocessor at the end of 1984. Sample quantities are expected at the end of 1986, with full production beginning in mid-1987. The device is expected to be upwardly compatible with Motorola's 68000 family. Hitachi had been regarded as a potential second source for the Motorola 68020 and it is not yet clear what effect the announcement of a proprietary 32-bit device will have on the situation.

Inmos

Inmos is in the final development stages of a family of devices based on its unique, high-performance architecture. The family includes both a 16-bit and a 32-bit transputer as well as some intelligent microperipherals. Inmos will begin sampling the first parts of this family by the end of 1985 or early 1986.

Intel

Intel announced early this month that it plans to ship samples of its 80386 32-bit microprocessor in about six months. The device will be offered in 12- and 16-MHz versions, and Intel will also offer a 32-MHz clock generator and a floating-point coprocessor chip.

NEC

NEC's V series family of microprocessors will include 32-bit devices. The V-60 is scheduled for introduction in 1986 and the V-70, described by NEC as a second-generation 32-bit device, is planned for 1987. NEC has licensed both Sony Corporation and Zilog, Inc., as second sources. NEC is also licensed as a second source for Zilog's Z80,000.

Zilog

The Zilog Z80,000 is now expected to be sampled by the end of 1985. NEC is a licensed second source for the part.

Other Manufacturers

Data General, Digital Equipment Corporation, and Hewlett-Packard have all introduced 32-bit microprocessors for internal use, but it is not yet known whether they will offer these devices on the merchant market. The other companies listed in Table 1 are believed to be developing 32-bit devices for the merchant market.

SELECTING A 32-BIT MICROPROCESSOR

As Table 1 shows, 17 companies already produce or are planning to produce 32-bit microprocessors. How do you pick a winner from such a range of alternatives? The market is still too young to predict who the big winners will be, but there are several points worth considering.

For the first time, the computing power of a minicomputer will be available in a microprocessor. This means that the 32-bit device can be approached from two directions: it can provide an upward migration path for current users of 16-bit devices, and it can offer a lower-cost option to manufacturers of mini- and superminicomputers. These two categories of users make different demands on 32-bit devices. Those taking the upward migration path are looking for upward compatibility from existing 16-bit devices so that they can continue to exploit the existing software base. Those taking the downward path from the minicomputer environment are more concerned with getting the architectural capabilities available with advanced technology. In the long term, this diversity could set the stage for a larger number of suppliers to enter the market.

There are two new factors in the 32-bit market that could change the market pattern. The first is the presence of the captive manufacturers. Captive manufacturers were ahead of the merchants in their development of the 32-bit device. There has been an increasing trend for captive semiconductor manufacturers to offer their products on the merchant market. NCR's device, the NCR/32, is the first of such products to be offered, but others could follow. Such a development could herald the growth of a 32-bit niche market for those users who are looking for minicomputer capability in a microprocessor. Captive manufacturers have the advantage of a protected internal market to help them weather the vicissitudes of market introduction. However, the ability of captive manufacturers to market their products effectively will obviously be an important factor in the growth of this niche market.

The second factor to be considered in the 32-bit market is the development of proprietary devices by Japanese companies. In previous generations, Japanese manufacturers have second-sourced U.S. products.

The most important issue to consider in selecting a 32-bit microprocessor is whether you really need the added capabilities that the device can offer. Have you fully exploited the 16-bit options available? If your application requires 32-bit capability, then the next areas of consideration are similar to those for any microprocessor:

- Does the device match your application?
- Will it be available in sufficient quantities when you need it?
- Are the appropriate microperipherals and coprocessors also available?
- Are there adequate development tools?
- Is there a viable second source?

The point of divergence that you reach when selecting a 32-bit device is the decision about which category of 32-bit devices you should be considering. Is upward compatibility an issue? If so, you should be considering those devices that offer a migration path from earlier generations. Are you looking for minicomputer-like architecture? Devices developed initially for captive use will fit into this category. National Semiconductor's 32032 offers a VAX-like architecture, and Fairchild is promising to take a minicomputer-like approach to its 32-bit offering. Japanese companies will also be entering the market with devices that are not upwardly compatible with existing products. There is yet another segment, represented by AMD's 29300 family and also, perhaps, by the Inmos transputer. These devices offer alternatives for high-performance applications that do not fit into either of the other categories.

The ultimate success of 32-bit microprocessors may rest on the rate at which the market develops. If market acceptance of the 32-bit device is delayed, the winners could be those companies that gained an early share of the market, those companies with upward compatibility to a substantial installed base of 16-bit devices, or those companies with protected internal markets. Early acceptance of the 32-bit devices, on the other hand, may permit market growth adequate to support a wider range of successful products than we have seen in any previous generation.

Future newsletters on the 32-bit microprocessor will examine the growth of the market and the development of new devices. This information will help you to implement a selection strategy that will satisfy your product's requirements.

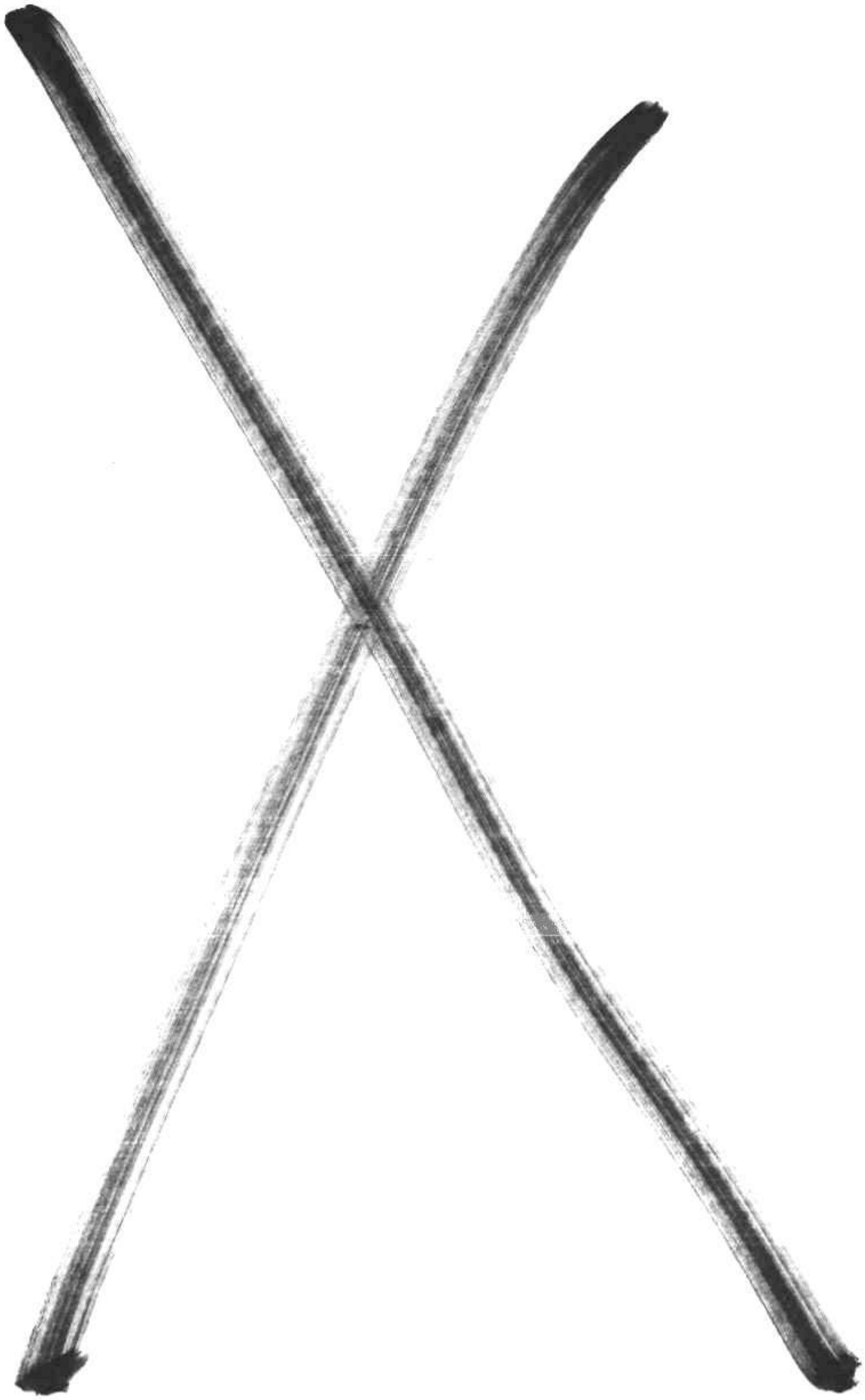
Mel Thomsen
Jean Page

Table 1

COMPANIES INVOLVED IN 32-BIT MICROPROCESSOR DEVELOPMENT

Advanced Micro Devices (Bipolar)	Matsushita
AT&T Technologies	Motorola
Data General	National Semiconductor
Digital Equipment Corporation	NCR
Fairchild Semiconductor	NEC
Hewlett-Packard	Texas Instruments
Hitachi	Toshiba
Inmos	Zilog
Intel	

Source: DATAQUEST
May 1985



June Newsletters

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

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: June

1985 CUSTOM INTEGRATED CIRCUIT CONFERENCE BUCKS THE TREND

OVERVIEW

Against a background of slow business in the standard product arena, the 1985 Custom Integrated Circuit Conference (CICC) once again continues to grow and improve in both quality and content. The IEEE committee that organized and steers the CICC warrants special recognition for its efforts. This is remarkable when one considers the current business climate along with a major logistical obstacle in reaching the conference this year; namely, a major airline strike that occurred the weekend before the conference. In terms of quality, it is important to note that most of the thinly disguised promotional presentations are gone and in their places are more in-depth technical papers. The technical committee screened more than 200 papers but accepted only 116.

DATAQUEST believes that this conference is especially important both to application-specific integrated circuit (ASIC) users and suppliers, since it continues to be the place to share technical views on the state of the industry. Table 1 shows the worldwide scope of the CICC presentation.

In touring the exhibits and attending the sessions, two major recurring themes became apparent:

- Most ASIC suppliers are cautiously optimistic about the business climate for the next 12 months. Gate array suppliers continue to experience a book-to-bill ratio between 0.85 and 1.0. We believe that the book-to-bill ratio in the standard cell group is well over 1.0.

- Several merchant silicon compilers were announced at CICC. The most noteworthy were Silicon Compilers General, Seattle Silicon's Concorde, VLSI Technology's cell-based compiler, and Silicon Design Laboratories' generator-development tools. In the past year attendees have heard papers on silicon compiler systems (SCSs) developed solely for captive users, but this year was the first time that merchant products were so widely available. We believe that this marks an important turning point for the standard cell market, since it is SCS that will fuel the growth of standard cells and cell-based designs for the balance of the decade.

HIGHLIGHTS

The following are our comments on some of the major trends.

Standard Cells Band with Gate Arrays

This conference, more than any other, offered a blend of standard cell and gate array design methodology.

- NEC presented a paper about a process that allows a user to create a standard cell using CMOS gate array technology. By using a compaction program that eliminates unused cells, NEC believes that as much as 30 percent of the chip area can be saved compared to using a conventional gate array design.

- Toshiba presented a paper that described a method called superintegration. The basis of this method is to use standard products such as microprocessors and associated peripheral products as super cells in a standard cell design.

- LSI Logic offered an approach called structured arrays. By using its 2-micron CMOS arrays along with a family of megacells including ROM, PLA, multipliers, and others, the user can design a very feature-intensive ASIC.

- Applied Micro Circuits Corp. announced a 1,600-gate array with 1,280 bits of RAM, where the RAM can be configured into a variety of sizes.

ASIC Linear Arrays--Breaking with Tradition

Conventional thinking says that using ASIC design methodology would not produce efficient linear custom chips. But this was certainly disputed at the CICC. For example, Linear Technology Inc., Burlington, Ontario, Canada, proposed a unique architecture that allows groupings of critical components. The layout overcomes many of the limitations of traditional linear arrays. Along the same lines, Micro Linear Corp. gave a paper on a method called Linear Mosaic, where similar groupings of devices called tiles are repeated in a regular manner on the chip. This arrangement would easily facilitate the use of predesigned macro cells and computer-aided layout programs.

Next Year--Rochester's New Convention Center

When the CICC meets in 1986, it will be in the new Rochester, New York, convention center. The date has also been moved up one week to May 12 through 14.

Andy Prophet

Table 1

1985 CICC PRESENTATIONS

Source Region	Count	Source Category	Count
North America	87	Company	89
Japan	11	Academic	25
ROW	1	Government	2
Western Europe	17		
Total	116	Total	116

Source: DATAQUEST
June 1985

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: June

PRELIMINARY FIRST QUARTER 1985 UPDATE-- MICROPROCESSORS AND MICROCONTROLLERS

Most microdevice areas faced a difficult first quarter in 1985. Lower unit shipments and lower ASPs affected company revenues. The growing 16-bit MPU market was the only area to experience increased unit shipments. Table 1 shows unit shipments and percent growth in first quarter 1985 from fourth quarter 1984.

Table 1

MICROPROCESSOR/MICROCONTROLLER UNIT SHIPMENTS
(Thousands of Units)

	Q4/84	Q1/85	Percent Growth
16-bit Microprocessors	2,593	2,690	3.7%
8-bit Microprocessors	18,306	16,943	(7.4%)
8-bit Microcontrollers	46,168	43,925	(5.0%)

Source: DATAQUEST
June 1985

ASPs were down approximately 10 percent to 15 percent in first quarter 1985 from fourth quarter 1984, affecting company revenues.

Lead times for most 8- and 16-bit microprocessors decreased to 6 to 10 weeks.

CMOS 8-bit microcontrollers and 8-bit microprocessors maintained 10 percent and 11 percent growth, respectively, in first quarter 1985 from fourth quarter 1984.

Further declines in microdevice areas are expected in the second quarter of 1985, with moderate recovery beginning in the third quarter.

Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: June

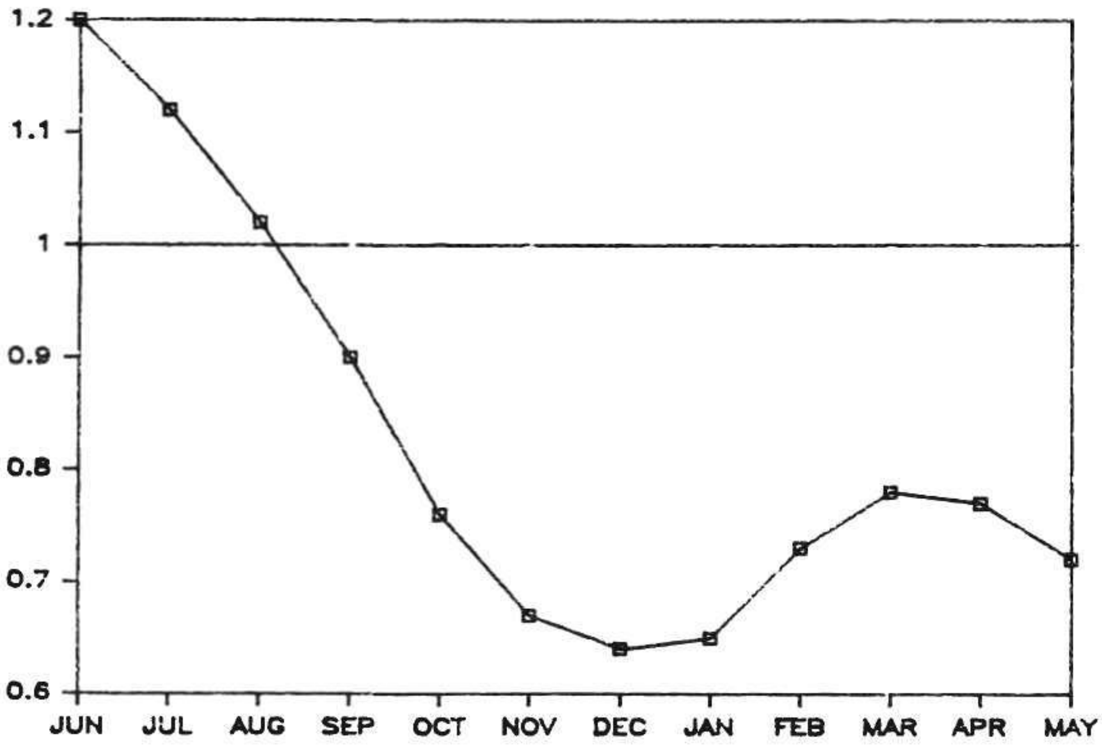
HARD TIMES HIT SEMICONDUCTOR INDUSTRY

INTRODUCTION

The semiconductor industry has experienced a downturn in semiconductor consumption in the last six months. The Semiconductor Industry Association (SIA) has reported a book-to-bill ratio of less than 1:1 since September of 1984 (see Figure 1). In order to survive the current crisis, the semiconductor companies have initiated a series of dramatic cutbacks.

Figure 1

BOOK-TO-BILL RATIO
JUNE 1984 TO PRESENT



Source: Semiconductor Industry Association June 1985

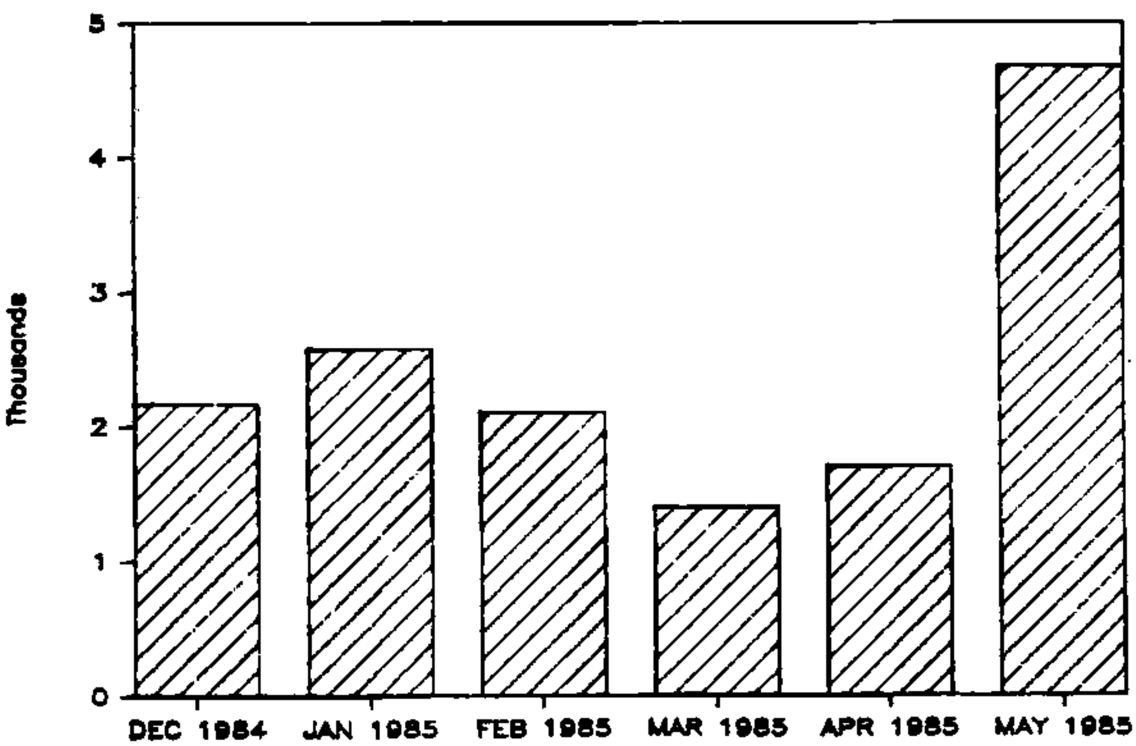
INDUSTRY CUTBACKS

Layoff/Reduction Statistics

More than 14,000 semiconductor industry employees have been laid off worldwide during the last six months as shown in Figure 2. Reductions in "employee equivalents" due to workweek reductions and other factors exceeded 30,000 (Figure 3). While actual totals of worldwide semiconductor industry employment are not available, DATAQUEST estimates that the reduction in "employee equivalents" represents roughly a 20 percent reduction in work force worldwide.

Figure 2

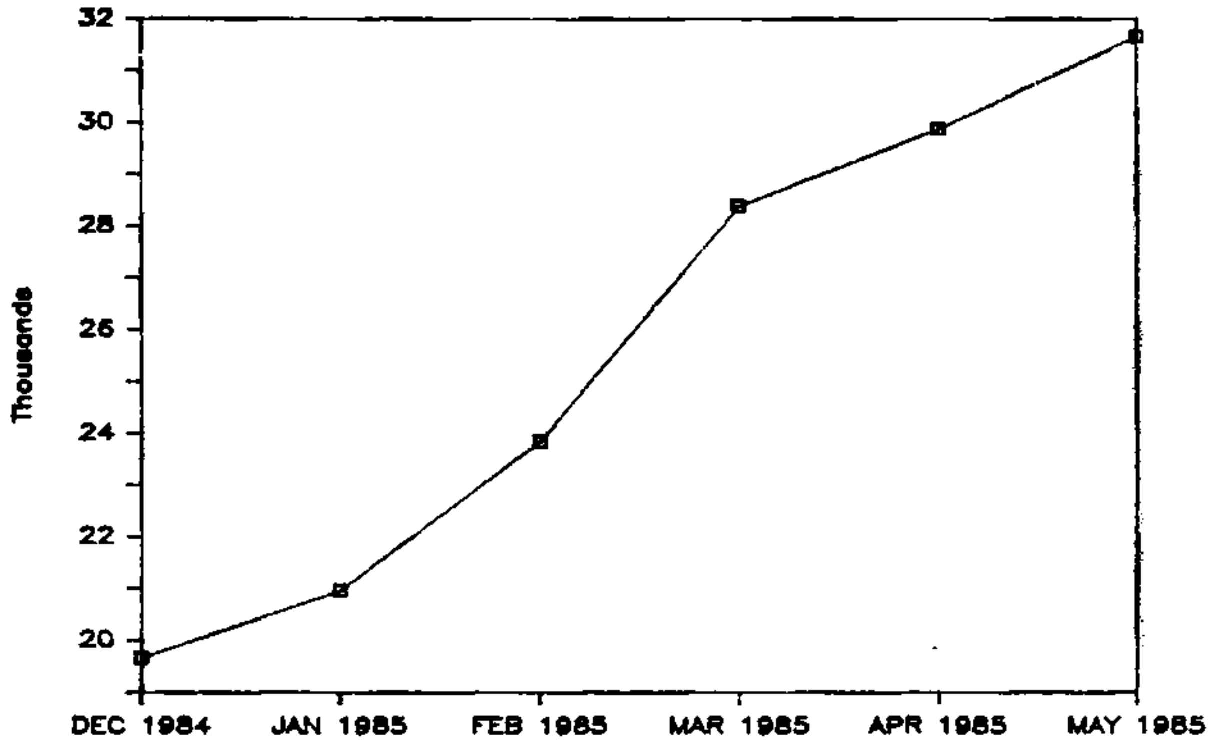
SEMICONDUCTOR INDUSTRY LAYOFFS
WORLDWIDE



Source: DATAQUEST
June 1985

Figure 3

SEMICONDUCTOR INDUSTRY TOTAL REDUCTIONS
EMPLOYEE EQUIVALENTS

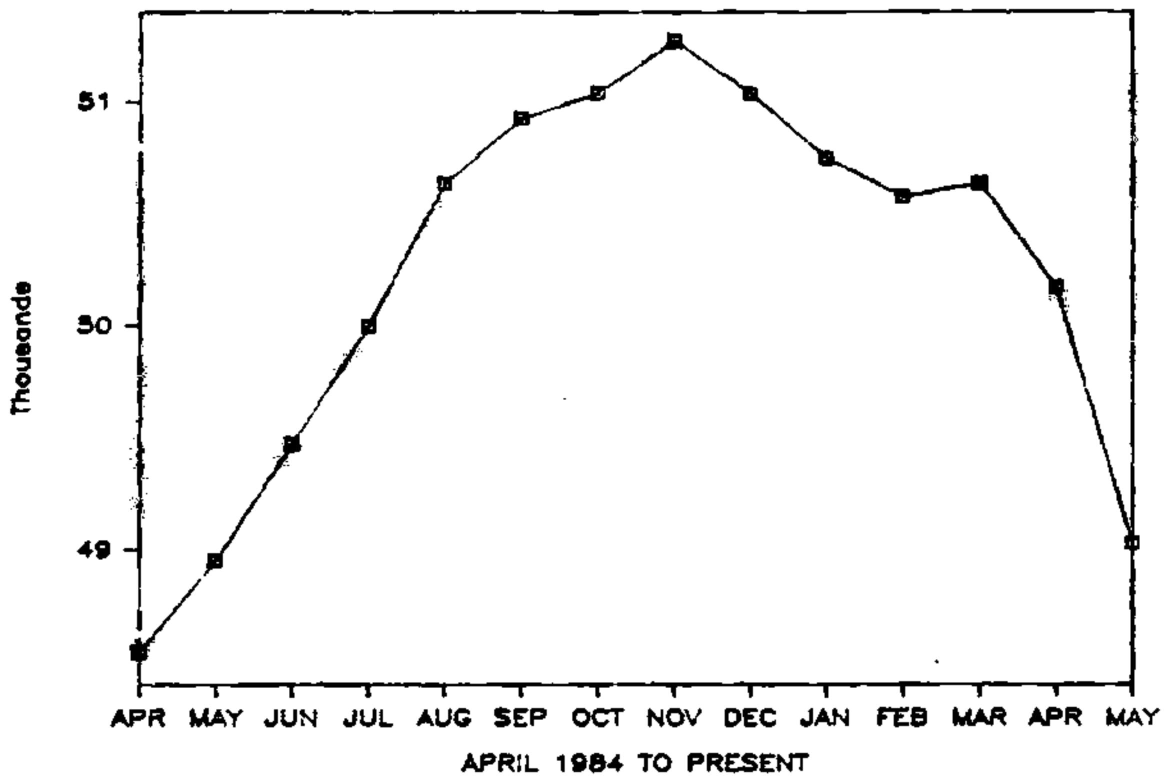


Source: DATAQUEST
June 1985

In Santa Clara County, the semiconductor industry employs roughly 50,000 employees. The total number employed reached a peak in November of 1984. Currently, we are at an employment level which corresponds to employment one year ago, in May of 1984 (Figure 4).

Figure 4

SEMICONDUCTOR INDUSTRY EMPLOYMENT
SANTA CLARA COUNTY



Source: DATAQUEST
June 1985

Alternatives to Layoffs

The semiconductor companies have implemented a variety of plans to avoid having to lay off employees. The first step taken by most companies facing a decline has been cutting back or curtailing hiring. The elimination of overtime has been instituted at a number of firms. Several have dismissed all of their temporary or agency contract employees. Others have postponed raises.

The most common cutback has been in the length of the workweek. At least seven semiconductor companies have implemented four-day workweeks with corresponding cuts in pay. (Some companies have allowed their employees to borrow from their accrued vacation time to avoid a pay loss.) This system has been better received than merely instituting a pay cut with no decrease in work hours.

Employees at several companies have been encouraged to work additional hours with no extra pay. The intention is to improve the company's productivity without any additional financial burden.

One company admitted to "accelerating the review of substandard employees." Otherwise known as firing, this is a touchy proposition, and must be undertaken cautiously.

A layoff is perhaps the most obvious and most visible solution. Though definitely effective in saving company dollars, it has by far the most drastic effect on the employees involved.

Motorola has re-initiated a work sharing program which was used heavily in 1982 during the last industry downturn. Most of Motorola's work force in Phoenix began this program in March of 1985. For a minimum of one-half day per week and a maximum of two days per week, Motorola "non-schedules" its employees. Those affected receive a proportionate amount of state unemployment insurance. To reduce labor costs by 10 percent, for example, employees would be non-scheduled one-half day per week. This would be done in lieu of a 10 percent layoff. This program is legal in Arizona and California. It was signed into law in Texas this spring, and will be available to Texas employers in 1986.

As a final, but somewhat risky option, some companies have decided to retain all employees and let the company sustain unnecessarily high costs of production during this downturn. Though profits are impacted heavily, employee morale remains high and the ability to quickly ramp up production remains intact.

DATAQUEST CONCLUSIONS

Most companies have used layoffs as the last alternative for cutting costs. However, layoffs are occurring sooner than they did during the 1982 industry decline.

DATAQUEST has forecasted that we are near the bottom of the industry decline and has predicted a moderate recovery beginning in the third quarter of 1985. We believe that the worst of the layoffs and company reductions may have already taken place as shown in Table 1. The actual numbers affected will continue to increase, but not substantially.

Sue Kelly

Table 1

RECENT SEMICONDUCTOR COMPANY CUTBACKS

AMD	4/26/85	Closes for 8 days 6/24 to 7/5/85 (8,000 affected, United States)
AMI	2/85	Layoff of 35 in Idaho (did include some temporary employees)
AMI	4/26/85	Layoff of 440 (190 in Santa Clara, 250 in Idaho; leaving 1,050 in Santa Clara, 1,000 in Idaho)
Exel	3/8/85	Layoff of 60 in San Jose (25 percent of local work force)
Fairchild	3/25/85	Closes for 4 weeks (2 weeks from 3/25/85, 2 weeks from 4/8/85)
Fairchild	5/2/85	Will lay off 650 by closing plants in California and New York
Gen. Inst.	5/15/85	Has had some cutbacks due to attrition and plant consolidation
Harris	2/26/85	Layoff of 125 (2 percent of force, in Florida)
Inmos	3/18/85	Layoff of 86 in Colorado (7.5 percent of local work force)
Inmos	4/1/85	Shortens workweek by 20 percent at Wales Plant (900 affected)
Inmos	4/1/85	Closes Wales plant an additional 4 days at Easter
Intel	2/18/85	Layoff of 900 in Oregon, California, and Arizona (4 percent of worldwide work force)
Intel	2/18/85	Shortens the workweek at 2 of its 7 manufacturing plants (Santa Clara and Oregon)
Micron	2/85	Layoff of 625 in Idaho (50 percent of work force)
MMI	3/14/85	Closes for 2 weeks beginning 3/18/85 for all manufacturing employees (1,400 Santa Clara, 1,400 Malaysia)
MMI	3/14/85	Shortens the workweek to 4 days for all non-manufacturing employees (800 Santa Clara)
Mostek	3/4/85	Salaries frozen and overtime pay suspended
Mostek	3/4/85	Layoff of 620 (10 percent of work force; 500 in Texas, 120 in Colorado)
Mostek	4/2/85	Layoff of 1,000 in Malaysia (30 percent of Malaysia's force)
Mostek	5/9/85	Layoff of 2,000 in Carrollton, Texas
Motorola	5/15/85	Reduction of 7,900 "employee equivalents" since Fall 1984 (18 percent of force) by workweek reduction, attrition, etc.
Motorola	5/25/85	Closes Austin, Texas, plant for 2 weeks Summer 1985 (6,000 affected)
NCR	3/18/85	Closes 2 plants for 2 weeks (600 workers affected in Colorado)
NSC	3/8/85	Layoff of 400 while re-tooling its Salt Lake City plant (20 percent of SLC plant)

(Continued)

Table 1 (Continued)

RECENT SEMICONDUCTOR COMPANY CUTBACKS

NSC	3/8/85	Shortens the workweek to 4 days for 10 weeks beginning 3/17/85 for 21,000 workers (50 percent of work force)
NSC	3/8/85	Management takes a 10 percent pay cut
NSC	6/4/85	Layoff of 1,300 (600 in Santa Clara, 300 other U.S. locations; an additional 400 in several months)
Rockwell	3/11/85	Layoff of 100 in California (4 percent of work force)
Seeq	1/28/85	Layoff of 35 in San Jose
Seeq	2/23/85	Layoff of 83 in San Jose (15 percent of force)
Seeq	2/23/85	Closes plant for 6 days beginning 3/1/85
Signetics	2/14/85	Layoff of 60 production workers (1 percent of worldwide work force)
Signetics	2/28/85	Layoff of 400 (3 percent) of worldwide work force
Signetics	2/28/85	Shortens the workweek to 4 days on alternate weeks from 3/15 to 6/10/85
Signetics	2/28/85	Closes some plants for 1-2 weeks beginning 4/1/85
Signetics	4/26/85	Planned to lay off 100 production workers in New Mexico on 5/1/85
Signetics	5/2/85	Will lay off 550 (400 in Sunnyvale, California, 150 in Orem, Utah)
Synertek	12/84	Honeywell closes Synertek, immediate layoff of 1,500 (1,000 in California, 500 in Singapore)
Synertek	12/84	Final layoff of 668 (200 in California, 450 in Bangkok, 18 in Munich)
Texas Ins.	1/85	Layoff of 2,000 in Texas
Texas Ins.	12/8/84	Shortens the workweek to 4 days
Texas Ins.	4/22/85	Planned to lay off another 1,000 during second quarter 1985
Toshiba	1/24/85	Layoff of 140 (27 percent of local work force)
Xicor	3/25/85	Layoff of 130 in Sunnyvale, California (18 percent of work force)
Xicor	3/25/85	Shortens the workweek to 4 days
Xicor	4/25/85	Layoff of 110 in Milpitas, California
Xicor	5/2/85	Layoff of 40 (7 percent of work force)
Xicor	5/13/85	Layoff of 70 in California (430 left)
Zilog	1/17/85	Layoff of 400 (19 percent of worldwide work force)
Zilog	4/29/85	Layoff of 30
Zilog	5/3/85	Layoff of 20
Zilog	5/3/85	Plans to lay off another 100
Zymos	4/22/85	Layoff of 119 in Sunnyvale, California (38 percent of work force)
Zytrex	5/15/85	Declares bankruptcy (Samsung may give Zytrex financial and manufacturing support to resume operations)

Source: DATAQUEST
June 1985

SIS Code: 1984-1985 Newsletters: June

JAPANESE COMPANIES BREAK THE SPEED LIMIT

Within the last month, Hitachi and Toshiba have made important product announcements that should make market leaders in the high-density EPROMs and fast static RAMs markets sit up and take notice. These two new product announcements are:

- The Hitachi 25ns 64K SRAM
- The Toshiba 150ns 256K EPROM

The Japanese memory manufacturers' increasingly dominant role in the commodity dynamic RAM and slow static RAM markets is well-known. Although they gained market share in MOS EPROMs and high-speed static RAMs during 1982 and 1983, their penetration in this market slowed considerably during the strong market of late-1983 and most of 1984. Since late 1984, however, an increasing number of new products have been announced in the high-density EPROMs and fast MOS static RAM areas, which will give the Japanese added leverage in markets heretofore dominated by leading U.S. and European manufacturers.

HITACHI 25NS 64K SRAM

Hitachi has announced a 64Kx1 static RAM with 25ns address access time. This is the fastest SRAM currently on the market. Hitachi uses its Hi-BiCMOS process: The memory cell is NMOS and the peripheral circuits combine CMOS and bipolar technologies. Pricing on this part is quoted at $68.50 each in quantities of 10,000. Samples are expected to be available in August with quantity shipments scheduled for the fourth quarter of 1985. (However, small quantities of engineering samples are reportedly at customers today, and performance is reported to be exceptional.)

Most 64Kx1s now on the market are 45ns or 55ns, although several sub-35ns parts were described at ISSCC in 1984 and 1985. Shipments of 64Kx1 MOS SRAMs totaled about 150,000 units in 1984, and are expected to be about 1.3 million in 1985.

TOSHIBA 150NS 256K EPROM

Toshiba has announced an NMOS 256K EPROM with access time of 150ns. This is the fastest EPROM of any density now on the market. The price for the 150ns part is $7.00 each in quantities of 1,000. Samples are available now.

Heretofore, 170ns was the fastest sustainable speed grade offered in any density EPROM. Later in 1985 or early 1986 we may see some significantly faster parts out of recent start-ups. At $7.00 each, this 150ns 256K costs about one-fourth as much as the 250ns 256K cost at year-end 1984.

Sue Kelly

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters

GENERAL INDUSTRY UPDATE

SUMMARY

The decline in U.S. semiconductor consumption, precipitated by major inventory corrections by semiconductor users and rapidly falling prices, has been deeper and lasted longer than expected. Declining demand for computers and office automation products in March and April of 1985 has exacerbated the situation, and reversed a trend toward increased bookings. DATAQUEST estimates that semiconductor consumption in the first quarter of 1985 was 19.5 percent lower than in the fourth quarter of 1984. We anticipate further declines in the second quarter of 1985, with a moderate recovery beginning in the third quarter.

We expect the U.S. economy to grow by a little more than 3 percent in 1985: less than half the growth rate of 1984.

The Semiconductor Industry Association (SIA) revised its March book-to-bill ratio to 0.80 to 1 for March, and announced a decline in April to 0.77 to 1. As Figure 1 shows, this represents a downturn in the ratio after a brief rally. Total bookings were down 7.5 percent from March. The depth of the decline of the book-to-bill ratio suggests that this recession could be as deep as that of 1975. However, we believe that the bottom of the trough has already been reached, and we can now expect the situation to improve.

ECONOMIC TRENDS

Although the index of leading indicators turned down in March, economists still expect the economy to continue to expand. The Federal Reserve Board acted to stimulate the economy and keep interest rates down by increasing the money supply. Unemployment levels remained unchanged in April at 7.3 percent.

The economic recovery is now in its third year, although its pace is considerably slower than that of the early stages.

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The trade deficit continues to be fueled by a strong dollar. The deficit for the first quarter of 1985 was $10.9 billion--up 17 percent from the $9.3 billion in the fourth quarter of 1984. No weakening of the dollar is expected until the U.S. budget deficit is cut and real interest rates decline in the United States.

The Federal budget deficit remains a problem. The Administration's projections probably underestimate future deficits, since they are based on the expectation of GNP growth rates of 4 percent per year through 1989. This would mean seven years of uninterrupted expansion. According to our estimates, the economy is expected to grow even more slowly in 1986 than in 1985, with GNP growth of only 2.9 percent.

DEMAND, SUPPLY, AND PRICES

The inventory problem has two components: over-buying in the 1984 upturn has left users with large inventories of components, and lower demand for their products has left them with large finished-goods inventories.

Semiconductor fabrication capacity increased 33 percent in the United States in 1984, and 31 percent in Japan. It will continue to increase throughout 1985 as capital commitments made in 1984 are met. This has resulted in strong price pressures, especially on commodity memory products. We estimate that semiconductor capacity is currently operating at a 60 percent utilization rate, and that price pressure will continue until the utilization rate reaches 80 percent. We estimate that the 80 percent rate of utilization will not be reached until 1987.

Japanese suppliers are especially prone to initiate price pressure because they operate at much higher debt to equity ratios than U.S. suppliers, and act to gain market share in order to service their debt.

The past two or three months have seen substantial layoffs at many semiconductor companies in response to the declining demand. We are already hearing semiconductor users expressing concern about the problems that this situation could cause as demand begins to increase. However, many manufacturers have resorted to shorter work weeks and mandatory vacations as a means of retaining a trained work force.

SEMICONDUCTOR INDUSTRY FORECAST

The continued softness in semiconductor orders, together with a weak market for computers and office automation products, has caused us to make a substantial downward revision in our forecast for 1985, as shown in Table 1. Year-to-year growth from 1983 to 1984 was a staggering 53.0 percent, and current buying patterns suggest that a high proportion of this growth was "borrowed" from 1985.

As Figure 2 shows, we estimate that semiconductor consumption in the United States declined 19.5 percent in the first quarter of 1985 compared with the last quarter of 1984. We expect this trend to continue into the second quarter, with consumption declining 10 percent compared with the first quarter. The third quarter should see the beginning of a modest upturn, with consumption increasing 2.5 percent compared with the second quarter. The fourth quarter of 1985 is expected to show an increase of 6.7 percent over the third quarter. The result of the sharp declines in the first and second quarters is that total U.S. semiconductor consumption in 1985 is expected to decline 20.4 percent in 1985 compared with 1984.

In the first quarter of 1986, we expect to see an increase in consumption of 4.5 percent over the fourth quarter of 1985. Total U.S. semiconductor consumption in 1986 is estimated to increase 20.5 percent over 1985, but even this growth will not raise consumption to the record levels of 1984.

Excess capacity, especially in the commodity areas such as DRAMs, will hamper the growth of the semiconductor market until demand catches up with supply (as it inevitably does). Price pressures will inhibit the growth of the market in dollar terms, even as unit shipments increase. We expect to see a modest return to growth in the third quarter of 1985, fueled mainly by increased demand for high-margin products.

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Howard Bogert
Barbara Van
Jean Page

Table 1

ESTIMATED QUARTERLY U.S. SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1984				
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Discrete	$ 475.0	$ 541.0	$ 564.0	$ 547.0	$ 2,127.0
IC	2,431.0	2,850.0	3,105.0	2,946.0	11,332.0
Total	$2,906.0	$3,391.0	$3,669.0	$3,493.0	$13,459.0
Quarter/Year Percent Change	9.9%	16.7%	8.2%	(4.8%)	53.0%

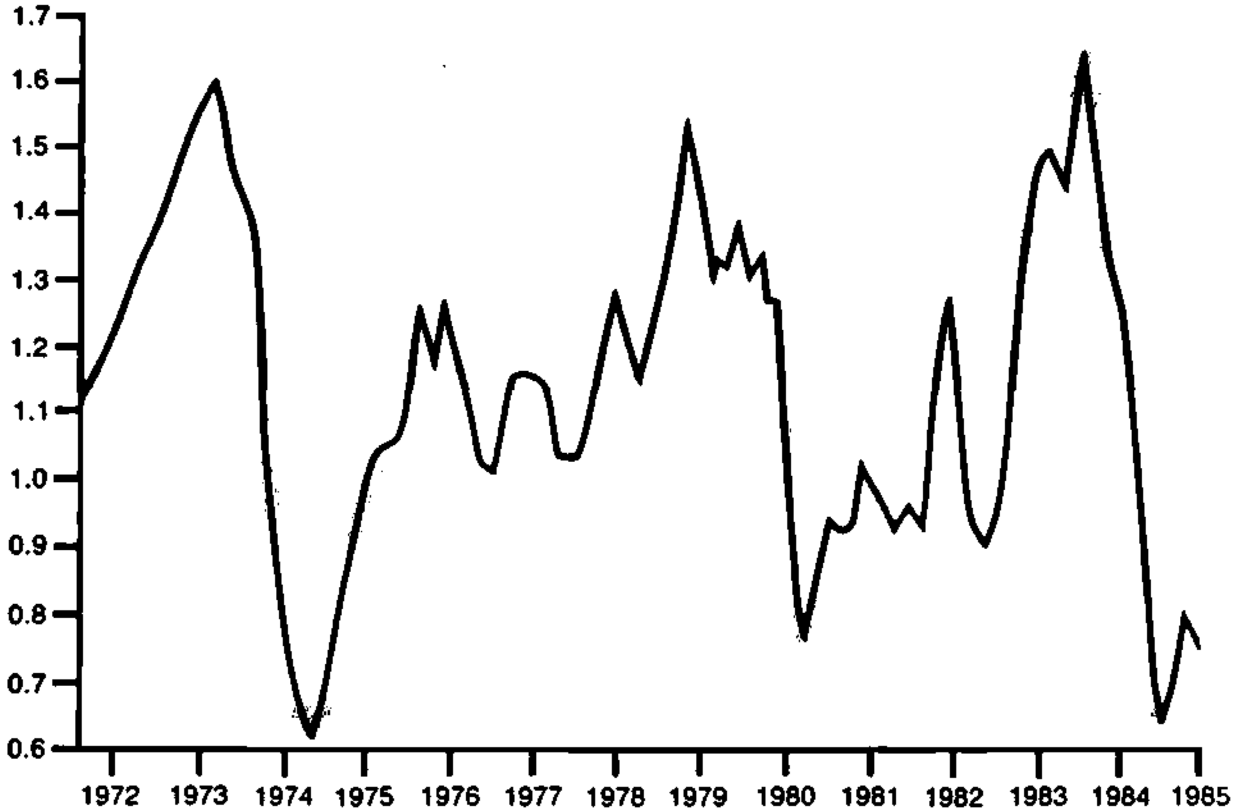
	1985				
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Discrete	$ 482.0	$ 434.0	$ 429.0	$ 447.0	$ 1,792.0
IC	2,331.0	2,098.0	2,166.0	2,322.0	8,917.0
Total	$2,813.0	$2,532.0	$2,595.0	$2,769.0	$10,709.0
Quarter/Year Percent Change	(19.5%)	(10.0%)	2.5%	6.7%	(20.4%)

	1986				
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Discrete	$ 485.0	$	$		$ 2,089.0
IC	2,409.0				10,819.0
Total	$2,894.0				$12,908.0
Quarter/Year Percent Change	4.5%				20.5%

Source: DATAQUEST
June 1985

Figure 1

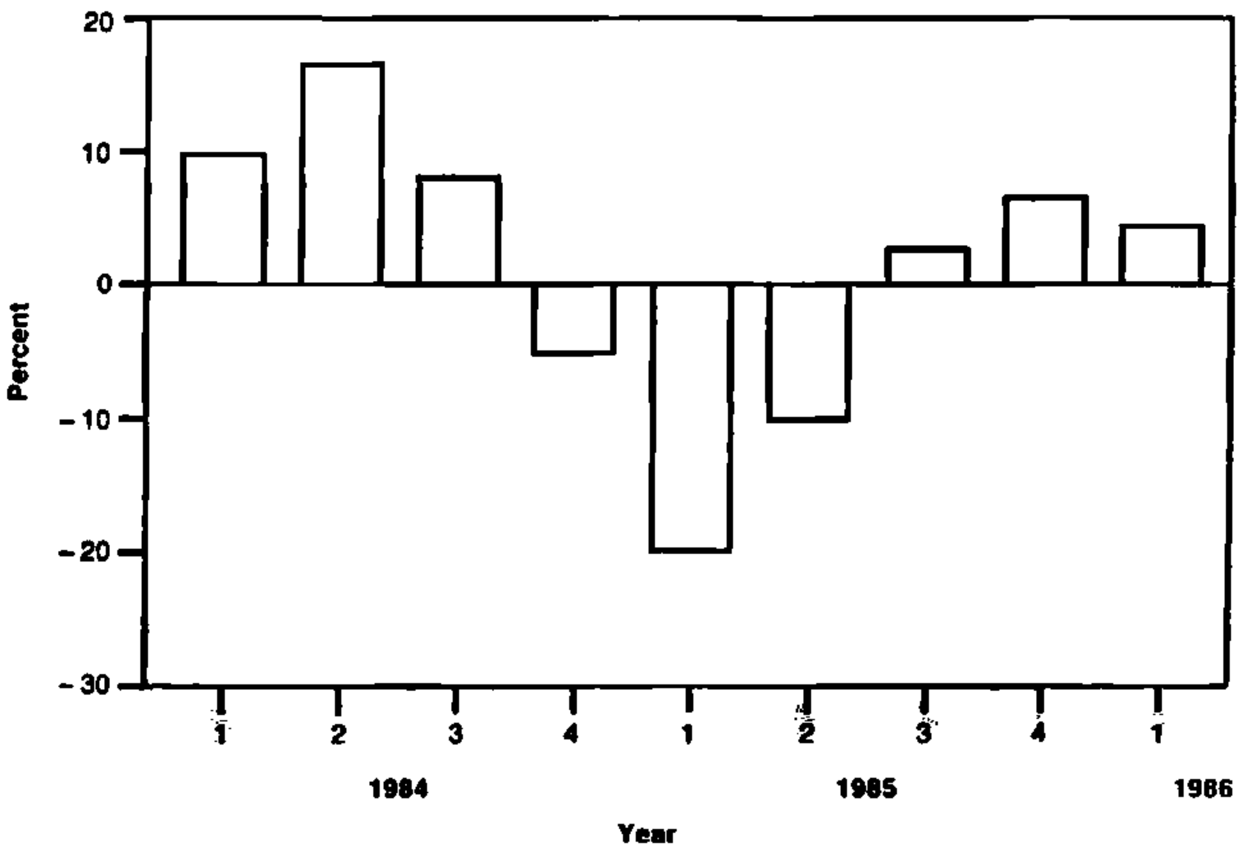
U.S. IC CONSUMPTION BOOK-TO-BILL RATIO
(Dollars)



Source: DATAQUEST
June 1985

Figure 2

QUARTER-TO-QUARTER CHANGE IN U.S. SEMICONDUCTOR CONSUMPTION
(Dollars)



Source: DATAQUEST
June 1985

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: June

THE SEMICONDUCTOR START-UP BOOM CONTINUES

Despite the industry downturn, semiconductor start-ups are alive and well. As shown in Table 1, DATAQUEST has recorded 48 semiconductor start-ups since late 1983--a record for the industry. This figure tops the 29 start-up companies recorded for the same period covered by our last newsletter on this subject ("The Boom in Semiconductor Start-ups," December 19, 1983). Twenty-eight of the start-ups are located in Silicon Valley. Moreover, DATAQUEST believes that at least 10 more companies have not yet been publicly announced, since they are maintaining their secrecy while seeking first-round financing and developing their products.

Since 1977, 98 start-up companies have entered the industry, while only a handful have gone bankrupt. We believe that this continuing start-up boom and high survival rate reflects the emergence of new market niches in application-specific ICs (ASICs), CMOS memory and logic, gallium arsenide (GaAs), linear, digital signal processing (DSP), and silicon compilers. Major developments include the following:

- Emergence of nine GaAs start-ups
- Proliferation of ASIC vendors due to the availability of improved CAD systems and excess plant capacity
- Shift to silicon compilation (Cirrus Logic, Seattle Silicon, and Silicon Design Labs)
- Appearance of specialized CMOS memory and logic manufacturers (application-specific standard circuits)
- Growth in linear products for telecommunications, consumer, and military markets
- Initial companies offering DSP, graphics chips, sensors, and DMOS discrete chips

During the summer, DATAQUEST will survey these start-up companies and issue an industry update newsletter. We would appreciate hearing news of any other start-ups.

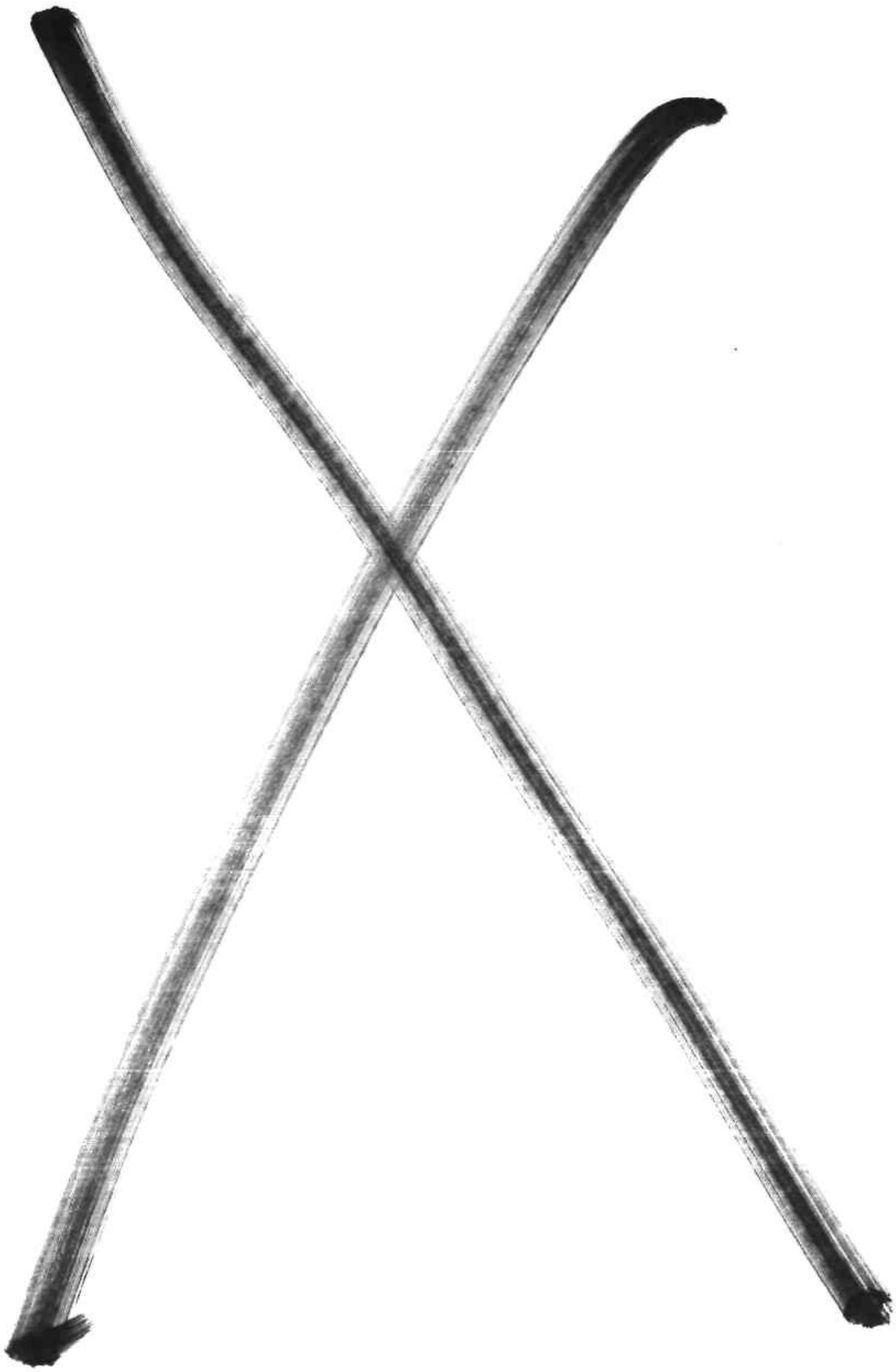
Table 1

SEMICONDUCTOR START-UPS
(1983 to 1985)

Company	Location	Products
Anadigics	Morristown, NJ	GaAs A/D converters
Array Logic	Melbourne, England	CMOS and bipolar ASICs
Barvon Research	Milpitas, CA	ASICs
Calmos	Kanata, Ontario	ASICs
Calogic	Fremont, CA	ASICs
Celeritek	San Jose, CA	GaAs FETs
China Micro	China	MOS ICs
Chips & Technologies	Milpitas, CA	ASICs
Cirrus Logic	Milpitas, CA	Silicon compilers
Crystal Semiconductor	Austin, TX	Telecom ICs
Custom Silicon	Lowell, MA	ASICs
Dallas Semiconductor	Dallas, TC	CMOS memories
Electronic Technology	Cedar Rapids, IA	ASICs
Inova Microelectronics	Campbell, CA	SRAMs
Integrated Logic Systems	Colorado Springs, CO	ASICs
Integrated Power Semiconductor	Santa Clara, CA Livingston, Scotland	Linear
Isocom	Campbell, CA	GaAs couplers
Ixys Corporation	Santa Clara, CA	Power monolithics
Logic Devices	Sunnyvale, CA	CMOS multipliers
Micro MOS	Santa Clara, CA	EPROMS
Microwave Technology	Fremont, CA	GaAs amplifiers
Modular Semiconductor	Santa Clara, CA	CMOS memories
Mosel	Sunnyvale, CA	EPROMs, SRAMs
NMB Semiconductor	Tokyo, Japan	CMOS memories
Pacific Monolithics	Sunnyvale, CA	GaAs monolithic ICs
Panatech Semiconductor	Santa Clara, CA	CMOS memories
Performance Semiconductor	Sunnyvale, CA	CMOS SRAMs, MPUs
Pivot III-V Corp.	Unknown	GaAs digital ICs
Quasel	Santa Clara, CA	CMOS memories
Seattle Silicon	Bellevue, WA	Silicon compilers
Sensym	Sunnyvale, CA	Pressure sensors
SID Microelectronica SA	Sao Paulo, Brazil	MOS ICs
Sierra Semiconductor	Sunnyvale, CA	Reconfigurable MPUs
Silicon Design Labs	Liberty Corner, NJ	Silicon compilers
Silicon Macrosystems	Santa Clara, CA	Static ROMs
Teledyne Microwave	Mountain View, CA	GaAs analog
Topaz Semiconductor	Santa Clara, CA	DMOS discretes
Triquint Semiconductor	Beaverton, OR	GaAs analog and digitizer
Unicorn Microelectronics	San Jose, CA	ASICs
Vatic Systems	Mesa, AZ	ASICs
VTC Inc.	Eagan, MN	CMOS logic
VISIC	San Jose, CA	CMOS RAMs
Vitelic	San Jose, CA	CMOS memories
Vitesse Electronics	Camarillo, CA	GaAs digital ICs
Xilinx	San Jose, CA	CMOS logic arrays
Xtar Electronics	Elk Grove, IL	Graphics chips
Zoran	Sunnyvale, CA	DSP

Source: DATAQUEST

Barbara Van
Sheridan Tatsuno



July Newsletters

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

- ASIC Design Centers--The Vital Link

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: July

ASIC DESIGN CENTERS--THE VITAL LINK

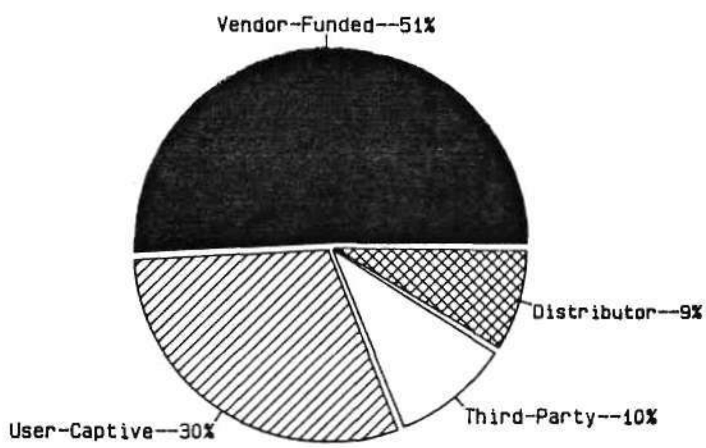
SUMMARY

As the application-specific-integrated-circuit (ASIC) market continues to flourish with new vendors and new products, design centers (DCs) have grown to be the key link between vendors and users. According to our June 1985 ASIC Design Center notebook section, four types of DCs (vendor-funded, distributor, third-party, and user-captive) are seriously competing for ASIC designs.

The success of a design center includes: personalized service, technical support, strong portfolio of products, user-friendly CAD tools, and location. The firm that has the most DCs near major concentrations of system designers has a good chance of capturing a large share of designs. Figure 1 shows North American design center segmentation.

Figure 1

NORTH AMERICAN SEGMENTATION DESIGN CENTERS



236 DESIGN CENTERS

Source: DATAQUEST
July 1985

This newsletter will investigate the issues surrounding ASIC design centers:

- Criteria for design center selection
- Important DC success factors
- Geographic distribution
- Low-cost CAD tools changing the role of design centers

The newsletter will also include listings of vendor-funded, distributor, and third-party design centers.

ASIC DESIGN CENTERS

ASIC merchant design centers, by definition, are centers where systems designers can design gate arrays, standard cells, or hand-crafted chips. While most centers vary in size, all offer some type of computer-aided design (CAD) tool and on-site technical support. A user may select a gate array or a cell library to design a unique feature-intensive product and then ship the tooling to a vendor for fabrication.

DATAQUEST defines the four different types of design centers as follows:

- Vendor-funded DCs are funded and staffed by the semiconductor manufacturer. They only carry ASIC products supported by the manufacturer.
- Distributor DCs are natural extensions of the traditional role of a distributor. These DCs often carry several competing ASIC products and offer design services for the casual user.
- Third-party DCs are independent of the manufacturer, the distributor, and the user. Their product portfolio is generally composed of non-competing ASICs, and the DC offers some in-depth technical expertise.
- User-captive DCs are generally found in large OEM companies that do their own designs, then have the ASICs manufactured at a silicon foundry.

Criteria for Design Center Selection

The criteria for evaluating DC selection vary for each user. The choice of a design center in most cases is determined by a mix of the following factors:

- Number of designs per year required by the user
- Technology required

- Depth of technical expertise required
- Thoroughness of training required
- Development costs
- Design cycle time
- Proximity to user

Important DC Success Factors

With the expanding number of merchant design centers, service is important to DC success. This is not to understate the role of technology, product offerings, or cost effectiveness--which are all very important--but to point out that in the ASIC marketplace, everything centers around service of one form or another.

A winning team in the ASIC design arena should offer:

- A location near a major concentration of system designers
- User-friendly CAD tools
- Technical support for a broad spectrum of customers and products
- Design hardware and software that minimize design error
- A portfolio of design solutions
- Competitive cost structures
- Personalized service

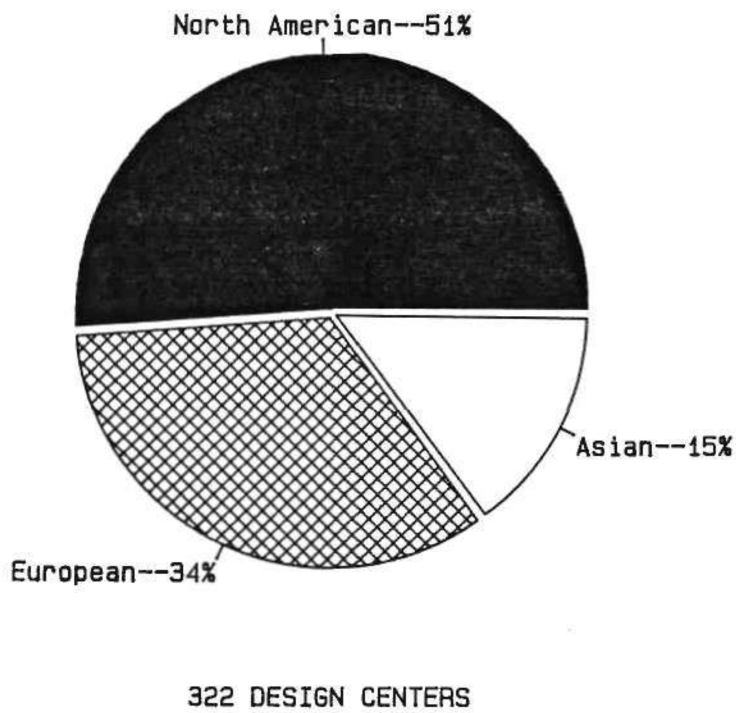
Geographic Distribution

Location is a key ingredient for the success of a design center. Most successful DCs are located near a major concentration of system designers. Figure 2 shows that on a worldwide basis, North America has a commanding lead with 168 merchant design centers. There are 109 European merchant design centers specializing in custom circuits, standard cells, and gate arrays. Because of the complexity of the European marketplace with its diverse languages and cultures, more centers per engineers can be supported. Asia has 44 merchant design centers, mainly specializing in gate array and standard cell design.

In North America, the Eastern region has a large concentration in the Boston area, followed by New York, Atlanta, Miami, and Ontario-Canada. The Central region has five concentration areas: Dallas, Phoenix, Chicago, Denver, and the Minneapolis/St. Paul area. The Western region has the greatest concentration in Silicon Valley (California), followed by the Los Angeles/San Diego area.

Figure 2

WORLDWIDE SEGMENTATION MERCHANT DESIGN CENTERS



Source: DATAQUEST
July 1985

Low-Cost CAD Tools Changing the Role of Design Centers

Today's silicon technology has fueled the growth of low-cost workstations and powerful EDA (Electronic Design Automation) software, which in turn have been the primary forces behind the explosion of the ASIC market. As engineering workstation prices continue to fall, the workstations continue to capture more of the design process.

We expect the average price of a 32-bit workstation to drop below $20,000 by 1988. Personal computer-based workstations that currently range from $10,000 to $20,000 (IBM PC AT based) already capture most of the design process in low gate-count gate arrays. These low costs will expand the installed base of user-captive DCs to the point where every engineer who needs one will have a workstation on his desk.

Along with the proliferation of low-cost workstations will come more changes in the role of the design center. DCs will take on an increasing role in the distribution and support of EDA tools throughout the user community. Thus, in addition to its traditional role as a center for design, the DC will act as a distribution point for EDA software.

DESIGN CENTER TABLES

Tables 1, 2, and 3 list the companies, number of locations, and product types offered for three types of merchant design centers (vendor-funded, distributor, and third-party). Firms that only offer full custom designs are excluded from the lists. For more detailed listings, please refer to the material behind the ASIC tab, in the SIS Products and Markets binder.

Bryan Lewis
Andy Prophet

Table 1

NORTH AMERICAN VENDOR-FUNDED DESIGN CENTERS

Company	Number of Locations	Products: Gate Array	Standard Cell	Full Custom
AT&T Design Center	2		Y	
Alphatron	1		Y	
Applied Micro Circuits Corp.	1	Y		
Barvon Research	1	Y	Y	
CADIC	1	Y	Y	
California Devices Inc.	1	Y		
Circuit Technology Inc.	1	Y	Y	
Custom Integrated Circuits	1	Y		
Custom MOS Arrays, Inc.	1	Y	Y	Y
Fairchild Camera & Inst. Corp.	5	Y		
Fijitsu Microelectronics Inc.	4	Y	Y	Y
GTE Microcircuits Division	1	Y		Y
General Electric Semiconductor	2	Y	Y	Y
General Instruments Microelectronic	2	Y	Y	
Gould/AMI	5	Y	Y	
Harris Corp.	2	Y	Y	
Hitachi	1	Y		
Holt, Inc.	1	Y	Y	Y
Honeywell Digital Products Center	2	Y		Y
Hughes Solid State Products	1	Y	Y	Y
ILSI	1	Y		
Integrated CMOS Systems	1	Y		
Intel Corp.	1		Y	
Interconics	1	Y		
Interdesign Inc.	2	Y		Y
International Microcircuits Inc.	1	Y		
International Microelectronic Prod.	1		Y	
LSI Logic Corp.	6	Y		
Linear Technology Inc.	1	Y		
MCE Semiconductor Inc.	1	Y	Y	Y
Master Logic	1	Y		
Matra Design Systems	1	Y		
Matsushita	2	Y		
Micro Linear	1	Y	Y	Y
Mostek Corp.	3	Y	Y	Y
Motorola Inc.	12	Y		
NCM Corp.	1	Y	Y	Y
NCR Microelectronics	1	Y	Y	
NEC Electronics USA Inc.	3	Y	Y	
National Semiconductor Corp.	2	Y	Y	Y
Oki Semiconductor	3	Y	Y	
Pacific Microcircuits	1	Y	Y	
Pico Design (Motorola Subsidiary)	1	Y	Y	Y
Plessy Semiconductor Division	1	Y	Y	Y
RCA Solid State Division	2	Y	Y	Y
Raytheon Semiconductor Division	2	Y		
S-MOS Systems, Inc.	2	Y	Y	

(Continued)

Table 1 (Continued)

NORTH AMERICAN VENDOR-FUNDED DESIGN CENTERS

Company	Number of Locations	Products: Gate Array	Standard Cell	Full Custom
SGS Semiconductor Corp.	1		Y	
STC Microtechnology	1	Y		
Sierra Semiconductor	1		Y	Y
Signetics Corp.	3	Y	Y	
Siliconix	1	Y		
Standard Microsystems Corp.	1		Y	
TLSI, Inc.	1		Y	Y
Telmos Inc.	1	Y		
Texas Instruments Inc.	6	Y	Y	
Toshiba	1	Y	Y	
Universal Semiconductor Inc.	1	Y		
VLSI Design Associates, Inc.	1	Y	Y	Y
VLSI Technology Inc.	5	Y	Y	Y
Vatic Systems	1	Y		
Waferscale Integration	2		Y	
ZyMOS Corp	1		Y	Y

Source: DATAQUEST
July 1985

Table 2

NORTH AMERICAN DISTRIBUTOR DESIGN CENTERS

Company	Number of Locations	Products: Gate Array	Standard Cell	Full Custom*
CAPSCO	1	Y	Y	
Classic Component Supply	1	Y		
Diplomat Electronics Corp.	3	Y	Y	
Hamilton/Avnet Design Center	4	Y	Y	
Pioneer-Standard Electronics Inc.	1	Y	Y	
Schweber Electronics Corp.	6	Y	Y	
Semiconductor Specialists Inc.	1	Y		
Western Microtechnology Inc.	1	Y	Y	
Wyle Laboratories Electronic Mkt.	3	Y	Y	

*Distributors do not offer full custom designs at this point in time.

Source: DATAQUEST
July 1985

Table 3

NORTH AMERICAN THIRD-PARTY DESIGN CENTERS

Company	Number of Locations	Products: Gate Array	Standard Cell	Full Custom
ALSI	1	Y	Y	Y
Aptec Microsystems	1	Y	Y	Y
Array Technology	1	Y	Y	Y
Calmos Inc.	1	Y		
Circuit Design Group, Inc.	1	Y	Y	Y
Custom Silicon, Inc.	1	Y	Y	
DNA, Inc.	1	Y	Y	
Design Engineering Corp.	2	Y	Y	
Electronic Technology Corp.	1	Y		
Integrated Circuit Systems Inc.	1		Y	
KMOS Semicustom Design Inc.	1	Y		
Micro-Systems Engineering, Inc.	1	Y		
Micronics Inc.	1	Y		
Ontario Centre for Microelectronics	1	Y	Y	
Owl Electronic Laboratories, Inc.	1		Y	Y
Pacific Monolithics	1			Y
San Jose Microtechnology Inc.	1	Y	Y	
Silicon Development Corp.	2	Y	Y	Y
Source III, Inc.	1	Y	Y	Y
Sunshine Semiconductor	1	Y		
Texas Arrays	1	Y		
Torric Corp.	1	Y	Y	Y
Western Design Center	1			Y

Source: DATAQUEST
July 1985

August

August Newsletters

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

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: August

ONE-TIME-PROGRAMMABLE MICROCONTROLLER

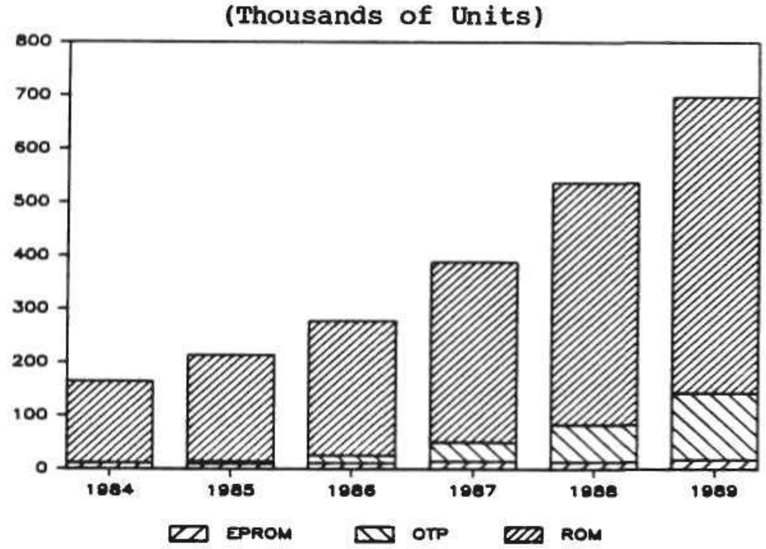
SUMMARY

DATAQUEST estimates that 8-bit microcontroller unit shipments grew from 90,615 million units in 1983 to 164,358 million units in 1984, an 81 percent increase. In spite of this phenomenal increase, many users came to grief and missed production targets due to supply not meeting demand. One way out of the supply problem was to use EPROM microcontrollers as production gap fillers. This was essentially a stop-gap solution because of the high cost of EPROM MCUs--2 to 3 times higher than ROMs. Recognizing a trend, manufacturers have not been slow to respond to the basic demand for a lower-cost user-programmable fast turnaround MCU; earlier this year, Intel and Hitachi announced OTP (one-time-programmable) plastic microcontrollers. DATAQUEST believes that the OTP will replace most EPROM MCU usage in pilot/low-volume production, and will start to eat into the volume ROM MCU marketplace.

Figure 1 shows DATAQUEST's estimates for the worldwide MCU marketplace in thousands of units.

Figure 1

WORLDWIDE 8-BIT MCU SHIPMENTS FORECAST
(Thousands of Units)



Source: DATAQUEST

PRODUCTS

Intel has announced the P8748H, P8749H, and P8751H versions of the 8748H, 8749H, and 8751H microcontrollers. NEC is producing plastic 8748 and 8749 variants and a proprietary 8741. Hitachi has introduced the 63701XO and 63705VO versions of its 6301 and 6805 microcontroller families. Motorola has versions of the 6801 and 6805 family in EPROM, which it is offering in a low-cost ceramic package. Hitachi and Motorola are the only suppliers offering CMOS-OTP.

Mostek started shipping its 38P7X during the third and fourth quarters of 1984. General Instrument started shipping an EPROM version of Pics in fourth quarter 1984.

MARKETPLACE ANALYSIS

For this newsletter, DATAQUEST has divided the marketplace into three areas.

Prototype Quantities (0-200 pieces per annum)

EPROM parts are used for software debugging and for the prototype runs. OTP usage will only become cost effective once the software has been fully debugged and the end product is considered ready for prototyping.

Pilot Production (200-5,000 pieces per annum)

Devices under this heading are used for customer field trials, quality checks, and low-volume production runs. This market has traditionally used a mixture of EPROM and ROM MCU. DATAQUEST considers this market ideally suited to the cheaper, more flexible OTP alternative.

Volume Production (5,000 pieces per annum and upwards)

This is the most price-sensitive sector, using EPROM MCUs only in emergency supply situations. Consequently, the amount of business taken from the ROM MCU is a function of the price relationship between the MCU and OTP. Opinions vary as to what MCU:OTP price ratio is necessary before the OTP starts being considered for high-volume applications. Bearing in mind the undoubted advantages in flexibility the OTP offers over the ROM equipment, DATAQUEST estimates that users will only consider OTP usage in volumes of up to 50,000 per annum, if price ratios of 1:1 to 1:15 are achieved by the manufacturers.

Figure 2 shows that EPROMS will continue to be used for software development in small quantities. OTP will fill in the area between small production lots and medium-volume production, and the ROM-based version for high-volume production.

Table 1 shows DATAQUEST's estimates for the worldwide MCU marketplace in thousands of units. Expressed as a percentage of total unit shipments, EPROM parts will decrease from approximately 6.8 percent in 1984 to 2.5 percent by 1989. This is consistent with MCU usage being limited to the field of software development.

Figure 2

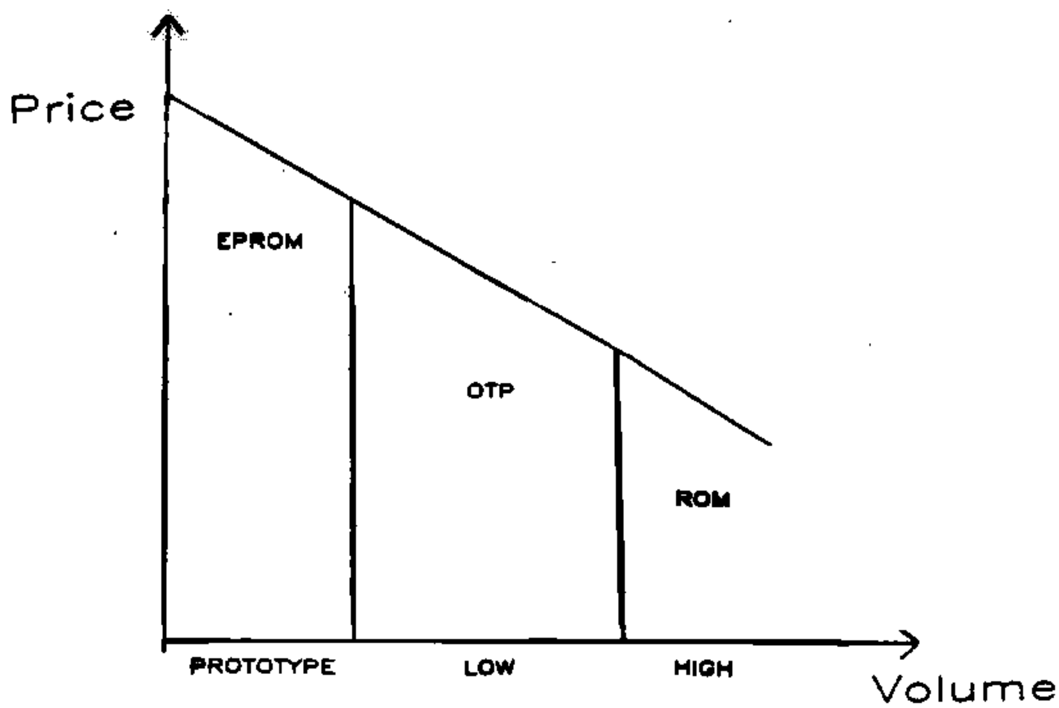


Table 1

ESTIMATED WORLDWIDE 8-BIT MCU SHIPMENTS
(Thousands of Units)

	1984	1985	1986	1987	1988	1989
EPROM MCU	11.1	10.0	11.1	14.4	13.4	17.4
OTP	-	4.3	13.9	35.4	69.8	125.6
ROM MCU	153.3	199.4	252.8	339.1	453.4	554.6
Total	164.4	213.7	277.8	388.9	536.6	697.6

Source: DATAQUEST

ADVANTAGES

Production

From the ROM MCU user's viewpoint, the OTP offers a method of regulating production runs, unforecasted production increases being satisfied with off-the-shelf product. Inventory holdings are reduced/simplified because one OTP part can replace all masked variants of an MCU. An OTP device can also make the logistics of production control/scheduling easier.

A survey of purchasing patterns shows that approximately 70 percent of the patterns account for only 30 percent of the volume. This means that an ever-increasing amount of planning and tracking time goes into managing relatively small product runs through the production areas.

Judicious use of OTPs can simplify planning, ease production flow, and reduce costs associated with inventory holding and obsolete product write-offs.

A final point to be noted is that since OTPs are plastic, they are also suitable for use in automatic PCB placing equipment.

Marketing

Marketing gains due to decreasing the time it takes for new products to bring software changes to market can be implemented overnight. This is a far cry from the three to four months required for a ROM MCU. This flexibility is especially important in the fast-moving consumer segment applications, which are subject to frequent software iterations such as the current automotive ignition/engine control projects.

End Users

Many industries have realized the advantages of OTP MCUs. The following applications show how pervasive the OTP has become:

- Telecommunications: PBXs, Smart Phones, and Digital Switches
- Automotive: Braking Systems (Anti-Skid)
- Office Automation: Disk Drives, Printers, LANs, and Smart Typewriters
- Electronic Instrumentation: Logic Analyzers and Oscilloscopes
- Industrial Control: Numerical Control and Robotic Control

DISADVANTAGES

Reliability

The OTP concept was established through the use of plastic memory EPROM devices in the late 1970s. These devices suffered from long-term reliability problems--a stigma which today's products find difficult to shake off, in spite of improved processing, materials, and packaging techniques.

Cost

Die sizes are larger than the ROM-based product, and testing times are longer. This results in a cost premium that dictates against their usage in very high-volume applications.

CONCLUSION

OTP growth will initially be at the expense of the EPROM. However, as user confidence in the parts grows and more manufacturers step into the marketplace, demand will increase. More lower-volume and fast-moving projects will start up on OTPs. DATAQUEST estimates that by 1989, OTPs will account for 156,000 units, or 18 percent of the MCU marketplace.

DATAQUEST believes that the OTP can increase the growth of electronics by encouraging industry entrepreneurs to bring more projects to production. Many good ideas have been killed off by the slow three to four months turnaround time of the ROM MCU, US$3,000 to US$4,000 mask charges, and minimum order requirements of 5,000 pieces.

(This newsletter is reprinted with the permission of DATAQUEST's European Semiconductor Industry Service.)

Janet Rey
Jim Beveridge

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: August

THE NEW MITSUBISHI SAIJO FACTORY-- A FULLY AUTOMATED FACILITY

INTRODUCTION

DATAQUEST recently had the exceptional opportunity to visit Mitsubishi Electric Corporation's impressive new semiconductor factory located in Saijo on the island of Shikoku, Japan. DATAQUEST was escorted on the factory visit by Dr. Hiroyoshi Komiya, Deputy Manager of the Saijo factory, and Mr. Shigeru Funakawa, Semiconductor Overseas Marketing Manager for Mitsubishi. This factory, the first semiconductor facility on the island of Shikoku, was completed in early 1984 and is a fully automated front- and back-end facility dedicated to the production of DRAMs. The entire production process from bare silicon wafer start to final packaged and tested part is completely automated.

Dr. Komiya has been invited to give a talk on the Saijo facility at DATAQUEST's annual Semiconductor Equipment and Materials Conference held October 14 through 17 in Tucson, Arizona. The theme of the conference will be "An Industry in Transition." Dr. Komiya's talk on the Saijo facility at the conference should, indeed, be a very interesting topic, as attested to by the following brief overview of our visit to the facility.

THE SAIJO FACTORY

Presently, the Saijo factory consists of production buildings B and C, each of which has three floors covering 22,000 square meters of floor space. Building B is dedicated solely to the production of 64K DRAMs and has a capacity of 10 million parts per month. It was constructed at a cost of $127 million, including all capital equipment and automation hardware and software. Volume production of 64K DRAMs on 5-inch wafers began in March of 1984. Building C is dedicated to 256K DRAM production and was constructed at a cost of $190 million. It has a capacity of 7 million parts per month and volume production was scheduled to begin in July 1985. Next to Building C is an empty lot--yes, you guessed it--for a 1-Mbit DRAM facility, which is scheduled to be in production in the near future.

DATAQUEST visited the Building B 64K DRAM facility and the following discussion pertains to that facility. It is our understanding that the 256K DRAM facility is constructed along similar lines.

Device production occurs on two floors. The wafer fabrication area is located on the first floor and is a Class 10/Class 100 facility designed with a "main street" and "side street" concept. Up and down the wide main street move trackless but optically guided, automatically guided vehicles (AGVs) carrying cassettes of wafers. Branching off from main street at right angles are narrower side streets dedicated to the various wafer fabrication processes. For instance, there is a photolithography side street along which are clustered steppers and photoresist processing equipment. Dry etchers are clustered along another side street.

The AGVs in main street transfer their cassettes of wafers to I/O stations located at the junctions of the main and side streets. Robots moving in the side streets transfer the cassettes from the I/O stations to the various pieces of processing equipment located up and down the side street. The entire wafer fabrication production sequence is entirely automated; at no point in the production sequence do operators handle the wafers. Inspection at various points in the production process is done via CCTV by operators outside the clean room.

The first floor also includes the wafer test area laid out in the same main and side street approach. This area was designed to be Class 1000, but because of the reduction of people present (there appeared to be two) Class 100 levels were actually being reached. DATAQUEST noticed that in the wafer test area there were additional stationary robots transferring cassettes among several pieces of equipment clustered about them.

At the completion of wafer fabrication and probing, the wafers are automatically moved in an elevator up to the second floor where assembly and test occurs. On the second floor, overhead robots running on ceiling tracks transfer the devices among the various types of test equipment. All phases of assembly and test are fully automated including encapsulation and burn-in. Optical pattern recognition systems are used for automatic inspection of the marking step.

Communications and Control

The following is a brief overview of the factory automation system. A central factory computer interfaces with two control computers, one for each floor. For the first floor wafer fabrication and test area, the control computer interfaces to several process control CPUs, each of which interfaces with several individual pieces of process equipment. The first floor control computer also interfaces to another CPU for traffic control of the AGVs in main street. The AGVs communicate to the traffic control CPU through the I/O stations. The AGV receives its instructions from the I/O station. This is in contrast to the U.S.-manufactured Veeco and Flexible Manufacturing Systems AGVs, both of which communicate directly to their control computer via an infrared link. The control computer on the second floor has a similar architecture.

In the factory computer control center, operators sit at a long console and monitor factory status via CRT monitors in the console. In front of the console is a large illuminated electronic board that schematically depicts the entire two-floor production process and the various pieces of equipment. Every bare wafer is marked and, although lots are usually tracked, individual wafers can be called up and located in the factory by the monitoring and tracking system.

Process data are collected by the system and analyzed. Dr. Komiya noted that as the human element has been removed, the process data have tended to exhibit a very tight distribution about the mean. The factory central computer also communicates with Mitsubishi's Kita-Itami Works. For instance, quality control data are sent to Kita-Itami for further analysis, the results of which are fed back to the Saijo factory computer.

Mitsubishi built all robots and AGVs in the factory as well as writing the factory automation software. It took Mitsubishi three years to complete the system.

Results of Automation

DATAQUEST was told that the 64K DRAM facility was obtaining a defect density of 0.1 defects/mask level/cm^2. This should be compared to a world class Class 100 facility that can obtain 0.5 defects/level/cm^2. Mitsubishi has paid much attention to the reduction of particulate levels in the fab. All robotic equipment and AGVs were designed to contribute minimum levels of particulates. Mitsubishi worked closely with the equipment vendors to minimize the equipment particulates and, further, the process equipment was cleaned before it was installed in the clean room.

Cycle time for the wafers for the first floor (wafer fabrication and probing) is about three weeks. This should be compared to the 6 to 10 weeks required for an average U.S. fab cycle, with 6 weeks being a very good cycle time. Cycle time for the second floor (assembly and test) is about one week.

Although Mitsubishi would not disclose its device yields, it indicated that automation resulted in about a 20 percent relative increase in yields. Mitsubishi also believes that the Saijo facility can produce the lowest-cost 64K DRAM in the world. Taking all factors into consideration, DATAQUEST estimates that this facility is obtaining yields of between 85 percent and 90 percent for 64K DRAMs. DATAQUEST also estimates that the factory capacity of 10 million parts per month corresponds to 20,000 wafer starts per month at these yields.

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Howard Z. Bogert
Joseph Grenier

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: August

MOTOROLA ANALYSTS' MEETING

Motorola, Incorporated, held a financial analysts' meeting on July 31, 1985, at the O'Hare Marriott Hotel in Chicago, Illinois. The company's Semiconductor Products Sector seemed to be the area of greatest interest to the financial analysts attending the session. In addition to a long question and answer period after the semiconductor management team finished speaking, the majority of the questions at the end of the meeting addressed the semiconductor sector.

Highlights of the meeting included the following:

- Sales for the company in the second quarter of fiscal 1985 were down 3 percent from 1984 levels, and first-half sales were up less than 1 percent from 1984. Earnings for both the second quarter and the first half were down significantly.
- The Semiconductor Products Sector's sales in the second quarter of fiscal year 1985 were down 23 percent from 1984, and in the first half, were down 15 percent. The decrease in semiconductor sales and operating earnings was considered to be the most significant factor in the drop in company earnings during the first half.
- R&D funding for 1985 will increase 10 percent over the $411 million spent for R&D in 1984. Capital spending will be 20 percent lower than 1984 levels.
- Motorola anticipates that semiconductor demand will remain low in the third quarter, but some improvement may occur in the fourth quarter.
- The market for discrete devices, which accounted for approximately 27 percent of Motorola's total semiconductor revenues in 1984, has not been as severely affected as the IC market.
- Pricing seemed to be stabilizing in the second quarter, with the exception of DRAMs.

- Cost reduction measures will continue until business improves, and may possibly include a shutdown of several older IC wafer fabs.

- There will be a delay in the production start-up date of the 6-inch, 1-micron MOS wafer fab line in Scotland until business conditions improve.

- Chairman of the Board and CEO, Bob Galvin, described Motorola's strategy for "meeting the Japanese challenge."

COMPANY PERFORMANCE

Motorola's earnings in the second quarter of 1985 were $26 million or 22 cents per share, compared with $98 million or 83 cents per share in 1984. First-half earnings went from $176 million or $1.49 per share in 1984 to $67 million or 56 cents per share this year. This significant drop in earnings was primarily due to a 23 percent decrease in semiconductor sales. Semiconductor sales for the first half were down 15 percent. The decline in sales is in line with the current conditions in the semiconductor industry. Motorola sells a large percentage of its semiconductor products into the U.S. market, and DATAQUEST is forecasting a drop in U.S. semiconductor consumption of 22 percent during 1985. A decrease in operating earnings in the Government Electronics group also contributed to the drop in second-quarter earnings.

Other areas of the company fared somewhat better. Second-quarter sales of the Information Systems Sector were up 14 percent and Communications Sector sales were up 12 percent relative to last year. Automotive and Industrial Electronics Group and Government Electronics Group sales were down 3 and 4 percent, respectively, in the second quarter.

Sales for the entire company were $1.37 billion in the second quarter, down 3 percent from 1984 levels, and first-half sales of $2.69 billion were up less than 1 percent from 1984 sales.

Net margin on sales was 1.9 percent in the second quarter compared with 6.9 percent last year, and 2.5 percent in the first half, versus 6.6 percent a year ago.

SEMICONDUCTOR PRODUCTS SECTOR

Overview

Gary Tooker, Executive Vice President and General Manager of the Semiconductor Products Sector, spoke to the meeting about current conditions in the semiconductor area. Along with representatives of the other sectors in the company, Mr. Tooker expressed hope that the bottom of the market cycle has been reached, and that conditions will improve soon. He expects that third-quarter conditions will be much the same as those in the second quarter, but anticipates some improvement in the fourth quarter.

The commodity areas of logic, analog, and MOS memory have been the hardest hit. Microprocessors and ASICs are doing fairly well. Discrete products, which accounted for approximately 27 percent of Motorola's total semiconductor revenues in 1984, have not been as severely affected as ICs. Newer products are also doing better than older devices.

Pricing is significantly lower than a year ago, but seems to be stabilizing in the second quarter, with the exception of DRAMs.

End-Use Areas

Computer and PC market demand for semiconductors has decreased significantly, while the automotive and military markets have remained relatively strong. Distribution, consumer, and industrial markets are weak.

To provide some protection from the fluctuations in the semiconductor and computer markets, Motorola has tried to participate in a broad market spectrum and to limit backlog and sales to the PC market. Mr. Tooker explained that these moves have helped to limit the severity in the fall in orders.

Worldwide Regional Markets

All regional markets have declined in the last 12 months, especially Japan and Asia-Pacific, which is closely tied to the U.S. market. Motorola's Japanese bookings decreased rapidly beginning the fourth quarter of 1984. Europe lagged the United States by six to nine months, but is also down.

Cost Reduction Measures

Since the second half of 1984, Motorola, along with almost every other merchant semiconductor company, has initiated a series of cost reduction measures. These have included a hiring freeze since the third quarter of 1984, work-sharing, mandatory vacation days, reduced work weeks, layoffs, and the elimination of subcontract assembly and test. Most recently, a general salary freeze and pay cut for senior management took effect on July 1.

In addition to a reduction in expenditures, this has resulted in a work force decrease of more than 10 percent, and a drop in the equivalent worldwide census of almost 20 percent, taking into account the effects of work-sharing, required time off and the elimination of subcontract assembly and test.

Cost control measures, which will continue until business conditions improve, will include more layoffs, which will continue to be gradual and ongoing, and the possible shutdown of several older IC fabs. There will be a delay in the production start-up date of the 6-inch, 1-micron MOS wafer fab line in Scotland. This facility will remain in an engineering mode until business conditions improve.

Motorola plans to keep up its R&D efforts and to continue to invest in product development and technology and packaging capabilities. The company expects 1985 R&D expenditures to be 10 percent higher than last year's.

Semiconductor Design and Technology Improvements

According to Jim Fiebiger, Senior Vice President and Assistant General Manager of the Semiconductor Products Sector, Motorola has emphasized recruiting top semiconductor design and process technology talent, despite the reduction in the work force. In addition, several facility improvements have occurred during the last year. The central semiconductor R&D lab has been upgraded with a pilot and development line that became operational last year. Chemical vapor deposition and molecular beam epi for advanced materials were also added. The MOS R&D lab was moved from Mesa, Arizona, to Austin, Texas, which is closer to the MOS memory and MPU design teams. A baseline 1-micron, HCMOS process will be used at that facility. Motorola is also bringing up an upgraded bipolar technology center, where advanced bipolar and biMOS development will be carried out. Also within that facility is the capability to do work in bipolar and HCMOS submicron geometries.

VHSIC Program

Motorola has been selected to participate in the government-sponsored VHSIC (Very High-Speed Integrated Circuit) program. The company has received funding for a 1.25-micron HCMOS yield enhancement program, and is participating in two of the three Phase II 0.5 micron efforts. Motorola will be working with TRW on a CMOS program, and with Honeywell in the bipolar area. Motorola is currently the only merchant semiconductor supplier to receive submicron Phase II VHSIC funding.

New Products

Mr. Fiebiger discussed a number of new products that Motorola has introduced in the last year, as well as the status of some previously announced parts:

- A new 600-watt, 100-MHz TMOS RF power transistor, introduced last quarter, is the industry's highest-power single-chip device.

- Surface-mount packaging capacity for discretes has been expanded fourfold to serve that rapidly growing market.

- In the standard logic and analog IC group, 34 bipolar FAST devices, 45 high-speed CMOS devices, and eight 10KH ECL parts have been introduced.

- A number of new telecom products are planned for the next year, including a UDLT voltage regulator, mono circuit, post-tone dialer family, and a bipolar speakerphone IC.

- Several ECL SRAMs have been introduced this year: a 15ns 1Kx4, a 25ns 4Kx1, and a 10ns 256x4. Motorola is also sampling a 25 ns 16Kx1, and will sample a 15ns 4Kx4 ECL SRAM early next year.

- The 16K (x1, x4 and x8) HCMOS fast SRAMs are in production now, and 64K devices are in pilot production or will be sampled by next quarter.

- Three 256K DRAM parts are being developed. The die size of the HMOS device now being shipped is 55,000 sq. mil, and Motorola intends to have first silicon for a 42,000-sq.-mil version of that device this quarter.

- A 1Mb DRAM is in process. Silicon by first quarter of next year is the goal.

- A very fast (120ns), 34,000-sq.-mil HCMOS 256K EPROM should be sampled next quarter. A similar high-performance 1Mb version is targeted for sampling in the first half of 1986. Both UV-EPROM and plastic OTP EPROMs will be available for all parts.

- Motorola's first biMOS array will be a 6000-gate device with first silicon scheduled for later this year.

- Orders are being taken for a 3-micron, HCMOS standard cell offering, which presently has 161 macro functions in the cell library. Designs can be done with Motorola's internal CAD system or on the Mentor or Daisy workstations.

- In association with NCR, Motorola plans to offer a 2-micron, double-layer metal standard cell family later this year. NCR and Motorola announced a partnership on gate arrays and standard cells in July 1985. They will extend the standard cell family to include MCU core, PLA, RAM, and ROM functions early next year.

- The 68020-based VME130 single-board computer has had very strong market acceptance. Motorola continues to expand the VME family, and projects 89 percent growth of sales in that area this year.

- The MC68881 32-bit floating point coprocessor came out on schedule and worked right the first time. This device is in early production.

- In late June, first silicon of a full-featured HCMOS 32-bit 68851 page memory management unit (PMMU) was produced. Beta site sampling began in July.

- An X.25 protocol controller is being sampled, and Motorola plans to sample a single-chip median access controller for 802.4 token bus chip and board level products. This part is targeted directly for GM's manufacturing automation program, which Motorola feels will probably become the standard.

- The high-performance 68HC11 MCU has formally been introduced. This is Motorola's first device with on-board EEPROM.

MOTOROLA PLANS TO "MEET THE JAPANESE CHALLENGE"

The last speaker of the day was Bob Galvin, Motorola's Chairman and CEO, who spoke about what Motorola calls the Japanese challenge. Mr. Galvin spoke of Motorola's plan, which calls for engineering excellence, resulting in low costs and high capacity, combined with expertise in marketing and sales. The company's long-time strategy has been twofold: to project the image of being a winner, which enables the enlistment of support from the government (economic and political); and to be willing to apply for the appeal of public policy. Motorola stated a willingness to perform the second step. An example of Motorola's intentions is the antidumping petition that it has filed with the U.S. Commerce Department. This petition was filed against the Japanese in the cellular system area.

Motorola plans to "challenge and cultivate Japan," in Mr. Galvin's words. He explained that the company respects the Japanese and other competitors very much, but it does not fear them.

DATAQUEST CONCLUSIONS

Along with the rest of the semiconductor industry, Motorola is facing a difficult year. Companies that are focused on the commodity market are having a particularly rough time, and Motorola does quite a bit of business in that area. However, the fact that the company is fairly diversified has helped it, and the continuing R&D efforts in both design and processing technology should prepare Motorola to respond quickly to the next upturn.

Susan Scibetta

September Newsletters

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

Nielsen Dataquest

RESEARCH BULLETIN

ESIS Code: Vol. IV Newsletters

MOTOROLA AND HITACHI ANNOUNCE A 68000 IN CMOS

Hitachi (Tokyo, Japan) and Motorola (Austin, Texas) have announced a second-source agreement for a full CMOS 16-bit microprocessor that is both pin and instruction compatible with the NMOS 68000. Hitachi, which has been a second source for Motorola's M68000, developed this CMOS version and has granted manufacturing and marketing privileges to Motorola. The agreement allows both companies to produce and market the processor worldwide. This agreement does not apply to Motorola's new 32-bit M68020 microprocessor.

CMOS TECHNOLOGY

The new version has the distinction of being fully CMOS. Other processors, such as the 32-bit M68020, are listed as CMOS, but in order to reduce die size, they use NMOS structures internally. The difference between these and fully CMOS processors is apparent in the power consumption; the CMOS version of the 68000 will consume approximately 20mA from a 5-volt supply at 12.5 MHz. This is at least a factor of 15 better than the standard NMOS version, which consumes approximately 300mA under the same conditions. Table 1 shows the range of 16-bit CMOS microprocessors now available to the marketplace.

APPLICATIONS

As depicted in Table 2, DATAQUEST predicts that CMOS microprocessor usage will grow rapidly during the rest of this decade. In addition to the obvious advantages of low power consumption, product designers have recognized the advantages of higher noise immunity, tolerance to temperature extremes, and tolerance to supply voltage variations.

This means that CMOS microprocessors will likely be used in applications such as portable PCs, portable communications equipment, industrial controllers, and sophisticated defense systems.

Jim Beveridge
Janet Rey

Table 1

16-BIT CMOS MICROPROCESSOR MANUFACTURING STATUS

Manufacturer	Product	Status
Harris	80C86	Production
Intel	80C86	Production
Western Design Center	W65SC816	Production
Hitachi	68HC000	Sampling
Motorola	68HC000	Sampling
NEC	V40	Sampling
Oki	80C86	Sampling

Table 2

16-BIT CMOS MICROPROCESSOR WORLD FORECAST
(Millions of U.S. Dollars)

	1984	1985	1986	1987	1988	1989	CAGR 1984-1989
United States	$12	$27	$43	$ 90	$161	$235	81.3%
Europe	2	5	8	12	19	30	71.9%
Japan	1	3	6	17	37	64	129.7%
ROW	0	0	1	2	4	7	-
Total	$15	$35	$58	$121	$221	$336	86.2%

Source: DATAQUEST
September 1985

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: September

DATAQUEST PUBLISHES UPDATED MOS MEMORY FORECAST

DATAQUEST's Semiconductor Industry Service recently published an updated MOS memory market forecast, which was mailed to binderholders on July 16, 1985. This newsletter summarizes key elements of that forecast and presents several top-level market aggregates. The full forecast contains six sections of detailed unit shipment and average selling price (ASP) estimates for 1985 through 1990 (with historical 1983 and 1984 estimates as well). Individual forecasts for all densities of devices available on the market are provided, as well as finer breakdowns for some products. Accompanying each forecast table is text summarizing (1) market overview, (2) changes in this forecast compared with our earlier forecast, and (3) short-term and long-term market outlook.

A full table of contents for the service section appears in Table 1 of this newsletter.

In our forecast, we have assumed another market contraction in 1989, resulting from factors similar to those experienced in the contractions of 1981 and 1985: strong demand in the preceding two years (1987 and 1988); a catching-up of capacity in late 1988; and a weak economy in the postelection year.

MOS MEMORY MARKET--FORECAST SUMMARY

The size of the MOS memory market in 1985 is expected to decrease 41 percent compared to 1984, to a level of about $3.9 billion, which means that the market in 1985 will be smaller than in 1983 ($4.1 billion). We expect steady growth after that to a 1988 market size of about $11.5 billion.

Table 2a summarizes several key market parameters for the MOS memory market as a whole. Table 2b segments the total market revenues into major product groups: DRAMs, SRAMs, EPROMs, ROMs, and EEPROMs/NVRAMs.

Table 1

TABLE OF CONTENTS
MOS MEMORY MARKET FORECAST SERVICE SECTION

Source: DATAQUEST

Table 2a

MOS MEMORY FORECAST SUMMARY

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$4,106	$6,530	$3,879	$5,122	$7,880	$11,456	$11,020	$14,180
Units (M)	1,275	1,701	1,683	1,877	2,712	3,862	3,939	4,563
ASP ($)	$3.21	$3.83	$2.29	$2.71	$2.89	$2.96	$2.79	$3.10
Price per Bit (Millicents/bit)	7.9	6.6	2.7	2.0	1.4	1.0	0.6	0.4
Total Bits Shipped (10^{12})	51	99	149	275	589	1,166	1,872	3,535

Table 2b

MOS MEMORY MARKET MAKEUP

	1983	1984	1985	1986	1987	1988	1989	1990
Total Revenues ($M)	$4,107	$6,531	$3,879	$5,122	$7,880	$11,456	$11,021	$14,180
DRAMs ($M)	$1,803	$3,519	$1,521	$2,056	$3,402	$ 5,425	$ 5,523	$ 7,730
SRAMs ($M)	$ 787	$1,187	$ 890	$1,187	$1,786	$ 2,472	$ 1,810	$ 1,947
EPROMs ($M)	$ 829	$1,192	$ 852	$1,084	$1,612	$ 2,127	$ 2,069	$ 2,584
ROMs ($M)	$ 541	$ 427	$ 389	$ 452	$ 569	$ 717	$ 844	$ 938
EEPROMs/NVRAMs ($M)	$ 102	$ 156	$ 182	$ 288	$ 446	$ 640	$ 695	$ 880
Other MOS Memory ($M)	$ 45	$ 50	$ 45	$ 55	$ 65	$ 75	$ 80	$ 100

Source: DATAQUEST

MOS DYNAMIC RAMs FORECAST

The MOS dynamic RAM market was the outstanding MOS memory market in 1983 and 1984 and has led the market contraction in 1985 as well.

- The 1985 market is expected to be 57 percent smaller (forecast to be $1.5 billion) than 1984's market, which totaled $3.5 billion; ASPs per bit will decline about 70 percent.
- Strong growth is forecast for 1987 and 1988 as capacity is absorbed and new products using advanced memories move into production.
- CMOS DRAMs are slow to become available and to be widely sourced at the 256K level but are expected to dominate the 1Mb level.

Table 3 shows aggregate market measures for 1983 through 1990 for the dynamic RAM market in terms of revenues, units shipped, average selling prices per unit, prices per bit, and total bits shipped.

A detailed breakout by technology (NMOS or CMOS) and device density is provided in the service section.

Table 3

MOS DYNAMIC RAMs FORECAST

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$1,803	$3,519	$1,521	$2,056	$3,402	$5,425	$ 5,523	$7,730
Units (M)	623	1,017	943	1,019	1,542	2,343	2,145	2,373
ASP ($)	$2.90	$3.46	$1.61	$2.02	$2.21	$2.32	$2.57	$3.26
Price per Bit (Millicents/bit)	6.2	5.2	1.5	1.2	0.9	0.8	0.5	0.4
Total Bits Shipped (10^{12})	29	68	95	177	364	719	1,135	2,185

Source: DATAQUEST

MOS STATIC RAMs FORECAST

MOS Static RAMs are segmented into NMOS or CMOS devices, or, alternatively, into fast (sub-70ns) or slow (100ns or greater) devices. The total SRAM market in 1984 was about $1.2 billion but is expected to decline to $885 million in 1985. Growth is expected to resume in 1986 and continue until a supply-demand balance or demand contraction again occurs. Key elements of the market outlook are summarized below:

- CMOS will be the overwhelmingly dominant technology in both fast and slow SRAMs from the 64K density forward.

- Fast SRAMs are expected to outperform slow SRAMs in the near future because of differences in market needs, applications, and the supplier base.

- Both fast and slow SRAMs will be impacted by high-performance and low-power CMOS DRAMs.

Table 4a shows the SRAM forecast totals for revenues, units shipped, average selling prices per unit, prices per bit, and total bits shipped. Table 4b shows the market segmentation for fast and slow SRAMs as well as NMOS and CMOS SRAMs.

Fully detailed breakouts that give yearly unit and price estimates for each speed group (fast/slow), technology (NMOS/CMOS), and organization (x1, x4, x8) are available in the service section.

Table 4a

MOS STATIC RAMs FORECAST

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$787	$1,187	$885	$1,185	$1,782	$2,469	$1,810	$1,947
Units (M)	230	281	295	345	393	470	512	571
ASP ($)	$3.42	$4.22	$3.00	$3.44	$4.54	$5.25	$3.54	$3.41
Price per Bit (Millicents/bit)	30.9	24.7	11.9	8.7	6.3	3.9	2.3	1.8
Total Bits Shipped (10^{12})	3	5	8	14	29	63	79	106

Table 4b

MOS STATIC RAMs FORECAST--KEY MARKET MEASURES

	1983	1984	1985	1986	1987	1988	1989	1990
Total Revenues	$787	$1,187	$885	$1,185	$1,782	$2,469	$1,810	$1,947
Fast SRAMs ($M)	$171	$ 319	$343	$ 512	$ 671	$ 816	$ 831	$ 894
Slow SRAMs ($M)	$624	$ 877	$549	$ 680	$1,116	$1,654	$ 979	$1,054
NMOS SRAMs ($M)	$334	$ 441	$264	$ 282	$ 266	$ 142	$ 92	$ 82
CMOS SRAMs ($M)	$453	$ 746	$621	$ 903	$1,516	$2,327	$1,718	$1,866

Source: DATAQUEST

MOS EPROMs FORECAST

The MOS EPROMs market is expected to decline from about $1.2 billion in 1984 to $852 million in 1985, and to then grow at a CAGR of 37 percent to $2.6 billion in 1990. EPROMs are increasingly becoming the NVM product of choice and are expanding their role in such applications at the expense of mask ROM, and, to a lesser extent, bipolar PROM and EEPROM.

Beyond 1985, the EPROM market is expected to experience significant shifts in packaging and device technology employed.

- In 1984, CMOS was only 11 percent of total EPROM revenues. However, it is expected to be 63 percent by 1988. (This 1988 level of CMOS penetration is less than we expected in our earlier forecast.)

- One-time-programmable EPROMs, which were less than 3 percent of total EPROM revenue in 1984, are expected to grow to 77 percent of the total by 1988 (also less than expected in our earlier forecast).

- High-speed UV-erasable EPROMs or OTPs will be increasingly available and will further challenge bipolar PROMs due to high density and low power.

Table 5 shows the EPROM market forecast composition in terms of revenues, units shipped, average selling prices per unit, prices per bit, and total bits shipped. Detailed breakouts by technology and package type are included in the service section.

Table 5

MOS EPROMs FORECAST

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$829	$1,192	$852	$1,084	$1,612	$2,127	$2,069	$2,584
Units (M)	172	223	238	278	417	639	779	962
ASP ($)	$4.81	$5.35	$3.58	$3.90	$3.49	$3.32	$2.66	$2.69
Price per Bit (Millicents/bit)	11.0	9.2	4.1	2.4	1.5	1.0	0.6	0.4
Total Bits Shipped (10^{12})	8	13	21	44	108	219	348	679

Source: DATAQUEST

MOS ROMs FORECAST

Despite rapid growth in all other MOS memory product groups, the MOS ROMs market has continued to decline since its peak (at about $710 million) in 1982 to about $427 million in 1984. It is expected to recover somewhat and grow to $938 million in 1990, but it will continue to be affected by EPROMs and OTPs, which have advantages of user flexibility and, in many cases, are very price competitive.

Key market influences for the coming five years are summarized below:

- CMOS ROMs are expected to constitute more than 90 percent of MOS ROM revenues in 1990, primarily at the 1Mb, 2Mb, and 4Mb densities.

- Lower-density ROMs (64K through 512K) will be under increasing pressure from OTP EPROMs as more manufacturers bring their OTPs to market.

Table 6 shows the MOS ROMs forecast in terms of total revenues, total units, average prices per bit and unit, and total bits shipped.

Table 6

MOS ROMs FORECAST

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$541	$427	$389	$452	$569	$717	$844	$938
Units (M)	210	126	137	140	178	216	247	280
ASP ($)	$2.58	$3.40	$2.84	$3.24	$3.20	$3.33	$3.42	$3.36
Price per Bit (Millicents/bit)	4.5	3.4	1.8	1.2	0.7	0.5	0.3	0.2
Total Bits Shipped (10^{12})	12	13	21	39	90	156	291	529

Source: DATAQUEST

MOS EEPROMs/NVRAMs FORECAST

The MOS EEPROMs market grew from about $102 million in 1983 to $156 million in 1984, as shown in Table 7. Growth was driven by low-density NVRAMs and EEPROMs, as well as by high-density ($\geq$16K) EEPROMs. In applications where EEPROM competes with EPROM or CMOS with battery backup, EEPROM has probably lost competitive ground since late 1984 because of extreme price erosion in those other markets.

Table 7

MOS EEPROMs/NVRAMs FORECAST

	1983	1984	1985	1986	1987	1988	1989	1990
Revenues ($M)	$102	$156	$182	$288	$446	$640	$695	$880
Units (M)	31	44	60	85	125	180	240	358
ASP ($)	$3.31	$3.57	$3.01	$3.39	$3.56	$3.55	$2.90	$2.46
Price per Bit (Millicents/bit)	150.9	123.1	63.3	28.3	12.9	6.8	3.9	2.4
Total Bits Shipped (10^9)	68	127	287	1,019	3,452	9,352	17,768	36,283

Source: DATAQUEST

The NVRAM/EEPROM market is forecast to be $880 million in 1990, made up largely of dedicated low-density devices ($\leq$ 2K) or large device arrays ($\geq$256K). Key market influences are summarized below:

- Despite considerable price pressure in 1985, the market is expected to grow in dollars and units compared with 1984.
- CMOS has tremendous potential in EEPROMs but now represents only about 8 to 10 percent of total revenues.
- High-speed CMOS EEPROMs (for bipolar PROM replacement) just began to appear in early 1985 and are expected to contribute significantly to EEPROM revenues in coming years.

Lane Mason

Nielsen Dataquest USER UPDATE

SUIS Code: Newsletters
No. 85-16

SEMICONDUCTOR INDUSTRY UPDATE BUYER ALERT!
RESERVE YOUR CAPACITY NOW!

It's beginning to look like the end is near for the worst semiconductor recession ever.

- Users report that inventories are almost in line.
- Orders seem to have bottomed and are ready to start growing again.
- Brokers are buying up excess product at rock bottom prices, expecting to capitalize on a rising spot market in 1986.
- Discrete and linear demand have already started upward.
- Financial news from the semiconductor industry cannot get much worse (National expects to lose more than $40 million this quarter).
- A few purchasing managers are concerned about parts shortages in 1986.

Statistically, this recession (or should we say depression?) looks very much like the one that occurred in 1974 and 1975. That one was very steep and was followed by a strong resurgence in business.

NOW IS THE TIME TO MODIFY YOUR BUYING STRATEGIES

The operative strategy in 1985 has been to find ways to buy ICs in the United States at Far East prices. The time has come to reserve capacity with your vendors to assure availability of product as the semiconductor industry recovers in 1986.

Dataquest Incorporated, A Subsidiary of A.C. Nielsen Company / 1290 Ridder Park Drive / San Jose, CA 95131 / (408) 971-9000 / Telex 171973

While both U.S. and Japanese manufacturers have built the facilities to produce the product required for 1986 and possibly 1987, DATAQUEST believes that reductions in force have left U.S. companies without the trained personnel to increase production as quickly as customer demand is expected to grow. Surveys of Japanese semiconductor manufacturers show that they have reduced production, but have also built inventories (maybe excessively) and kept a larger work force in place to respond to renewed industry growth. DATAQUEST believes that quarter-to-quarter growth in 1986 will be very strong and that U.S. semiconductor manufacturers, who have reduced their work force by as much as 30 percent, will quote rapidly lengthening lead times and have periodic shortages of product during the second half of 1986 unless customers begin reserving capacity now.

THE SHAPE OF THE RECOVERY

Estimated quarterly consumption for 1985 and 1986 is shown in Table 1. By the end of 1985, we expect to have experienced five successive quarters of steeply declining revenues. In 1986, after a modest first-quarter upswing, we expect to see three of the strongest quarterly growth rates since our recorded data began in 1966. You can compare with previous years by referring to the industry growth charts in the Market Analysis section of Volume I of your SUIS notebooks.

Table 1

ESTIMATED U.S. QUARTERLY SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1984	Q1	Q2	Q3	Q4	1985
Discrete	$ 2,229	$ 448	$ 430	$ 403	$ 407	$ 1,688
IC	11,104	2,328	2,068	1,675	1,386	7,457
Total	$13,333	$2,776	$2,498	$2,078	$1,793	$ 9,145
Percent Change	51.5%	(19.5%)	(10.0%)	(16.8%)	(13.7%)	(31.4%)

	1985	Q1	Q2	Q3	Q4	1986
Discrete	$ 1,688	$ 431	$ 465	$ 480	$ 510	$ 1,886
IC	7,457	1,436	1,824	2,184	2,712	8,156
Total	$ 9,145	$1,867	$2,289	$2,664	$3,222	$10,042
Percent Change	(31.4%)	4.1%	22.6%	16.4%	20.9%	9.8%

Source: DATAQUEST

Figures 1 and 2 provide insight into the expected recovery from the end equipment perspective. The shipment rate of change curves help anticipate industry growth trends. Computers and office equipment and communications equipment represent two of the largest commercial semiconductor consumers in the United States. Both sectors are expected to grow 10 percent or more in 1985. This indicates an underlying growth in demand for semiconductor devices in these industries, which we expect to continue into 1986.

Relative growth of inventories versus shipments provides a leading indicator of purchasing trends. Inventory growth in excess of shipment growth indicates inventory accumulation, which must be corrected by a period of inventory growth that is less than shipment growth. During the correction period, purchases of semiconductors drop below actual consumption levels, resulting in a decline in semiconductor industry revenues. Our surveys indicate that this correction has already occurred in the computer and office equipment industry and is expected to end by the fourth quarter. The computer industry is expected to start the recovery in the first quarter. Communications equipment manufacturers were still accumulating inventory at midyear. Our surveys of these companies indicate that they will begin their recovery cycle close to mid-1986. Once both sectors kick in, we expect strong semiconductor growth through 1986 and into 1987.

CONCLUSION

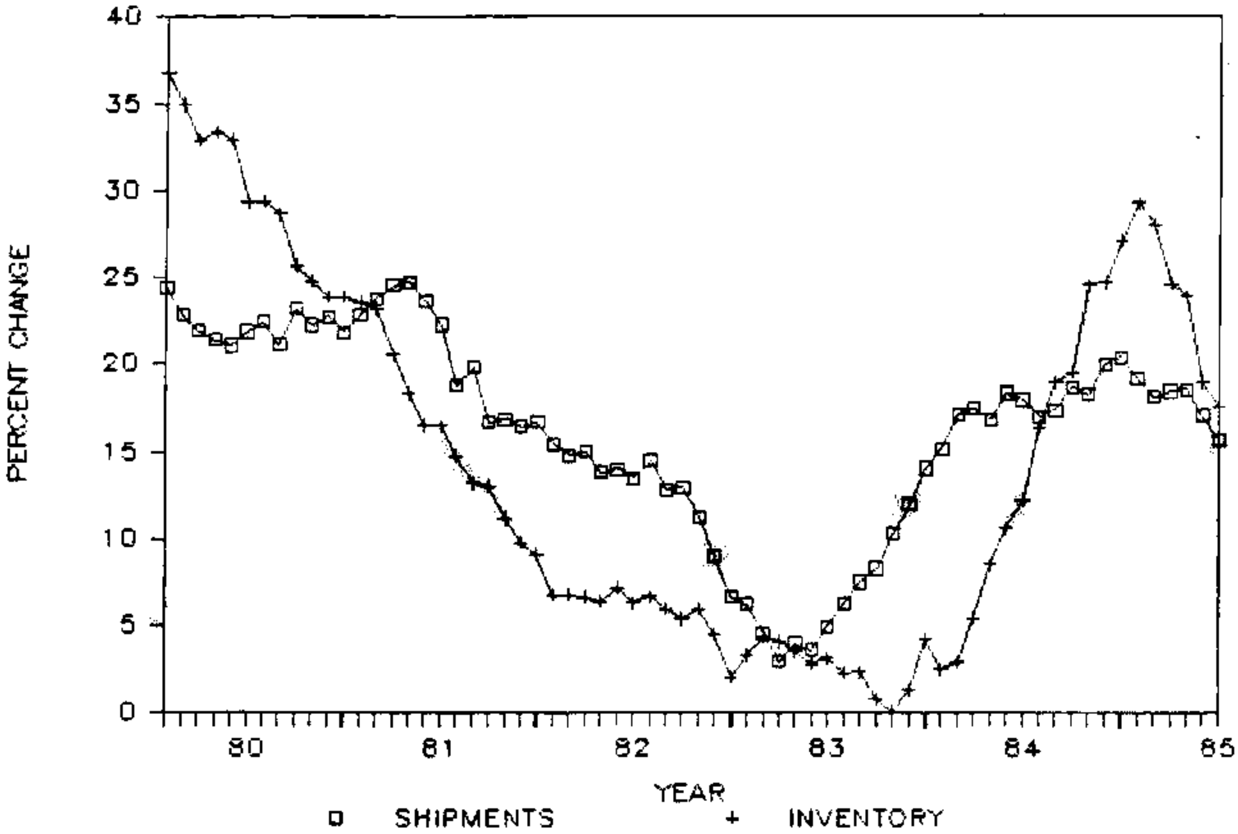
DATAQUEST believes that the effects of a sharp recovery in demand can be minimized if vendors and customers work together at this stage of the business cycle. Among the benefits for all concerned will be:

- Prices will be lower over the long haul.
- Lead times will remain shorter, enabling better control of inventories.
- Semiconductor companies will be able to plan ahead better, to anticipate and respond to growth in demand, and to control manufacturing costs better.

Stan Bruederle

Figure 1

OFFICE AND COMPUTING MACHINES
(Rate of Change)



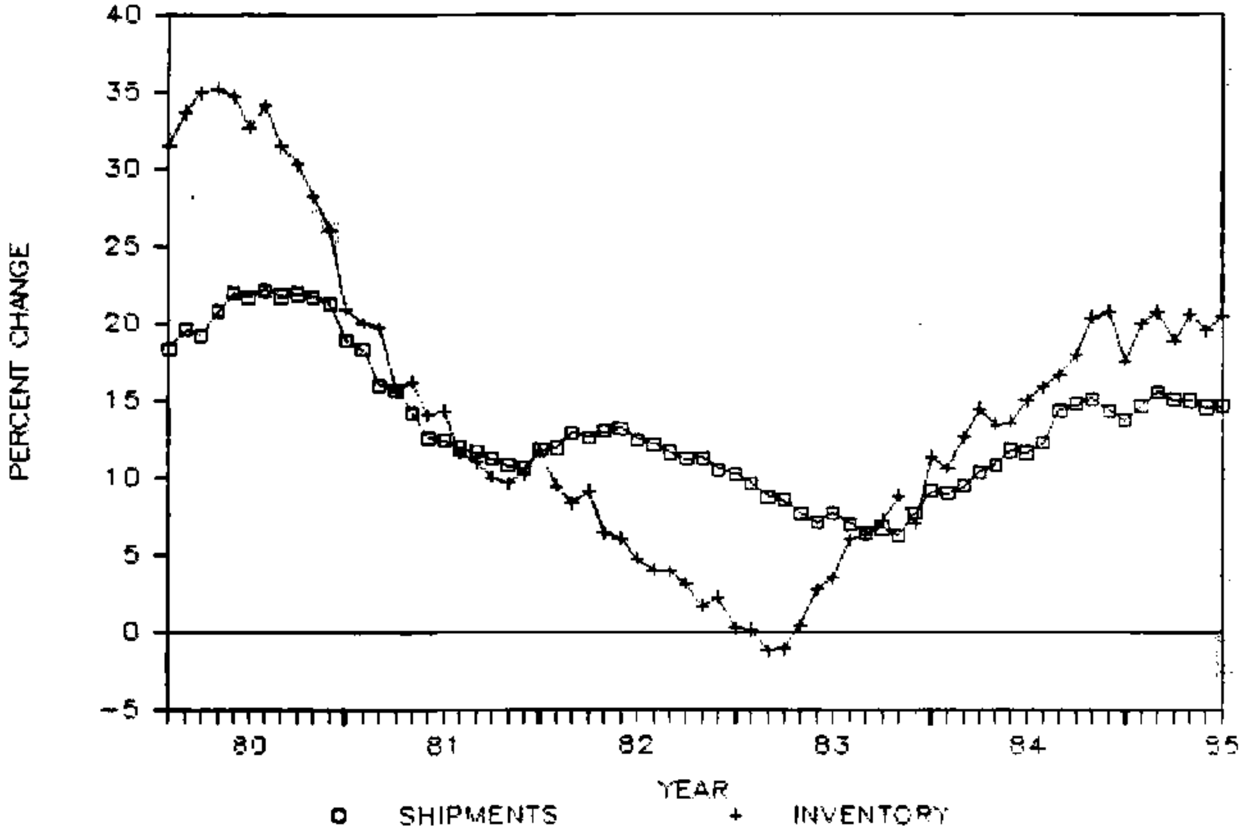
Last data: June 1985

Shipments = 12/12 Rate of Change
Inventory = 1/12 Rate of Change

Source: U.S. Department of Commerce
DATAQUEST

Figure 2

COMMUNICATIONS EQUIPMENT
(Rate of Change)



Last data: June 1985

Shipments = 12/12 Rate of Change
Inventory = 1/12 Rate of Change

Source: U.S. Department of Commerce
DATAQUEST

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: September

SEMICONDUCTOR INDUSTRY PULSE: FAINT GLIMMERS OF SUNSHINE AMID THE GLOOM

U.S. semiconductor consumption continues to fade as the book-to-bill ratio remains well below one. Currently, it appears that growth in semiconductor consumption will not resume before the first quarter of 1986. Nonetheless, some faint glimmers of sunshine are beginning to pierce this gloomy picture. There are signs that the excess inventory accumulation of 1984 may be nearing an end, that discrete and linear demand has already turned upward, that effective capacity has been significantly reduced, and that semiconductor purchasing managers are even beginning to be concerned about parts shortages in 1986.

CONSUMPTION BY SEGMENT

The table below shows DATAQUEST's estimates for the change in consumption by industry segment. Note the sharp decrease in the memory market.

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

	1984	1985	Percent Change
Memory	$ 3,773	$2,222	(41.1%)
Microdevices (MOS)	1,750	1,188	(32.1%)
Logic	4,215	2,977	(29.4%)
Linear	1,366	1,070	(21.7%)
Discrete/Opto	2,229	1,688	(24.3%)
Total Semiconductor	$13,333	$9,145	(31.4%)

Source: DATAQUEST

Excessive inventory accumulation always occurs during a rapid growth year as delivery times lengthen and buyers increase their stocks of parts to protect themselves. This reverses on the down side and leads to a demand for semiconductors far below their actual use in end equipment. DATAQUEST believes that this cycle should end sometime during the fourth quarter of 1985, leading to an increase in bookings at that time.

Discrete/opto and linear demand, both bookings and billings, have already turned upward. DATAQUEST believes that inventory accumulation was significantly lower in this sector of the industry and that the upturn in discrete demand will be followed by increased demand for integrated circuits.

Effective capacity has been reduced through shortened workweeks and layoffs, and future capacity will be further reduced through the curtailment of capital spending plans both in the United States and Japan. U.S. spending in 1985 has been reduced 24 percent from 1984 and Japanese spending has been reduced 18 percent in yen. The reduction in Japanese capital spending is particularly significant, since it constitutes the first reduction since DATAQUEST has been keeping records. Estimated quarterly consumption for 1985 and 1986 is shown below.

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Percent Change	(31.4%)	4.1%	22.6%	16.4%	20.9%	9.8%

Source: DATAQUEST

THE ECONOMY

DATAQUEST believes that the U.S. economy, while not robust, will not experience a significant decline in 1986. Instead, it will simply stumble along its present course with neither a boom nor a bust. With this scenario, there should be enough growth in end equipment demand to allow semiconductor consumption to return to higher levels as inventories are depleted and prices halt their precipitous decline.

Howard Z. Bogert
Barbara Van

October Newsletters

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

(continued)

October Newsletters

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: October

DATAQUEST PUBLISHES MEMORY MODULE MARKET ANALYSIS

DATAQUEST's Semiconductor Industry Service recently published a service section on Memory Module Packaging. This section was mailed to binder holders on October 8, and is located in the Products and Markets binder behind the Memory section tab. This new section contains detailed information on several aspects of the Memory Module Market, including:

- Descriptions of various types of memory modules
- History of the memory module market
- Advantages of modules
- Disadvantages of modules
- Applications where modules are being used
- Memory module market potential
- Company profiles of module suppliers, including names and addresses

MEMORY MODULE MARKET--SUMMARY

As semiconductor end users have demanded more function per chip size, new packaging alternatives have been introduced. One approach in semiconductor packaging has been to assemble prepackaged memory chips onto a single-in-line (SIP) or dual-in-line (DIP) substrate to create a memory module. This solution answers the needs of many end users, but has some drawbacks.

Memory Modules--Advantages

There are many advantages to using memory modules, including:

- Space savings due to denser packaging
- Ability to utilize surface-mount chips without a costly upgrade to surface-mount equipment
- Fewer PC board layers required due to increased levels of interconnects in the module
- Reduced assembly costs due to fewer components
- Improved reliability
- Stability under thermal stress
- Ease of upgradability to the next density
- Faster speed mix than with monolithic chips
- Ease of repair for socketed modules
- Improved heat dissipation
- Improved performance

Memory Modules--Disadvantages

Memory modules also have some disadvantages, including:

- Cost premium
- Mechanical instability
- Lack of second sources
- Lack of standards
- Module height exceeds monolithic chip height

Memory Module--Applications

Memory modules are being used in a variety of applications, including:

- Military equipment
  - Aerospace industry
  - Defense equipment

- Data processing equipment
  - Computers
    - Cache memory
    - Writeable stores for medium and large computers
    - CAE workstations
  - Graphics terminals
  - Point-of-sale terminals
- Industrial equipment
  - Process control instruments
  - Portable medical equipment
  - Remote instrumentation

Modules are used in all areas for prototyping new equipment ahead of the next-generation chip availability.

Essentially any application in which size, efficiency, or reliability is a vital concern, is a potential market for memory modules.

AVAILABILITY

Memory modules are available from at least a dozen semiconductor companies. In addition, a large number of repackaging houses are buying DIPs or chip carriers and assembling them into modules. Many of these repackagers have standard products and most will do custom orders. Repackaging houses appear to have less than 10 percent of the memory module packaging market. The vast majority of memory modules are being produced by the semiconductor companies.

MARKET POTENTIAL

DATAQUEST estimates that the current size of the memory module market (excluding stacks--units consisting of two chips placed one on top of another) is $200 million. The stack market accounts for an additional $70 million per year. SIP modules currently account for about 80 percent of the module market in units, but DIP modules may be responsible for nearly half of the dollars. This is due to the high average selling price of DIP modules sold to the military market. Currently, around 20 percent of all 256K DRAM units are packaged as modules. One major supplier predicts that next year nearly half of all 1Mb DRAMs may be in modules. If modules continue to receive an increasingly positive reception from the end-user market segments, the percentage of units packaged as modules could increase dramatically.

Susan Kelly

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: October

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Susan Kelly

Nielsen Dataquest RESEARCH BULLETIN

SIS Code: 1985-1986 Newsletters: October

THE RACE GETS HOT: THREE NEW 32-BIT MICROPROCESSORS ANNOUNCED IN OCTOBER

SUMMARY

After many months of little excitement in the semiconductor industry, Inmos, Fairchild, and Intel will all formally announce their high-performance 32-bit microprocessors during October. They will join AT&T, Motorola, National, and Texas Instruments in the battle to capture high-performance design wins. With seven major manufacturers and six unique architecture types, DATAQUEST believes that the early introduction phase of the market is over. Later entrants must replace these devices in the buyer's mind on the basis of technical or business issues if they are to be successful.

We believe that during the next 12 to 15 months, each manufacturer will attempt to position his family of devices as the best choice for specific market segments. Much attention will be focused on capturing highly visible designs. In addition, the producers will continue to round out their respective product families with more support chips. We also expect the announcement of second-source agreements during this positioning phase of the market. Users will be reevaluating 32-bit strategies and may shift design plans as new MPUs are available.

EARLY ENTRANTS

National Semiconductor was the first to enter the 32-bit MPU market when it introduced the 32032 almost two years ago. National's market leadership position along with its second-source alliance with Texas Instruments makes the company a formidable marketing force.

Motorola was the second entry with its 68020, which it introduced in June 1984. Motorola enjoys a large installed base of the 16-bit 68000 and the upgrade path to the 32-bit MPU is very convenient for users.

AT&T is a recent entrant to the merchant microprocessor market, but it has extensive in-house experience with the WE32100 and previous MPUs. AT&T is closely identified with the UNIX operating system, which has become the de facto standard for high-performance microprocessor systems.

OCTOBER 1985 ENTRANTS

The Inmos transputer has a truly unique architecture. This device is ideally suited to concurrent processing and array type applications using multiple transputers, as well as to general-purpose applications using single devices. Some extremely high-performance systems have been demonstrated using an array of these devices.

Fairchild believes that its Clipper is the supercomputer of MPUs. Like Inmos, Fairchild will target very high-performance applications. The company's development efforts capitalize on the architectural Cray-like concept that gives Clipper its performance.

Intel has not formally announced its long-awaited 80386, but we believe that announcement is imminent, perhaps within days of this bulletin. Intel's obvious market strength is its tremendously large installed base of software-compatible 8- and 16-bit microprocessors. The 80386 is a likely upgrade for many of those systems and can also be considered for other high-performance applications that are not presently dominated by the Intel architecture.

WILL HISTORY REPEAT ITSELF?

Four or five models dominate the market for both 8- and 16-bit microprocessor generations. Five 8-bit devices have 85 percent market share, and four 16-bit devices have more than 87 percent market share. Based on past experience, there now may be too many devices in the 32-bit MPU market for all of them to achieve success. DATAQUEST believes that many other manufacturers are planning to participate in this market. Our advice is to hasten their product introductions or to alter their strategies and consider an alliance with one of the above companies.

Mel Thomsen
Janet Rey

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: October

BOOM IN GALLIUM ARSENIDE START-UPS

SUMMARY

The boom in semiconductor start-ups continues, with at least 15 device manufacturers entering the GaAs merchant market in the last two years. DATAQUEST believes that other GaAs start-ups will publicly announce their plans for entry by mid-1986. Growing participation in this market has placed new demands on the infrastructure, including materials and equipment suppliers; additional start-ups in these areas are expected.

CAPITALIZATION

The companies listed in Table 1 have committed an estimated capitalization of $270 million. The funding requirement of a GaAs digIC (digital integrated circuit) start-up is typically $20 million or more, and is expected to exceed $30 million before achieving consistent volume production. Wafer volumes are much lower than is the case in silicon IC manufacture; however, equipment redundancy is still required to minimize throughput time. The expected ASPs of GaAs ICs make this technology attractive to a growing number of entrants.

Table 1

III-V START-UPS AND PRODUCTS

Company	Analog ICs	DigICs	Opto	FETs	Foundry	Cap/Merch
ABM	N/A	N/A	Yes	N/A	No	Merchant
Anadigics	Yes	Yes	No	N/A	N/A	Merchant
Celeritek	Yes	N/A	N/A	Yes	N/A	Merchant
Hittite	Yes	N/A	N/A	N/A	No	Merchant
Honeywell	Yes	Yes	Yes	Yes	Yes	Both
Isocom	No	No	Yes	N/A	No	Merchant
ITT	Yes	N/A	Yes	N/A	No	Captive
Les Tech. OMVPE	No	No	No	No	Epi Wafers	Merchant
Lytel	N/A	N/A	Yes	N/A	N/A	Both
MicroWave Tech.	Yes	N/A	N/A	Yes	N/A	Merchant
Pacific Mono.	Yes	N/A	N/A	N/A	No	Merchant
Gain Electronics	N/A	N/A	N/A	N/A	N/A	Merchant
Plessey	Yes	Yes	Yes	Yes	Yes	Both
Sanders	Yes	N/A	N/A	N/A	No	Captive
Tachonics	N/A	N/A	N/A	N/A	N/A	Both
TriQuint	Yes	Yes	N/A	Yes	Yes	Both
Vitesse	N/A	Yes	N/A	N/A	Yes	Both

N/A = Not Available

Source: DATAQUEST
October 1985

GaAs START-UPs

The companies discussed below join Avantek, GigaBit, Harris, Hewlett-Packard, Motorola, Rockwell, Texas Instruments, and other pioneers in III-V technology.

ABM Semiconductor, San Jose, California

This company was founded in February 1985, by Yoshiji Kurahashi, its president and founder. A spokesperson indicated the company plans to sell GaAs optoelectronic products manufactured by its parent company Kodenshi of Japan, and to perform GaAs chip design for fabrication by local foundries. The present staff comprises three employees.

Anadigics, Morristown, New Jersey

This company was founded in January 1985. The president, Ronald Rosenweig, was the founder of Microwave Semiconductor, which was started in 1968 and was sold to Siemens in 1979. Anadigics' products will include GaAs analog ICs, A/D converters, digICs (digital ICs), and MMICs (microwave monolithic ICs). Prototypes are expected by the second half of 1986. Gevenco (GE) is a backer and has provided equipment financing. A $9.7 million equity private placement was completed in second quarter 1985, and commitments for an additional $8.3 million were reported.

Celeritek, San Jose, California

The president of Celeritek is Tamar Husseini; key personnel were with Avantek for at least eight years. The company received $3.2 million funding from Sutter Hill and others in March 1985. Its products will include 2- to 6-GHz and 6- to 18-GHz low-noise temperature compensated amplifiers and GaAs FETs. The first GaAs FET shipments are expected by March 1986.

Hittite Microwave Corp., Lexington, Massachusetts

The president of Hittite is Yalcin Ayasli, formerly with Raytheon Research. A spokesperson said the company has an Air Force contract for GaAs designs. Plans are to design and develop custom and proprietary GaAs MMICs for military and commercial applications.

Honeywell, Inc., GaAs IC Product Center, Richardson, Texas

The deputy program manager is W.N. Shaunfield. In March 1985, Honeywell announced plans to participate in the merchant GaAs IC market. Honeywell is working with Rockwell, funded by DARPA, to establish GaAs device production fabrication capability at a rate of at least 100 wafers per week. Products include a 432-gate array, a 4-GHz amplifier, 6K gate arrays, and SRAMs.

Isocom, Campbell, California

Colin Rees is the president of Isocom. The company's products include optocouplers, phototransistors, and other GaAs and silicon devices. Sales in 1984 were approximately $4 million. A 20,000 square-foot plant is located in the United Kingdom. The company had about 30 employees in mid-1985.

ITT GaAs Technology Center, Roanoke, Virgina

Dr. Dennis Fisher, is the director of the center. This activity became a separate entity within ITT two years ago, and presently supports only ITT internal needs. The primary focus is on development and production of MMICs for defense and non-defense applications. The center is considering possible future participation in the merchant market.

Les Technologies OMVPE, Quebec, Canada

This company's product is epitaxy on GaAs wafers. Sampling is under way. A spokesperson said this company has $2 million in backing, including $1 million in Quebec government funding.

Lytel, Somerville, New Jersey

Lytel was incorporated in November 1983 and is backed by a very large "Fortune 100" company; capitalization exceeds $20 million. Dr. Eugene Gordon heads the activity, now staffed at more than 70 and growing rapidly. The 60,000-square-foot facility includes a clean room. The company's first products are indium phosphide high-power lasers for fiber optics applications. The focus is on quality, reliability, delivery performance, and "speaking the customers' language."

MicroWave Technology, Inc., Fremont, California

Tom Baruch, the president, was formerly with Exxon. Dr. Masa Omori is the vice president of engineering. The company's products include microwave components and GaAs ICs in advanced packages, such as PICOPAK. The company had about 50 employees in mid-1985.

Pacific Monolithics, Sunnyvale, California

The company was founded in March 1984 and Allen Podell, formerly with Hewlett-Packard, is president. Don Bond, the CEO, joined in July 1985. Pacific's products include both custom and standard designs. In May 1985, the trade press discussed a $20 GaAs MMIC from Pacific Monolithics for TVRO down converter applications.

Gain Electronics, New York, New York

The company was founded in 1984. Raymond Dingle, the president, was formerly with AT&T Bell Labs. This company is believed to be acquiring a 50,000-square-foot facility in New Jersey.

Plessey Three-Five Group, Towchester, Northamptonshire, United Kingdom

This company's products include GaAs ICs, fiber optic devices, and low-noise FETs. A foundry service for GaAs ICs is available, offering D-FETs with 0.9-micron nominal gate lengths integrated with ion-implanted diodes and resistors, MIM and interdigitated capacitors, and spiral DI bridge inductors.

Sanders Associates, Nashua, New Hampshire

Sanders is investing approximately $25 million in a state-of-the-art captive GaAs IC facility.

Tachonics Corp., Bethpage, New York

Tachonics' parent, the Grumman Corporation, Bethpage, New York, will invest between $15 million and $20 million in plant and equipment. The effort is headed by Dr. Chuni L. Ghosh, formerly of ITT. Grumman is looking for a site in the Boston-Washington corridor for Tachonics' planned 20,000-square-foot facility. The company initially will employ 25 persons, and will produce GaAs devices in support of internal needs; later it will supply merchant market needs.

TriQuint Semiconductor, Beaverton, Oregon

The company was founded in March 1985. Al Patz, the company president, and other key persons, are from Tektronix, which is furnishing 80 percent of the backing. The emphasis is on foundry service; the process features two-layer metal, E/D (enhancement/depletion), and 1-micron gates on 3-inch wafers. TriQuint's first products include the Q-Chip array. The company reportedly has more than 25 customers, including RCA for an 8-bit 100-MIPS RISC microprocessor.

Vitesse Electronics, Camarillo, California

Vitesse was founded in August 1984. Dr. Alfred S. Joseph is the president. Vitesse is following a vertical integration strategy; it is the first of the recent start-ups devoted to producing both GaAs LSI and systems using these components. A foundry is expected to be in operation by late this year; its capabilities will include the E/D process on 3-inch wafers. The company's 60,000-square-foot facilities include approximately 12,000 square feet of class 10 wafer fabrication area. The initial capital of $30 million was principally from Norton Company, Worchester, Massachusetts.

Sheridan Tatsuno
Mel Thomsen

NOTE

The contents of this Research Newsletter summarize a special DATAQUEST study of the emerging industry for GaAs and other III-V compounds. The study is not an integral part of the Semiconductor Industry Service. We will appreciate your feedback as it will be considered in determining the extent of future analysis and reporting in this area.

Nielsen Dataquest RESEARCH NEWSLETTER

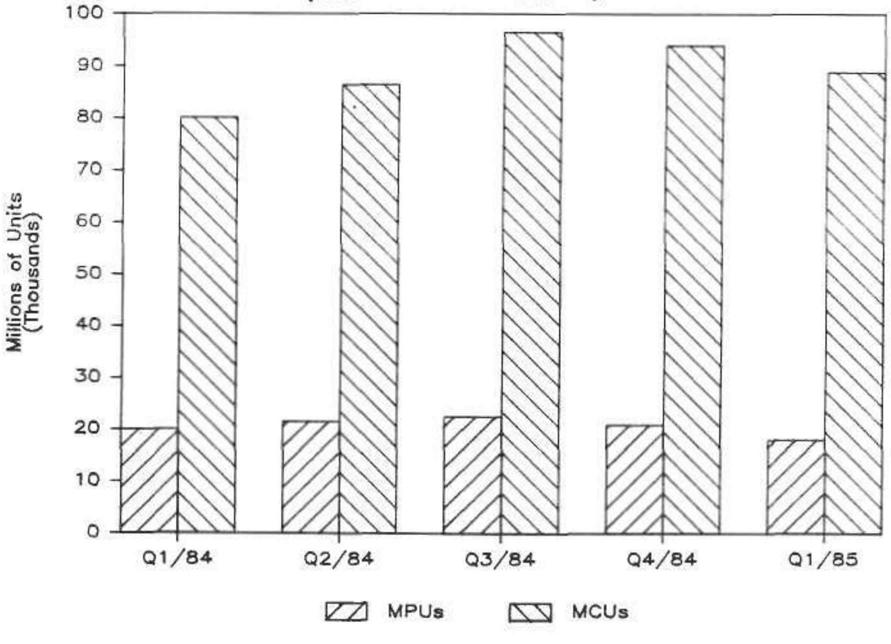
SIS Code: 1985-1986 Newsletters: October

FIRST QUARTER 1985 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the first quarter of 1985, worldwide microprocessor and microcontroller unit shipments decreased approximately 8.1 million units or 7.1 percent from fourth quarter 1984. Estimated shipments of all microcontroller devices totaled approximately 88.8 million units. Shipments of 4-bit MCUs decreased 6.0 percent and 8-bit MCU shipments decreased 5.0 percent. Estimated shipments of all microprocessor devices totaled approximately 18.0 million units. Shipments of 16-bit MPU shipments were down approximately 3.4 percent, while 8-bit MPU shipments decreased approximately 15.4 percent. Figure 1 shows MCU and MPU unit shipments from first quarter 1984 through first quarter 1985.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS FIRST QUARTER 1984 THROUGH FIRST QUARTER 1985 (Millions of Units)



Source: DATAQUEST
October 1985

Table 1 shows the quarterly revenue for microcontrollers and microprocessors from the first quarter 1984 through the first quarter 1985.

Table 1

TOTAL MICROCONTROLLER AND MICROPROCESSOR REVENUE SHIPMENTS
FIRST QUARTER 1984 THROUGH FIRST QUARTER 1985
(Millions of Dollars)

	Q1/84	Q2/84	Q3/84	Q4/84	Q1/85
MCU	$312.9	$345.7	$380.9	$372.2	$293.9
MPU	119.5	146.2	161.0	169.9	131.0
Total	$432.4	$491.9	$541.9	$542.1	$424.9

Source: DATAQUEST
October 1985

Table 2 shows the change in total microcontroller unit shipments from the fourth quarter of 1984 through the first quarter of 1985.

Table 2

TOTAL MICROCONTROLLER UNIT SHIPMENTS
FOURTH QUARTER 1984 THROUGH FIRST QUARTER 1985
(Thousands of Units)

	Q4/1984		Q1/1985		Percent Growth
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Q4 to Q1
4-Bit	49,065	52.2%	46,114	51.9%	(6.0%)
8-Bit	44,911	47.8	42,622	48.0	(5.0%)
16-Bit	32	0.0	50	0.1	56.3%
Total	94,008	100.0%	88,786	100.0%	(5.6%)

Source: DATAQUEST
October 1985

Table 3 shows the change in total microprocessor unit shipments from the fourth quarter of 1984 through the first quarter of 1985.

Table 3

TOTAL MICROPROCESSOR UNIT SHIPMENTS
FOURTH QUARTER 1984 THROUGH FIRST QUARTER 1985
(Thousands of Units)

	Q4/1984		Q1/1985		Percent
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q4 to Q1
8-Bit	18,306	87.5%	15,491	86.0%	(15.4%)
16-Bit	2,593	12.4	2,501	13.9	(3.6%)
Others	30	0.1	30	0.1	-
Total	20,929	100.0%	18,022	100.0%	(13.9%)

Source: DATAQUEST
October 1985

Table 4 shows the change in the shipments of the leading 8-bit MPUs from the fourth quarter of 1984 through the first quarter of 1985.

Table 4

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
FOURTH QUARTER 1984 THROUGH FIRST QUARTER 1985
(Thousands of Units)

	Q4/1984		Q1/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q4 to Q1
8085	4,520	24.7%	5,110	33.0%	13.1%
Z80	5,855	32.0	4,561	29.4	(22.1%)
6802	1,307	7.1	1,353	8.7	3.5%
8088	1,950	10.7	1,110	7.2	(43.1%)
6809	1,304	7.1	1,045	6.8	(19.9%)
Others	3,370	18.4	2,312	14.9	(31.3%)
Total	18,306	100.0%	15,491	100.0%	(15.4%)

Source: DATAQUEST
October 1985

Table 5 shows the percent changes in estimated shipments of 16-bit microprocessors from the fourth quarter of 1984 through the first quarter of 1985.

Table 5

16-BIT MICROPROCESSOR SHIPMENTS
FOURTH QUARTER 1984 THROUGH FIRST QUARTER 1985

	Q4/1984		Q1/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q4 to Q1
8086	975	37.6%	835	33.4%	(14.4%)
68000	741	28.6	628	25.1	(15.3%)
80186	515	19.9	530	21.2	2.9%
80286	110	4.2	205	8.2	86.4%
Z8000	135	5.2	117	4.7	13.3%
32016	75	2.9	103	4.1	37.3%
Others	42	1.6	83	3.3	97.6%
Total	2,593	100.0%	2,501	100.0%	(3.6%)

Source: DATAQUEST
October 1985

Table 6 shows market share by technology for 8-bit microcontroller and microprocessor devices from the first quarter of 1984 through the first quarter of 1985, and indicates increased shipments of 8-bit CMOS microcontrollers and microprocessors.

Table 6

UNIT MARKET SHARE BY TECHNOLOGY FOR
8-BIT MICROCONTROLLERS AND 8-BIT MICROPROCESSORS
FIRST QUARTER 1984 THROUGH FIRST QUARTER 1985

Device	Tech	Q1/84	Q2/84	Q3/84	Q4/84	Q1/85
8-Bit MCU	CMOS	10.1%	9.9%	9.7%	10.2%	11.6%
8-Bit MCU	NMOS	89.9	90.1	90.3	89.8	88.4
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	10.7%	10.8%	10.3%	11.6%	12.0%
8-Bit MPU	NMOS	89.3	89.2	89.7	88.4	88.0
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
October 1985

During first quarter 1985, approximately 71.6 percent of all 8-bit CMOS MCU unit shipments and approximately 41.1 percent of all 8-bit CMOS MPU unit shipments were Japanese manufactured and shipped. Even though U.S. manufacturers ship more 8-bit CMOS MPUs, approximately 1.1 million units, their Japanese counterparts shipped twice as many or approximately 3.5 million 8-bit CMOS MCUs. DATAQUEST believes that as CMOS technology progresses, the Japanese position will become stronger in both MPU and MCU market segments.

We expect new chip designs with smaller features to make the 8-bit CMOS market surge. Telephone, automobile, keyboard, and consumer goods (such as intelligent blenders) are expected to be big markets for 8-bit CMOS devices. The Pacific Asia region may dominate in manufacturing the CMOS consumer products due to the high volume and low cost of this huge market.

Table 7 shows the market share changes in shipments (not consumption) by geographical region for microcontrollers and microprocessors, from first quarter of 1984 through first quarter of 1985.

Table 7

MARKET SHARE BY REGION FOR MICROCONTROLLERS AND MICROPROCESSORS FIRST QUARTER 1984 THROUGH FIRST QUARTER 1985

Device	Region	Q1/84	Q2/84	Q3/84	Q4/84	Q1/85
4-Bit MCUs	United States	18.9%	17.8%	21.2%	18.8%	19.3%
	Japan	80.4	81.0	77.3	78.7	77.8
	Europe	0.7	1.2	1.5	2.5	2.9
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MCUs	United States	55.1%	57.2%	50.7%	49.3%	47.4%
	Japan	36.1	33.2	38.3	38.2	38.8
	Europe	8.8	9.6	11.0	12.5	13.8
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPUs	United States	61.4%	60.7%	61.2%	59.0%	48.6%
	Japan	32.2	31.7	31.0	35.3	44.9
	Europe	6.4	7.6	7.8	5.7	6.5
Total		100.0%	100.0%	100.0%	100.0%	100.0%
16-Bit MPUs	United States	78.6%	78.3%	75.9%	75.8%	78.0%
	Japan	17.3	13.8	16.2	16.7	14.2
	Europe	4.1	7.9	7.9	7.5	7.8
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
October 1985

ANALYSIS

DATAQUEST estimates that microprocessor and microcontroller revenue shipments for first quarter 1985 were $425 million, down 22 percent from the fourth quarter 1984. End users continued to cancel orders and renegotiate ASPs downward during the second and third quarters of 1985. However, the current booking level indicates a more stabilized fourth quarter for micro devices.

We expect total worldwide micro device revenue to be $2,638 million in 1985, down 19.4 percent from 1984. The U.S. micro device consumption will take the hardest hit during 1985, down 32.1 percent from 1984.

Janet Rey

Nielsen Dataquest

October 8, 1985

Dear Client:

The enclosed newsletter was recently published by DATAQUEST's Semiconductor User Information Service. We are sending it to all clients of the Semiconductor Industry Service and the Semiconductor Applications Markets Service as well, because we believe it will also interest you.

DATAQUEST's Semiconductor User Information Service is intended for decision makers in procurement strategic planning, purchasing and material management, and component engineering and vendor selection at companies that use semiconductor products.

Sincerely,

Mel Thomsen
Associate Director
Semiconductor Industry Service

Anthea Stratigos
Product Manager
Semiconductor Application Markets

Enclosure

MT/AS/ch

Nielsen Dataquest USER UPDATE

SUIS Code: Newsletters
No. 85-16

SEMICONDUCTOR INDUSTRY UPDATE BUYER ALERT!
RESERVE YOUR CAPACITY NOW!

It's beginning to look like the end is near for the worst semiconductor recession ever.

- Users report that inventories are almost in line.
- Orders seem to have bottomed and are ready to start growing again.
- Brokers are buying up excess product at rock bottom prices, expecting to capitalize on a rising spot market in 1986.
- Discrete and linear demand have already started upward.
- Financial news from the semiconductor industry cannot get much worse (National expects to lose more than $40 million this quarter).
- A few purchasing managers are concerned about parts shortages in 1986.

Statistically, this recession (or should we say depression?) looks very much like the one that occurred in 1974 and 1975. That one was very steep and was followed by a strong resurgence in business.

NOW IS THE TIME TO MODIFY YOUR BUYING STRATEGIES

The operative strategy in 1985 has been to find ways to buy ICs in the United States at Far East prices. The time has come to reserve capacity with your vendors to assure availability of product as the semiconductor industry recovers in 1986.

While both U.S. and Japanese manufacturers have built the facilities to produce the product required for 1986 and possibly 1987, DATAQUEST believes that reductions in force have left U.S. companies without the trained personnel to increase production as quickly as customer demand is expected to grow. Surveys of Japanese semiconductor manufacturers show that they have reduced production, but have also built inventories (maybe excessively) and kept a larger work force in place to respond to renewed industry growth. DATAQUEST believes that quarter-to-quarter growth in 1986 will be very strong and that U.S. semiconductor manufacturers, who have reduced their work force by as much as 30 percent, will quote rapidly lengthening lead times and have periodic shortages of product during the second half of 1986 unless customers begin reserving capacity now.

THE SHAPE OF THE RECOVERY

Estimated quarterly consumption for 1985 and 1986 is shown in Table 1. By the end of 1985, we expect to have experienced five successive quarters of steeply declining revenues. In 1986, after a modest first-quarter upswing, we expect to see three of the strongest quarterly growth rates since our recorded data began in 1966. You can compare with previous years by referring to the industry growth charts in the Market Analysis section of Volume I of your SUIS notebooks.

Table 1

ESTIMATED U.S. QUARTERLY SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1984	Q1	Q2	Q3	Q4	1985
Discrete	$ 2,229	$ 448	$ 430	$ 403	$ 407	$ 1,688
IC	11,104	2,328	2,068	1,675	1,386	7,457
Total	$13,333	$2,776	$2,498	$2,078	$1,793	$ 9,145
Percent Change	51.5%	(19.5%)	(10.0%)	(16.8%)	(13.7%)	(31.4%)
	1985	**Q1**	**Q2**	**Q3**	**Q4**	**1986**
Discrete	$ 1,688	$ 431	$ 465	$ 480	$ 510	$ 1,886
IC	7,457	1,436	1,824	2,184	2,712	8,156
Total	$ 9,145	$1,867	$2,289	$2,664	$3,222	$10,042
Percent Change	(31.4%)	4.1%	22.6%	16.4%	20.9%	9.8%

Source: DATAQUEST

Figures 1 and 2 provide insight into the expected recovery from the end equipment perspective. The shipment rate of change curves help anticipate industry growth trends. Computers and office equipment and communications equipment represent two of the largest commercial semiconductor consumers in the United States. Both sectors are expected to grow 10 percent or more in 1985. This indicates an underlying growth in demand for semiconductor devices in these industries, which we expect to continue into 1986.

Relative growth of inventories versus shipments provides a leading indicator of purchasing trends. Inventory growth in excess of shipment growth indicates inventory accumulation, which must be corrected by a period of inventory growth that is less than shipment growth. During the correction period, purchases of semiconductors drop below actual consumption levels, resulting in a decline in semiconductor industry revenues. Our surveys indicate that this correction has already occurred in the computer and office equipment industry and is expected to end by the fourth quarter. The computer industry is expected to start the recovery in the first quarter. Communications equipment manufacturers were still accumulating inventory at midyear. Our surveys of these companies indicate that they will begin their recovery cycle close to mid-1986. Once both sectors kick in, we expect strong semiconductor growth through 1986 and into 1987.

CONCLUSION

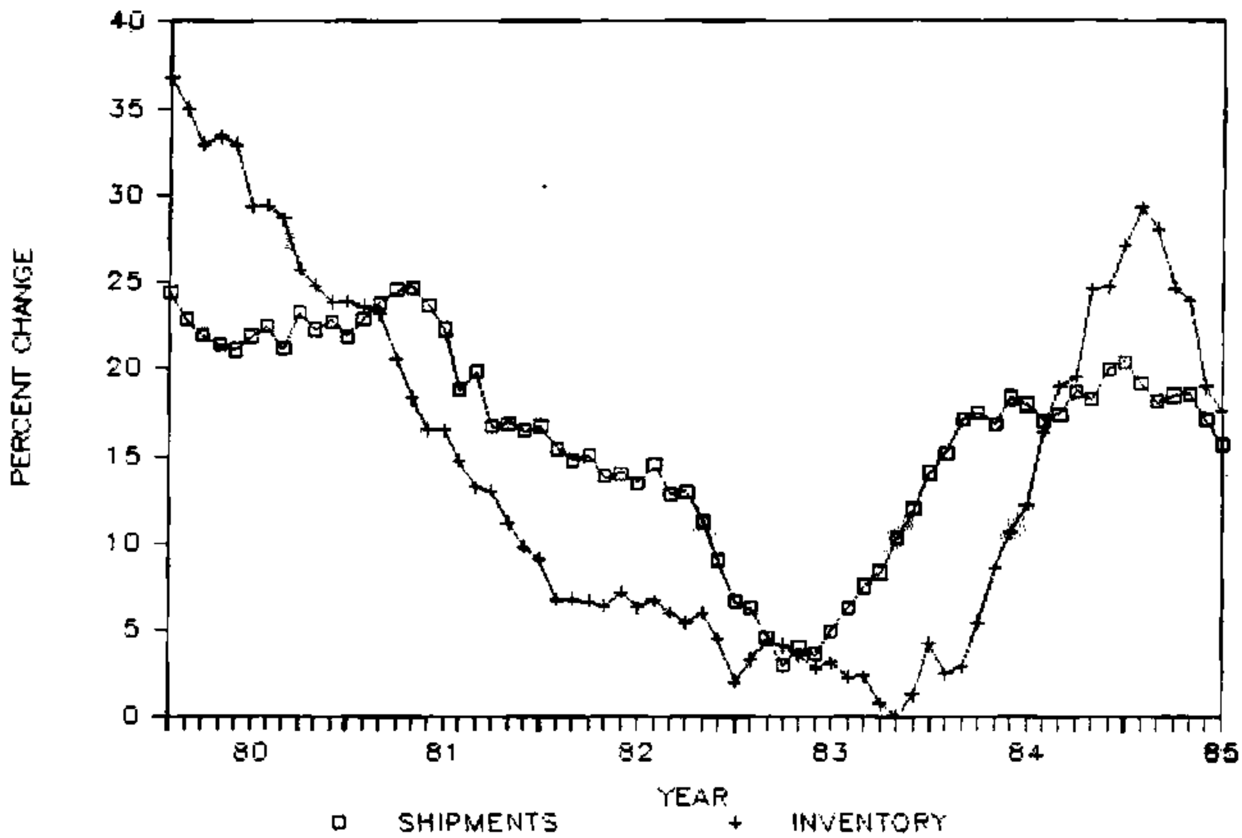
DATAQUEST believes that the effects of a sharp recovery in demand can be minimized if vendors and customers work together at this stage of the business cycle. Among the benefits for all concerned will be:

- Prices will be lower over the long haul.
- Lead times will remain shorter, enabling better control of inventories.
- Semiconductor companies will be able to plan ahead better, to anticipate and respond to growth in demand, and to control manufacturing costs better.

Stan Bruederle

Figure 1

OFFICE AND COMPUTING MACHINES
(Rate of Change)



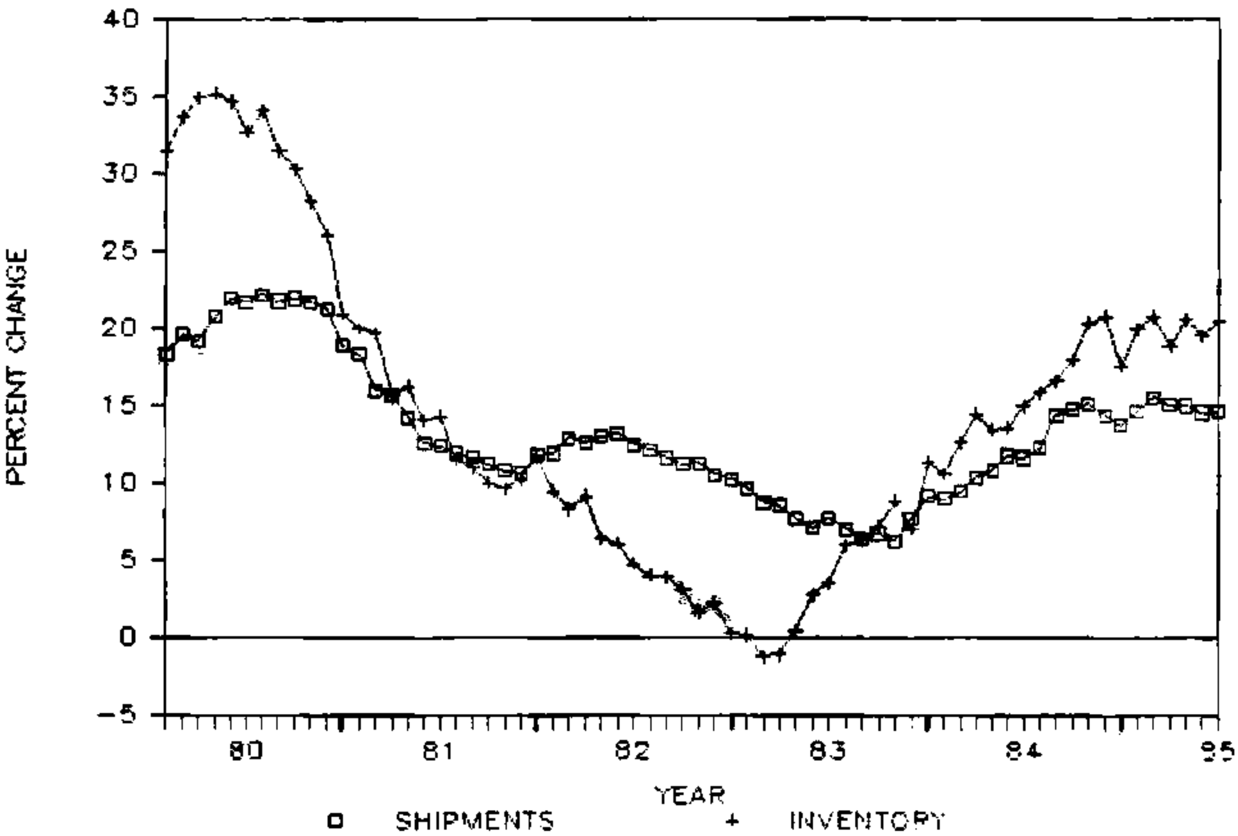
Last data: June 1985

Shipments = 12/12 Rate of Change
Inventory = 1/12 Rate of Change

Source: U.S. Department of Commerce
DATAQUEST

Figure 2

COMMUNICATIONS EQUIPMENT
(Rate of Change)



Last data: June 1985

Shipments = 12/12 Rate of Change
Inventory = 1/12 Rate of Change

Source: U.S. Department of Commerce
DATAQUEST

SIS Code: 1984-1985 Newsletters: October

NINTH ANNUAL SIA FORECAST DINNER: FORECASTING THE RECOVERY

SUMMARY

The Semiconductor Industry Association's ninth annual forecast dinner was held amid a mood of optimism combined with deep concern for the future viability of the U.S. semiconductor industry.

The evening began with a roast of retiring SIA president Tom Hinkelman and was emceed by Charlie Sporck, president of National Semiconductor Corporation. The featured speakers were Dr. Gil Amelio, president of Rockwell International's semiconductor products division, and Dr. Bob Noyce, vice chairman of Intel Corporation.

Mr. Sporck compared the U.S. semiconductor industry to a football player who is bleeding from an injury in a game where the competition is not penalized for breaking the rules. Although the U.S. industry has managed to survive under these conditions, the bleeding has not stopped. He called for forced change through "forms of leverage that some may call protectionist."

FORECAST

Dr. Amelio presented the consensus forecast for 1985 through 1986, which was prepared by the World Semiconductor Trade Statistics (WSTS) forecast committee, comprising representatives from 30 semiconductor manufacturers worldwide.

The WSTS forecast calls for a worldwide consumption decline of 17 percent in 1985, followed by three years of growth: 18 percent in 1986, 23 percent in 1987, and 23 percent in 1988. Over the long term, Japan will be the fastest-growing market, gaining several points in world market share in 1985 and maintaining them through 1988. Dr. Amelio pointed out that NMOS and PMOS memory are still showing no sign of recovery, while analog ICs are doing well, particularly in Japan, where the consumer electronics market is still fairly strong. Bipolar digital ICs are also doing well, having maintained a book-to-bill ratio of 1.0 since May.

Dr. Amelio pointed to several causes of 1985's disastrous market decline:

- A slowdown in the OEM market, particularly computers, which account for 40 percent of the U.S. semiconductor market
- A huge semiconductor inventory at OEMs (estimated to have been between $2 billion and $2.5 billion)

He believes that end users (i.e., consumers and businesses) have slowed consumption because they want more innovative products. OEMs will continue to slim down their semiconductor inventories as part of better asset management, but eventually demand will firm, as will prices. Finally, new, innovative products will spur end-user demand.

U.S.-JAPAN TRADE

Dr. Noyce's topic was U.S.-Japan trade friction. While admitting that many unfair trade practices do exist on the part of the Japanese, he believes that unfair practices are not the sole cause of the U.S. industry's current dilemma. Prior to 1980, the United States enjoyed years of trade surplus. Since 1980, however, the U.S. trade deficit has escalated dramatically. U.S. manufacturers are no longer competitive in the world market, Americans are substituting foreign sources of goods and services for domestic sources, and thousands of formerly U.S. manufacturing jobs are being moved offshore.

Dr. Noyce stated that the high value of the U.S. dollar bears a direct relationship to the current U.S. savings and trade deficits. The implication of this is that if the U.S. savings rate increases to the point of becoming a savings surplus, the U.S. dollar will fall in value and the trade deficit will become a trade surplus. Approximately 65 percent of U.S. corporate profits go into savings, while only 4.5 percent of personal income is saved. If President Reagan's tax proposal is passed, shifting more of the tax burden onto corporations and off of individuals, the resulting decrease in corporate profits would lower the corporate savings rate, decrease net savings in the country, and increase import penetration by $22 billion.

Dr. Noyce concluded that the solution to the problem is in the hands of the United States, which must produce a surplus of goods to send overseas, rather than bringing in goods from other countries. This can be done by increasing personal and government savings.

DATAQUEST ANALYSIS

A dichotomy of opinion on the trade issue was clearly in evidence at the dinner. Although most attendees agreed that free trade is best in the long run, many called for short-term protectionist measures. Even those against any form of protectionism would probably agree with Mr. Sporck's often-repeated rallying cry: "Protectionism beats extinction any day."

Barbara Van
Patricia S. Cox

November Newsletters

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

- Seventh Annual GaAs Symposium November 12-14, 1985
- Dataquest's Semiconductor Industry Conference: Snapshot of an Industry in Transition
- National Semiconductor Analysts Meeting
- Semiconductor Industry: Layoff Update
    - Table 1, Estimated Number Of Employees, Pages 1 & 2
    - Figure 1, Semiconductor Industry Layoffs Worldwide, Page 4
    - Table 2, Recent Semiconductor Company Cut Backs, Pages 5, 6, & 7

Nielsen Dataquest

RESEARCH BULLETIN

SIS Code: 1984-1985 Newsletters: November

SEVENTH ANNUAL GaAs SYMPOSIUM
NOVEMBER 12-14, 1985

Interest in gallium arsenide (GaAs) ICs has grown rapidly in recent years. Attendance at the IEEE-sponsored GaAs IC symposium has grown more than 30 percent annually since 1982, reaching 850 at this year's meeting in Monterey, California. Abstract submittals increased 24 percent over 1984, indicating substantial growth in development activity.

HIGHLIGHTS

General

- Forty-nine papers, approximately evenly split among analog ICs, digital ICs, and technology topics
- Authors from 26 companies, 5 universities, and 2 other organizations
- Three panel discussions covering millimeter-wave ICs, LSI issues, foundry operations, and standardization

Key Papers

- A GaAs, 12-bit, 1-GHz digital-to-analog converter (DAC)--Hewlett-Packard Labs
- A 115-GHz, monolithic, GaAs, FET oscillator--Texas Instruments
- A 2.6ns, t_{aa}, 1K x 4 SRAM using enhancement/depletion MESFETs (two papers)--Hitachi
- An ECL-compatible, 1K SRAM (with smallest cell reported to date)--Texas Instruments

- A 400-MHz band prescaler (for hand-held radio)--Toshiba
- An 8 x 8 multiplier (5.6ns at 1.45V) with 20-bit accumulator--Sony
- A high-temperature (180 degrees C) GaAs hall-effect sensor--Siemens

OBSERVATIONS AND CONCLUSIONS

GaAs IC technology is extending semiconductors to new frontiers of speed, speed/power efficiency, temperature extremes, and radiation resistance. Analog GaAs ICs are already commercially viable, with free-world market shipments exceeding $50 million annually.

However, present merchant market activities in GaAs digital ICs are severely limited by quality of starting material, threshold control, lack of test equipment for use in a production environment, chip interface/packaging standardization, and other restrictions. DATAQUEST believes that the 1985 GaAs digital IC market will be less than $15 million worldwide.

Explosive merchant market growth rates exceeding 100 percent a year for SRAMs, gate arrays, and other LSI devices are achievable as the restrictions mentioned above are resolved. At such time, demand will rapidly grow to more than $1 billion annually. The wafer-processing capacity required to support such a business level is quickly achievable, and the technical expertise is available, as demonstrated by this year's papers.

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Mel Thomsen
Gene Miles

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: November

DATAQUEST'S SEMICONDUCTOR INDUSTRY CONFERENCE: SNAPSHOT OF AN INDUSTRY IN TRANSITION

SUMMARY

The shutter clicked and the moment was captured. The image: an industry in transition--technologically, economically, strategically, and philosophically. Ready or not, a basic shift in the nature of the business is occurring. Low-cost, high-volume ("jelly bean") manufacturing is being transformed into a value-based, service-oriented industry. Captive manufacturers are going merchant. One industry executive described this fundamental change in the market as "cost-driven to customer-driven."

An industrial community, emerging from bad times and eager to move forward, gathered in October at Tucson's Sheraton El Conquistador at DATAQUEST's eleventh annual Semiconductor Industry Conference. The goal was to try to understand both the changes taking place and the future directions to take. By the end of the conference, the mood had shifted to reaffirmed confidence in the strengths and resilience of this marketplace.

The speakers, from the industry, finance, and government, analyzed various aspects of this change. The following central themes were addressed by several of them:

- ASICs and future products
- Software
- Silicon compilation
- The economy
- Japan
- Semiconductor equipment and materials

This newsletter summarizes the proceedings of the conference and discusses the common concerns of both presenters and attendees.

ASICs AND FUTURE PRODUCTS

> The opportunity of ASICs is to take over from conventional electronic circuits. ASICs are a creativity tool and creativity is not a particularly Japanese characteristic.
>
> K. K. Yawata
> Nihon LSI Logic

> Alliances between system houses and semiconductor manufacturers will become commonplace as ASICs eclipse microprocessors. Standard cells offer the greatest flexibility and most effective and efficient use of silicon.
>
> Eli Harari
> WaferScale Integration

From the number of speakers addressing this issue, it is clear that application-specific integrated circuits (ASICs) represent more than just a fashionable trend. With more than 150 companies offering ASIC products, including the major IC firms, ASICs are the products of a transformed IC industry. All these companies offer a host of products that users can design to fit their particular applications. The advantages ASICs offer are:

- Reduction in system size
- Decrease in system power consumption
- Major savings in system cost

One speaker noted that customer service is now the major factor in determining ASIC market share. Most speakers acknowledged that ASICs are both design- and creativity-oriented and that the creativity comes from the users. ASICs have expanded the base of product innovation, spearheading the transformation of the IC market from one of high-volume, cost-based manufacturing into a customer-driven, value-based products market. Or, as Art Collmeyer, of Weitek, characterized it, a transformation from "silicon cranks" to "think tanks."

ASICs also represent a significant competitive edge for the United States. A speaker from Japan noted that it would be a long time before Japan becomes competitive in the U.S. ASIC market, due both to the creative nature of ASIC design and to the substantial lead the United States possesses in CAD.

Future products were the subject of several presentations and panel discussions. Anthony Livingston, of Gigabit Logic, noted that a variety of gallium arsenide (GaAs) ICs are now migrating from the laboratory to the production environment. Because of their high-speed properties, GaAs ICs are currently marketed primarily to the military and telecommunications markets. One conference panel discussed billion-transistor ICs and their potential for use in such real-time applications as simultaneous language translation during overseas telephone calls.

The discussion of future products underscored the need for the industry to examine new IC product definitions coming from end-use markets. Anthea Stratigos, of DATAQUEST's newly inaugurated Semiconductor Application Markets (SAM) service, sponsored a workshop at the conference to examine more fully semiconductor industry trends and issues from an application perspective.

SOFTWARE

> Silicon design and system design will and must merge, (but) CAD advances are required to advance silicon design.
>
> Dave House
> Intel

> Product innovation is risky, as the market can only support a few winners. Partnering reduces this risk, spreads out the cost of development, and paves the way to industry standards, second-sourcing, etc.
>
> Art Collmeyer
> Weitek

> Currently available analog design tools lag two to four years behind digital CAD/CAE tools.
>
> Alan Grebene
> Microlinear

From the several references to software during the proceedings, it became clear that the current generation of CAD/CAE tools significantly lags process technology and remains, for some, a major bottleneck in the design cycle. This appears to be particularly true in the area of automated IC design. For this reason, one speaker noted, CAD software applicability remains a more critical issue to users than price.

It is not only the IC companies that are in transition, but also those companies around them, such as CAD/CAE vendors. The CAE market faces enormous challenges in incorporating test, process, and design expertise into their application software, as well as in automating the entire design process. A few speakers suggested closer collaboration or partnering between IC and CAD companies as a means of developing the design tools required by system designers. The United States, however, significantly leads Japan in electronic design automation--by at least ten years according to one conference speaker.

SILICON COMPILATION

> Silicon compilation is the automatic generation of full custom ICs from specifications provided by the user. It will drive the standard cell market. The challenge is user-variable circuitry; the ultimate goal is application standard architectures.
>
> Dick Gossen
> Silicon Design Labs

> Users want evolutionary tools, not revolutionary tools. Silicon compilation will be the major design methodology for ASIC design and possibly standard circuit design.
>
> Douglas Fairburn
> VLSI Technology Incorporated

One of the conference's afternoon panel discussions concentrated on silicon compilation. This session was chaired by the Semiconductor Industry Service's Andrew Prophet, with representatives of the major companies in this market participating. DATAQUEST forecasts that silicon compilation will play a major role in the growth of the ASIC market, driving the standard cell and cell-based markets beyond the $2 billion mark by the end of this decade. Panel members presented a brief overview of both their companies and products and attempted to define this new design methodology. Although the first-generation silicon compiler tools are available, vendors must still convince system designers to use them and to evolve the product offerings themselves towards true silicon compilation.

THE ECONOMY

> There is no reasonably acceptable way to reduce the deficits to acceptable levels without some tax increases. Whether they will affect your companies directly, or your customers, is something you ought to be looking at.
>
> Lawrence Chimerine
> Chase Econometrics

Large in the minds of many conference attendees was the state of the U.S. economy and its relation to the IC industry--that is, the fundamental ability of the economy to support the ongoing business of the semiconductor industry. Lawrence Chimerine, chief economist at Chase Econometrics, delivering what many attendees considered the best presentation of the conference, stressed that growth per se will not get the United States out of its current trade deficit problems.

Mr. Chimerine identified the two primary factors currently limiting economic growth as high interest rates and the overvalued U.S. dollar. In his opinion, the underlying reason for both remains the enormous and still-increasing federal budget deficit. He predicted that the federal deficit will remain at approximately $200 billion per year through the remainder of the decade unless strong actions are taken with regard to both taxes and spending. He specifically recommended increasing taxes and cutting programs.

Other speakers representing the financial community discussed U.S. venture capital versus Japan's low cost of capital, warning against a protectionist response to Far Eastern competition.

JAPAN

> The Japanese tend to be production-oriented, emphasizing yield and maximized output. This is due to Japan's culture, educational system, and national focus, which all stress homogeneity and uniformity rather than creativity.
>
> K. K. Yawata
> Nihon LSI Logic

Several presentations dealt specifically or in passing with the Japanese semiconductor industry. A European speaker characterized the U.S. market as in danger of becoming "Japan allergic." There is no doubt that this competitive challenge remains a major preoccupation of many players in this marketplace.

Other speakers concentrated on the strengths of the U.S. semiconductor industry. The strengths most often cited were in the area of applications and value-based products, such as ASICs. Also mentioned was the significant lead U.S. CAD/CAE vendors have over their foreign counterparts in application software. A discussion of relative differences in patterns of long-term planning, government participation, and capital funding provided significant insight into Japan's competitive advantages.

Interestingly enough, it was a speaker from Japan who discussed Japan's disadvantages vis-a-vis the U.S. market. Discussing ASICs in Japan, K. K. Yawata, of Nihon LSI Logic, conceded that the U.S. advantage lies in "creativity" products and tools. In Japan, where yield is emphasized and output maximized, the creativity associated with ASIC design is often slighted in favor of production. Dr. Yawata also estimated that it would take at least a decade or two before Japan catches up with the United States in CAD/CAE. Design application software, therefore, remains the number one issue for the largely hardware-oriented Japanese.

Dr. Yawata also forecast that 8-inch wafers would reach the marketplace sometime in 1988, while downplaying Japan's role in their evolution. Several attendees, however, privately shared doubts that the Japanese electronics industry's philosophy of "kei-haku-tan-sho" ("lighter, thinner, shorter, or smaller") would preclude them from further 8-inch wafer development. Others felt that Dr. Yawata slighted Japan's creative powers in his presentation, perhaps out of courtesy to the largely American audience.

SEMICONDUCTOR EQUIPMENT AND MATERIALS

As an adjunct to the main conference, DATAQUEST's newly launched Semiconductor Equipment and Materials Service (SEMS) held its first annual conference. One of the conference's main themes was the need for new equipment and materials to meet the challenges posed by the high-density, high-performance, submicron ICs. As devices go below 1 micron, manufacturers will run into physical limitations in materials, photolithography, and yields.

SEMS conference speakers noted that manufacturers are going to have to provide silicon wafers with much more stringent chemical characteristics. Also addressed were the problems associated with wafer dimensions reaching the absolute limits imposed by modern optics. Automatic inspection equipment, direct-write E-beam, and X-ray lithography were analyzed as means of resolving this problem. As process engineers push technology to its limits, yields are in great danger of falling, due to both contamination and variable process control. Thus, contamination control and wafer fab automation are viewed as absolute necessities for future evolution, a viewpoint also echoed by an SIS conference speaker.

DATAQUEST CONCLUSIONS

> This is a historical year, the worst recession in semiconductor history. Downturns in the industry have been cyclical, occurring in 1975, 1981, and in the current year. Long-term planning is hindered by (short-term) lending policies. (However), we anticipate an upturn in bookings in fourth quarter 1985, with billings reflecting this in second quarter 1986.
>
> Howard Bogert
> DATAQUEST

> The industry is undergoing a cost-driven to customer-driven transition. (It is necessary) to develop a willingness to change and change quickly to suit future conditions, particularly in customer relations. "Customer consciousness" involves responsiveness, integrity, and consistency.
>
> F. Joseph VanPoppelen
> National Semiconductor

These two quotations best summarize the current state of the semiconductor industry's evolution. There was no attempt at the SIS conference to deny the severity of the economic events of 1985. All the messages were there for the taking. We believe that the bottom has been reached. It is time to pick up the pieces and move forward into 1986. The current period remains full of challenging opportunities, as reflected in the views expressed by both speakers and attendees at the conference.

This is the time to build, buy equipment, be ready to ramp up, and form strategic alliances. Customers value service and responsiveness to their problems over marginal price/performance advantages. The customer is a sophisticated, highly-talented engineer who will require superior products and support. The new semiconductor industry is about creativity and synergy, not jelly beans.

(This newsletter was written jointly by DATAQUEST's Semiconductor Industry Service and the CAD/CAM Industry Service.)

Bryan Lewis
Tony Spadarella

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: November

NATIONAL SEMICONDUCTOR ANALYSTS' MEETING

The highlight of National Semiconductor's analysts' meeting was the announcement of National's second-generation 32-bit microprocessor, the 32332. National Semiconductor held its analysts' meeting on October 25 at the Marriott Hotel in Santa Clara. Charlie Sporck, National Semiconductor's president and CEO, presided over the meeting of stockholders and gave a brief overview of the Semiconductor, Datachecker, and National Advanced Systems Divisions. Three special speakers focused on National's "right moves" or activities in new products, advanced technologies and facilities, and research: Art Stabenow, vice president of worldwide wafer fabrication, technology, and analog products; Clark Davis, director of technology for the logic group; and Richard Sanquini, division vice president of microprocessors.

FINANCIAL RESULTS

National's first quarter of 1986 ended September 22 with sales of $423.4 million. A net loss of $53.5 million was reported. This poor performance is attributed to the Semiconductor Division, which experienced reduced demand and pricing pressure. Capital spending dropped in the first quarter to $41.8 million relative to $103.1 million in the same quarter one year ago. In the meantime, research and development expenditures climbed to $62.1 million, or 14.7 percent of sales, 4.7 percent above the like period of 1985.

SEMICONDUCTOR OVERVIEW

The Semiconductor Division noted a steady deterioration throughout the year. Profits, bookings, and backlog have declined. In order to combat its negative profitability, National is cutting costs through layoffs, wage freezes, and reduced expenditures. R&D spending is unaffected, however.

In spite of this gloomy report, National believes that it is at the bottom of the recession. During the past two months, National has witnessed a bookings improvement, and a modest growth in bookings is expected throughout calendar 1985 into 1986. Mr. Sporck forecasts that by the middle of 1986 the industry will be in a reasonably healthy market. If this forecast is realized, National expects to see improved profits due to its current cost-cutting measures.

POSITIONING FOR THE FUTURE

In order to position itself effectively for the future, National is focusing on emerging growth markets, advanced technology, enhanced design and manufacture, and continued R&D spending. Chief among these emerging growth markets are logic, interface, linear, telecom, gate arrays and standard cells, and the series 32000 family. National has committed itself to CMOS technology. Approximately half of National's R&D spending is committed to CMOS. National has been in the CMOS market since the early 1970s and views this technology as the answer to increasing densities. The company currently offers a broad spectrum of CMOS products.

National's new Arlington, Texas, facility is dedicated to 2-micron CMOS. The facility runs 6-inch wafers with manufacturing capacity of 320 square feet. The fab produced good die within 19 weeks of opening. A class 10 fab, the facility has one fab running and space for two more. The Arlington facility will run gate arrays in double-metal CMOS.

Research and development activity continues to increase yearly, with the focus on proprietary products, emerging growth areas, advanced technologies, and manufacturing. National also participates in the joint R&D organizations of SRC and MCC.

32-BIT MICROPROCESSORS

Two of National's top 20 products worldwide are attributed to its 32000 microprocessor family. The 32-bit family is all software-compatible using the AT&T validated UNIX operating system. The family includes the central processing unit (CPU), timing and control unit (TCU), interrupt control unit (ICU), floating-point unit (FPU), and memory management unit (MMU), as well as a large peripheral family. The 32-bit set was designed as a 32-bit microprocessor with clean architecture.

National's new 32332 device upgrades the speed capability of the 32032 while being fully compatible with the existing 32000 family. The 32332 is three times faster than the 32032 and is currently being sampled at beta sites. National plans to surpass this speed capability in the 1987 time frame with the 32C532, which will be seven times faster than the 32032.

National's 32-bit microprocessor is currently designed into numerous workstations, business computers, robotics, multiprocessor systems, and OEM systems. Current users in the workstations, business computers, and robotics application areas include Intergraph, Siemens, and Bosch, respectively. National is seeing increased 32-bit design activity and currently has 1,500 potential users worldwide evaluating the 32000 family.

SUMMARY

In an effort to combat declining profitability, National is cutting costs wherever possible. Cost cutting is expected to continue until National is operating at a profitable level. At the same time, National has targeted high-growth markets for expansion of proprietary products. These markets include linear, telecom, logic, microprocessor, interface, and graphics circuits. Research will continue in new products and technologies to bolster National's position for the market upturn and the future.

Barbara A. Van

Nielsen Dataquest RESEARCH NEWSLETTER

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SEMICONDUCTOR INDUSTRY: LAYOFF UPDATE

The semiconductor industry has been struggling to survive the worst year in its history. Nearly all semiconductor companies have reduced employment levels either through layoffs or attrition. DATAQUEST has predicted that semiconductor consumption will begin to increase early in 1986. (See the SIS DATAQUEST Research Bulletin titled, "Semiconductor Industry Pulse: Faint Glimmers of Sunshine Amid the Gloom," dated September 4, 1985.) DATAQUEST expects employment levels to hold constant for several months and then to increase cautiously as the industry recovers.

Nearly all semiconductor companies have reduced their total employment levels by a combination of layoffs and attrition. (See Table 1.) Integrated Device Technology (IDT) and Cypress Semiconductor were the only companies who had increases in the employment number. Worldwide employment in the semiconductor industry is down an estimated 14 percent. DATAQUEST estimates that the current semiconductor industry recession has caused the elimination of over 60,000 jobs.

Employment numbers for the U.S. and European companies were, in most cases, obtained from the companies themselves. Some company employment figures were not available, and a DATAQUEST estimate was used. DATAQUEST estimates the drop in employee numbers for Japanese companies to be around 5 percent. Actual employee number figures for the Japanese companies can be misleading due to the large number of temporary workers employed by Japanese companies. Temporary workers are not counted in the total employment figures; therefore, when Japanese companies let the temporary workers go, there is no resulting drop in the total employment number.

Table 1

ESTIMATED NUMBER OF EMPLOYEES
(Semiconductor Operations)

	December 1984	October 1985	Percent Change
Total Market	450,495	386,649	(14%)
U.S. Companies	280,200	226,029	(19%)
AMD	15,000	14,000	(7%)
AMI	4,000	2,800	(30%)
Analog Devices	4,759	4,759	
Cypress	200	265	33%
Exel	240	58	(76%)
Fairchild	13,300	10,800	(19%)
General Electric	2,720	2,176	(20%)
General Instrument	8,000	7,000	(13%)
Harris	5,824	5,170	(11%)
Hewlett-Packard	2,400	2,400	
IDT	434	490	13%
Intel	17,000	14,500	(15%)
Intl Rectifier	2,200	2,198	
ITT	5,000	5,000	
Micron Technology	1,252	740	(41%)
Monolithic Memories	2,800	2,260	(19%)
Mostek	10,000	150	(99%)
Motorola	45,000	38,000	(16%)
National Semiconductor	36,000	29,000	(19%)
NCR	1,700	1,360	(20%)
RCA	8,040	6,432	(20%)
Rockwell	2,239	1,704	(24%)
SEEQ	655	465	(29%)
Signetics	12,500	8,300	(34%)
Siliconix	2,727	2,720	
Standard Micro	710	670	(6%)
Synertek	2,168	0	(100%)
Texas Instruments	40,000	35,500	(11%)
Unitrode	3,120	2,600	(17%)
Xicor	780	430	(45%)
Zilog	1,432	1,402	(2%)
Others	28,000	22,680	(19%)

(Continued)

Table 1 (Continued)

ESTIMATED NUMBER OF EMPLOYEES
(Semiconductor Operations)

	December 1984	October 1985	Percent Change
Japanese Companies	104,460	98,740	(5%)
Fujitsu	12,400	11,582	(7%)
Hitachi	16,560	15,467	(7%)
Matsushita	6,450	6,192	(4%)
Mitsubishi	8,950	8,440	(6%)
NEC	22,100	20,840	(6%)
Oki	4,330	4,044	(7%)
Sanyo	4,000	3,880	(3%)
Sharp	1,920	1,824	(5%)
Toshiba	14,900	14,006	(6%)
Others	12,850	12,465	(3%)
European Companies	62,175	58,950	(5%)
Inmos	3,650	2,190	(40%)
Philips	14,000	13,580	(3%)
SGS-Ates	10,150	9,850	(3%)
Siemens	11,250	10,900	(3%)
Telefunken	4,025	3,900	(3%)
Thomson	7,525	7,300	(3%)
Others	11,575	11,230	(3%)
Rest of World	3,660	2,930	(20%)

Source: DATAQUEST

The number of layoffs per month in the semiconductor industry reached a peak of 4,100 in May of 1985. (See Figure 1.) However, the frequency of major layoffs decreased until late October when Mostek closed its doors and left another 3,600 semiconductor employees jobless. (See Table 2.) Mostek's closure could help stabilize employment levels at other semiconductor companies. Zilog, for example, planned to increase hiring to be able to absorb some new Z80 microprocessor business as a result of Mostek leaving the market.

Sue Kelly

Figure 1

SEMICONDUCTOR INDUSTRY LAYOFFS WORLDWIDE
(Thousands of Employees)

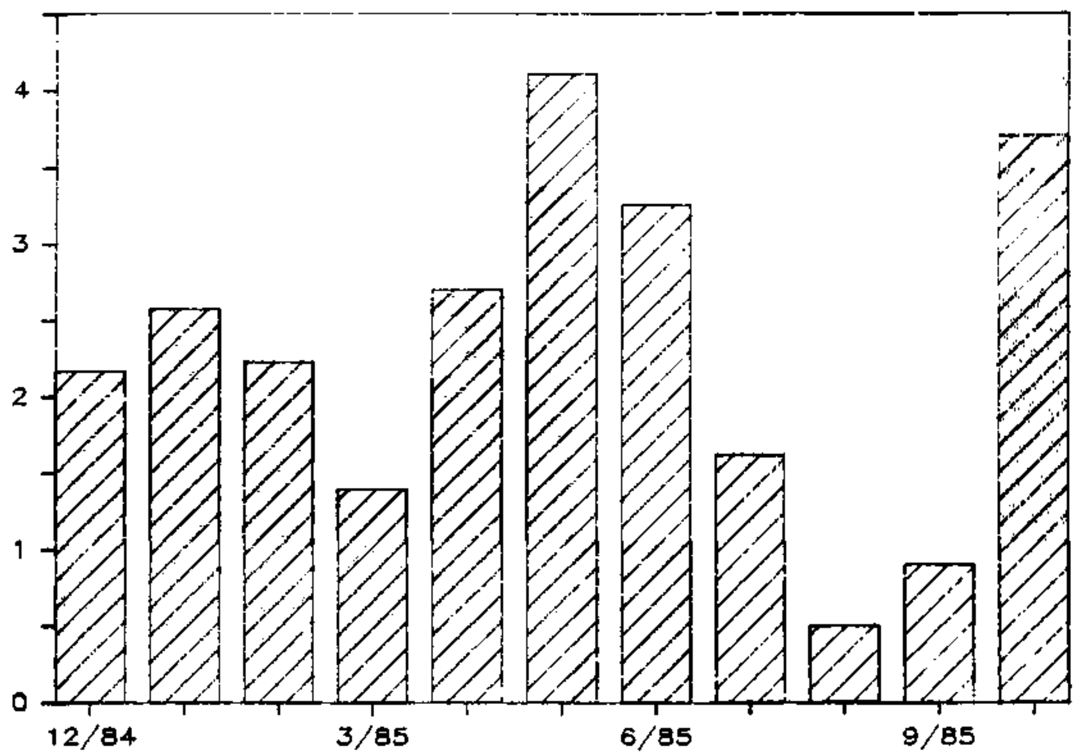


Table 2

RECENT SEMICONDUCTOR COMPANY CUT BACKS

Company	Date	Action
AMD	4/26/85	Closes for eight days, 6/24/85 to 7/5/85 (8,000 affected, United States)
	6/13/85	Shortens workweek to four days for the 12 weeks beginning July 8, 1985 (7,200 affected)
	6/13/85	All employees take 15 percent pay cut
	8/19/85	Extends reduced pay program for sales, marketing, and engineering personnel (10 percent cut) until the end of the year
	8/19/85	All employees, except support personnel, return to a five-day week
AMI	2/85	Layoff of 35 in Idaho (did include some temporary employees)
	4/26/85	Layoff of 440 (190 in Santa Clara, 250 in Idaho; leaving 1,050 in Santa Clara, 1,000 in Idaho)
	7/01/85	Layoff of 500 (300 in California and 200 in Idaho)
Analog Devices	7/01/85	Freezes all salaries for an unspecified amount of time
Exel	3/08/85	Layoff of 60 in San Jose (25 percent of local work force)
	10/10/85	Layoff of 110 (50 remain)
Fairchild	3/25/85	Closes for four weeks (two weeks from 3/25/85 and two weeks from 4/8/85)
	5/02/85	Will layoff 650 by closing plants in California and New York
	5/27/85	Planned to close wafer fab in Healdsburg, California, on June 7 (200 would be laid off)
General Instruments	5/15/85	Has had some cutbacks due to attrition and plant consolidation
Harris	2/26/85	Layoff of 125 (2 percent of work force, in Florida)
Hyundai	10/01/85	Layoff of 100 in Santa Clara, California
Inmos	3/18/85	Layoff of 86 in Colorado (7.5 percent of local work force)
	4/01/85	Shortens work week by 20 percent at Wales Plant (900 affected)
	4/01/85	Closes Wales plant an additional 4 days at Easter
	7/15/85	Layoff of 220 in United Kingdom (leaving 620 employees in Newport, South Wales, and 140 in Bristol)
Intel	2/18/85	Layoff of 900 in Oregon, California, and Arizona (4 percent of worldwide work force)
	2/18/85	Shortens the work week at two of its seven manufacturing plants (Santa Clara and Oregon)
	6/26/85	Layoff of 950 (750 immediately, 200 more by end of year)
	6/26/85	All employees will take seven days off without pay in third quarter 1985
	6/26/85	No merit pay increases until first quarter 1986
	6/26/85	Closes Fab #2 (A bipolar PROM line)
	9/30/85	Cuts wages of all 14,500 workers by 4 to 8 percent
	10/07/85	Announces closure of all U.S. operations six days at Christmas
LSI Logic	7/85	Planned a three-day shutdown in July, affecting 1,000 employees
	7/85	Planned to shut down for an additional week in third quarter 1985
Micron	2/85	Layoff of 625 in Idaho (50 percent of work force)
MMI	3/14/85	Closes for two weeks beginning 3/18/85 for all manufacturing employees (1,400 in Santa Clara, 1,400 in Malaysia)
	3/14/85	Shortens the workweek to four days for all nonmanufacturing employees (800 in Santa Clara)
Mostek	3/04/85	Salaries frozen and overtime pay suspended
	3/04/85	Layoff of 620 (10 percent of work force; 500 in Texas, 120 in Colorado)
	4/02/85	Layoff of 1,000 in Malaysia (38 percent of Malaysian work force)
	5/09/85	Layoff of 2,000 (1,600 in Carollton, Texas, 400 in Colorado Springs; 38 percent of force)
	5/20/85	Plans to lay off 140 in Ireland (25 percent of Irish work force)
	8/19/85	Layoff of 500 in Texas (17 percent of local work force; U.S. work force now at 2,500)
	9/24/85	Layoff of 1,250 in Malaysia (650 remain in Malaysia; 3,750 employees remain worldwide)
	10/17/85	United Technologies (Mostek's parent company) announces closure of all Mostek operations

(Continued)

Table 2 (Continued)

RECENT SEMICONDUCTOR COMPANY CUT BACKS

Company	Date	Action
Motorola	5/15/85	Reduction of 7,900 "employee equivalents" since Fall 1984 (18 percent of force) by worldwide reduction, attrition, etc.
	5/15/85	Implements "voluntary layoff" plan that would provide employees with severence pay
	5/25/85	Closes Austin, Texas, plant for two weeks in summer 1985 (6,000 affected)
	5/25/85	Layoff of 24 (total work force is 14,000 in Arizona)
	5/25/85	Closes for an additional one to four days after Memorial Day
	7/08/85	Layoff of 45 in Texas (planned to layoff about 50 more during the next several weeks)
	10/07/85	Will layoff 1,700 workers in the next few weeks
	10/07/85	Employees will take 5 to 10 percent pay cuts until 3/31/86
NCR	3/18/85	Closes two plants for two weeks (600 workers affected in Colorado)
NSC	3/08/85	Layoff of 400 while retooling its Salt Lake City plant (20 percent of SLC plant)
	3/08/85	Shortens the work week to 4 days for 10 weeks, beginning 3/17/85, for 21,000 workers (50 percent of work force)
	3/08/85	Management takes a 10 percent pay cut
	6/04/85	Layoff of 1,300 (600 in Santa Clara, 300 other U.S. locations, an additional 400 in several months)
	6/25/85	Closes Seremban, Malaysia plant (1,000 affected over four to six months)
	8/05/85	Closes for five days in the fiscal quarter ending September 22
	9/09/85	Extends shutdown to nine days (8,000 affected)
Rockwell	3/11/85	Layoff of 100 in California (4 percent of work force)
SEEQ	1/28/85	Layoff of 35 in San Jose
	2/23/85	Layoff of 83 in San Jose (15 percent of work force)
	2/23/85	Closes plant for six days beginning March 1, 1985
	5/27/85	Layoff of 70 employees (10 percent of work force)
	5/27/85	Closes some plants for the first week of July
Siemens AG	1985	Shortens workweek in Vilach, Austria (500 of its 1,400 employees affected)
Signetics	2/14/85	Layoff of 60 production workers (1 percent of worldwide work force)
	2/28/85	Layoff of 400 (3 percent of worldwide work force)
	2/28/85	Shortens the work week to four days on alternate weeks from March to June 10, 1985
	2/28/85	Closes some plants for one to two weeks beginning April 1, 1985
	4/26/85	Planned to lay off 100 production workers in New Mexico on May 1, 1985
	5/02/85	Planned to lay off 550 (400 in Sunnyvale, California, and 150 in Orem, Utah)
Synertek	12/84	Honeywell closes Synertek, immediate layoff of 1,500 (1,000 in California and 500 in Singapore)
	12/84	Final layoff of 668 (200 in California, 450 in Bangkok, and 18 in Munich)
Texas Instruments	12/8/84	Shortens the workweek to four days at some plants
	1/85	Layoff of 2,000 in Texas
	4/22/85	Planned to lay off another 1,000 during second quarter 1985
	5/85	Closes some plants for two weeks in May and June
	7/04/85	Closes for two weeks around July 4 holiday
	7/29/85	Layoff of 1,800 in semiconductor operations
Toshiba	1/24/85	Layoff of 140 (27 percent of local work force)

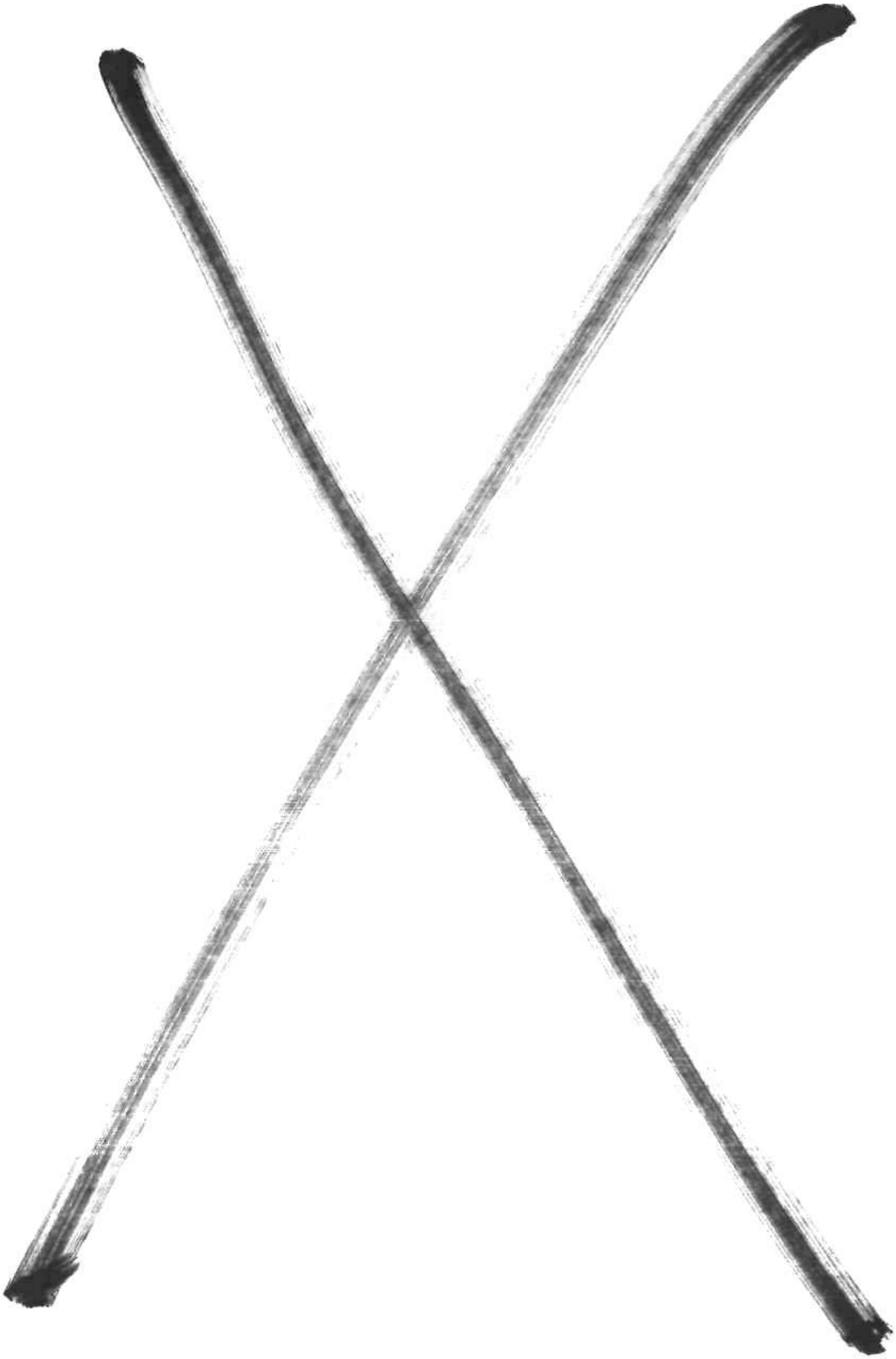
(Continued)

Table 2 (Continued)

RECENT SEMICONDUCTOR COMPANY CUT BACKS

Company	Date	Action
Xicor	3/25/85	Layoff of 130 in Sunnyvale, California (10 percent of work force)
	3/25/85	Shortens the workweek to four days
	4/25/85	Layoff of 110 in Milpitas, California
	5/02/85	Layoff of 40 (7 percent of work force)
	5/13/85	Layoff of 70 in California (430 left)
Zilog	1/17/85	Layoff of 400 (19 percent of worldwide work force)
	4/29/85	Layoff of 30
	5/03/85	Layoff of 20
	5/03/85	Planned layoff of 100
Zymos	4/22/85	Layoff of 119 in Sunnyvale, California (30 percent of work force)
Zytrex	5/15/85	Declares bankruptcy (Samsung may give Zytrex financial and manufacturing support to resume operations)

Source: DATAQUEST



December Newsletters

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

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December Newsletters

Dataquest
a company of The Dun & Bradstreet Corporation

RESEARCH NEWSLETTER

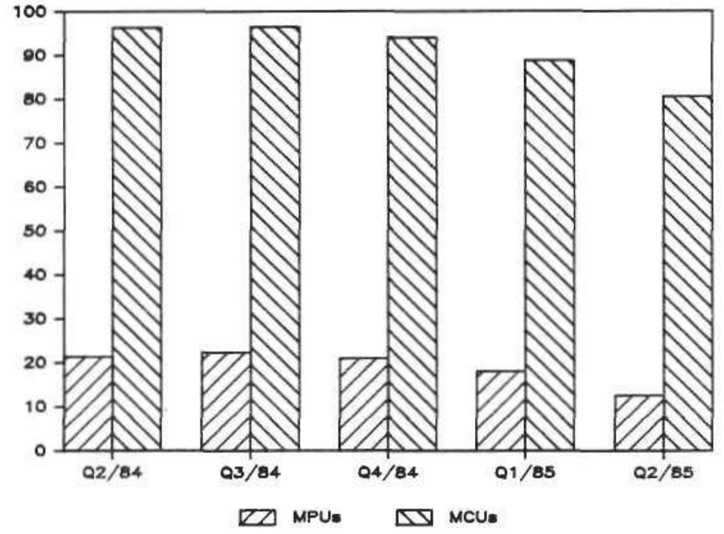
SIS Code: 1984-1985 Newsletters: December

SECOND QUARTER 1985 MICROPROCESSOR AND MICROCONTROLLER UNIT SHIPMENT UPDATE

During the second quarter of 1985, worldwide microprocessor and microcontroller unit shipments decreased approximately 12.3 million units or 11.3 percent from first quarter 1985. Estimated shipments of all microcontroller devices totaled approximately 84.4 million units. Shipments of 4-bit MCUs decreased 2.8 percent and 8-bit MCU shipments decreased 12.9 percent. Estimated shipments of all microprocessor devices totaled approximately 12.9 million units. Shipments of 16-bit MPU shipments were down approximately 30.2 percent, while 8-bit MPU shipments decreased approximately 28.5 percent. Figure 1 shows MCU and MPU unit shipments from second quarter 1984 through second quarter 1985.

Figure 1

MICROCONTROLLER AND MICROPROCESSOR UNIT SHIPMENTS
SECOND QUARTER 1984 THROUGH SECOND QUARTER 1985
(Millions of Units)



Source: DATAQUEST
December 1985

Table 1 shows the quarterly revenue for microcontrollers and microprocessors from the second quarter 1984 through the second quarter 1985.

Table 1

TOTAL MICROCONTROLLER AND MICROPROCESSOR REVENUE
SECOND QUARTER 1984 THROUGH SECOND QUARTER 1985
(Millions of Dollars)

	Q2/84	Q3/84	Q4/84	Q1/85	Q2/85
MCU	$345.7	$380.9	$372.2	$293.9	$255.6
MPU	146.3	161.0	169.9	131.0	102.0
Total	$492.0	$541.9	$542.1	$424.9	$357.6

Source: DATAQUEST
December 1985

Table 2 shows the change in total microcontroller unit shipments from the first quarter of 1985 through the second quarter of 1985.

Table 2

TOTAL MICROCONTROLLER UNIT SHIPMENTS
FIRST QUARTER 1985 THROUGH SECOND QUARTER 1985
(Thousands of Units)

	Q1/1985		Q2/1985		Percent Growth
MCU	Units	Percent of Shipments	Units	Percent of Shipments	Q1 to Q2
4-Bit	46,114	51.9%	44,809	55.5%	(2.8%)
8-Bit	45,320	49.5	39,487	46.8	(12.9%)
16-Bit	50	0.1	55	0.1	10.0%
Total	91,484	100.0%	84,351	100.0%	(7.8%)

Source: DATAQUEST
December 1985

Table 3 shows the change in total microprocessor unit shipments from the first quarter of 1985 through the second quarter of 1985.

Table 3

TOTAL MICROPROCESSOR UNIT SHIPMENTS
FIRST QUARTER 1985 THROUGH SECOND QUARTER 1985
(Thousands of Units)

	Q1/1985		Q2/1985		
MPU	Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth Q1 to Q2
8-Bit	15,489	85.6%	11,070	85.9%	(28.5%)
16-Bit	2,551	14.1	1,780	13.8	(30.2%)
Others	51	0.3	37	0.3	(27.5%)
Total	18,091	100.0%	12,887	100.0%	(28.8%)

Source: DATAQUEST
December 1985

Table 4 shows the change in the shipments of the leading 8-bit MPUs from the first quarter of 1985 through the second quarter of 1985.

Table 4

LEADING 8-BIT MICROPROCESSOR SHIPMENTS
FIRST QUARTER 1985 THROUGH SECOND QUARTER 1985
(Thousands of Units)

	Q1/1985		Q2/1985		
Device	Units	Percent of Shipments	Units	Percent of Shipments	Percent Growth Q1 to Q2
8085	5,110	32.9%	3,429	31.0%	(32.9%)
Z80	4,556	29.4	3,307	29.9	(27.4%)
6802	1,368	8.8	1,155	10.4	(15.6%)
6809	1,045	6.8	770	7.0	(26.3%)
8088	1,110	7.2	674	6.1	(39.3%)
Others	2,300	14.9	1,735	15.6	(24.6%)
Total	15,489	100.0%	11,070	100.0%	(28.5%)

Source: DATAQUEST
December 1985

Table 5 shows the changes in estimated shipments of 16-bit microprocessors from the first quarter of 1985 through the second quarter of 1985.

Table 5

16-BIT MICROPROCESSOR SHIPMENTS
FIRST QUARTER 1985 THROUGH SECOND QUARTER 1985
(Thousands of Units)

	Q1/1985		Q2/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q1 to Q2
68000	628	24.6%	447	25.1%	(28.8%)
8086	835	32.7	388	21.8	(53.5%)
80286	255	10.0	375	21.1	(47.1%)
80186	530	20.8	260	14.6	50.9%
Z8000	117	4.6	97	5.4	(17.1%)
32016	103	4.0	75	4.2	(27.2%)
Others	83	3.3	138	7.8	66.3%
Total	2,551	100.0%	1,780	100.0%	(30.2%)

Source: DATAQUEST
December 1985

Table 6 shows the changes in estimated shipments of 8-bit microcontrollers from the first quarter of 1985 through the second quarter of 1985.

Table 6

8-BIT MICROCONTROLLER SHIPMENTS
FIRST QUARTER 1985 THROUGH SECOND QUARTER 1985
(Thousands of Units)

	Q1/1985		Q2/1985		Percent
Device	Units	Percent of Shipments	Units	Percent of Shipments	Growth Q1 to Q2
8049	8,330	18.4%	6,177	15.6%	(25.9%)
6805	5,054	11.2	4,775	12.1	(5.5%)
8048	6,960	15.4	4,459	11.3	(35.9%)
8051	5,220	11.5	3,830	9.7	(26.6%)
Others	17,056	38.6	16,396	41.5	(3.9%)
Total	45,320	100.0%	39,487	100.0%	(12.9%)

Source: DATAQUEST
December 1985

Table 7 shows market share by technology for 8-bit microcontroller and microprocessor devices from the second quarter of 1984 through the second quarter of 1985, and indicates increased shipments of 8-bit CMOS microcontrollers and microprocessors.

During second quarter 1985, approximately 71.6 percent of all 8-bit CMOS MCU unit shipments and approximately 41.1 percent of all 8-bit CMOS MPU unit shipments were Japanese manufactured and shipped. Even though U.S. manufacturers ship more 8-bit CMOS MPUs--approximately 1.1 million units--their Japanese counterparts shipped twice as many or approximately 3.5 million 8-bit CMOS MCUs. DATAQUEST believes that as CMOS technology progresses, the Japanese position will become stronger than they are now in both MPU and MCU market segments.

Table 7

MARKET SHARE BY TECHNOLOGY FOR MICROCONTROLLERS AND MICROPROCESSORS
SECOND QUARTER 1984 THROUGH SECOND QUARTER 1985

Device	Tech	Q2/84	Q3/84	Q4/84	Q1/85	Q2/85
8-Bit MCU	CMOS	9.9%	9.7%	10.5%	11.6%	11.9%
8-Bit MCU	NMOS	90.1	90.3	89.5	88.4	88.1
Total		100.0%	100.0%	100.0%	100.0%	100.0%
8-Bit MPU	CMOS	10.8%	10.3%	11.6%	12.0%	14.3%
8-Bit MPU	NMOS	89.2	89.7	88.4	88.0	85.7
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST
December 1985

ANALYSIS

DATAQUEST estimates that microprocessor and microcontroller revenue shipments for second quarter 1985 was $357.6 million, down approximately $67 million or 15.8 percent from the first quarter 1985. First half 1985 shipments for MPUs and MCUs reflect a strong unit and price reduction caused by the explosion of the personal computer market, which consumed most of the micro device capacity during 1983 and 1984. For the remainder of the year, the impact of declining prices and unit volumes will continue, with a slight upturn in the fourth quarter.

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.

Janet Rey

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RESEARCH NEWSLETTER

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GLIMMER OF HOPE DAWNS ON THE SEMICONDUCTOR INDUSTRY

Just as the sky brightens at dawn before the sun rises to warm the earth, the semiconductor industry is showing signs that business will grow, indications that the future looks brighter than we had thought in September. At that time, we could see only "faint glimmers of hope amid the gloom." But the economy now seems to be developing a more robust growth pattern, and this bodes well for the latter part of 1986 and 1987.

THE ECONOMY

DATAQUEST believes that the U.S. economy is strengthening. Inflation is much less dramatic than we thought possible a few years ago, and, indeed, some segments of the economy are experiencing price declines. These segments include agriculture and oil as well as the personal computer and (of course!) semiconductor industries. We believe that the lack of inflation has made it possible for the Federal Reserve to increase the money supply much more rapidly than it could a few months ago. The Fed's accommodative stance should lead to better-than-expected growth in the economy in 1986. The current run-up to new highs in the stock market tends to support this viewpoint.

THE INDUSTRY

Our current forecast for the semiconductor industry is given in Table 1.

Table 1

ESTIMATED U.S. QUARTERLY SEMICONDUCTOR CONSUMPTION
(Millions of Dollars)

	1984	Q1	Q2	Q3	Q4	1985
Discrete	$ 2,229	$ 448	$ 430	$ 402	$ 412	$ 1,692
IC	11,104	2,328	2,068	1,819	1,744	7,959
Total	$13,333	$2,776	$2,498	$2,221	$2,156	$ 9,651
Percent Change	51.5%	(19.5%)	(10.0%)	(11.1%)	(2.9%)	(27.6%)

	1985	Q1	Q2	Q3	Q4	1986
Discrete	$ 1,692	$ 435	$ 471	$ 498	$ 542	$ 1,946
IC	7,959	1,820	2,057	2,226	2,548	8,651
Total	$ 9,651	$2,255	$2,528	$2,724	$3,090	$10,597
Percent Change	(27.6%)	4.6%	12.1%	7.8%	13.4%	9.8%

Source: DATAQUEST

We are still forecasting that U.S semiconductor consumption in 1986 will exceed that of 1985 by 9.8 percent, unchanged from our September forecast. Even so, 1985 will finish out the year some 27.6 percent below the banner year of 1984. However, forecast fourth-quarter consumption of $3,090 million in 1986 will be only 16 percent below the best quarter of 1984 ($3,669 million). If this rate is only sustained in 1987, the growth from 1986 to 1987 will be 17 percent. We do, however, expect growth considerably in excess of this 17 percent in 1987.

There are signs that prices are firming somewhat as producers reduce their effective capacity through layoffs or redirect production into other segments of the market. NEC's recent price increases are encouraging, as is the recent antidumping ruling in the Micron Technology case.

We still have not seen signs that all excess inventory is depleted. Many semiconductor purchasers are still buying directly from their vendors' inventories and, as a result, the "turns" business still constitutes 30 to 50 percent of the shipments of many semiconductor manufacturers. We anticipate that a sharp increase in bookings will occur sometime in the first quarter of 1986, as buyers begin to discover that certain part types are no longer immediately available. This will cause them to place longer-term orders and the "turns" business will decline.

FORECAST COMPARISON

Table 2 compares our current forecast with our previous forecast. Notice that we do not now expect shipments to decline as much in the third and fourth quarters of 1985 as we expected in September. We underestimated the effect of the "turns" business in keeping billings up in the absence of bookings. The higher base of shipments in the last quarters of 1985 makes it possible to achieve the forecast 9.8 percent growth in 1986 with somewhat smaller quarter-to-quarter percentage growth.

Table 2

FORECAST COMPARISON
(Millions of Dollars)

	1985		1986			
	Q3	Q4	Q1	Q2	Q3	Q4
Total Semiconductor						
Sept. Forecast	$2,078	$1,793	$1,867	$2,289	$2,664	$3,222
Dec. Forecast	$2,221	$2,156	$2,255	$2,528	$2,724	$3,090
Percent Change						
Sept. Forecast	(16.8%)	(13.7%)	4.1%	22.6%	16.4%	20.9%
Dec. Forecast	(11.1%)	(2.9%)	4.6%	12.1%	7.8%	13.4%

Source: DATAQUEST

CONCLUSIONS

DATAQUEST believes that the economy is growing stronger and that the semiconductor industry is about to see a resumption of growth. We expect some bookings growth in the fourth quarter and anticipate that the book-to-bill ratio will exceed 1 early next year. With this scenario, 1986 will be a year of recovery and 1987 will be a year of robust growth for the industry.

Barbara Van
Howard Bogert

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RESEARCH NEWSLETTER

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THE U.S. ECONOMY: BOOM OR BUST?

In a recent visit to DATAQUEST, Joseph W. Duncan, Corporate Economist and Chief Statistician of the Dun & Bradstreet Corporation, shared some of his views on the future of the U.S. economy. Due to the universal nature of the subject matter and the impressive credentials of Mr. Duncan, we believe that his views would be of interest to our clients. Mr. Duncan worked eight years as the chief statistician for the Office of Information and Regulatory Affairs of the U.S. Office of Management and Budget. Previously, he was a research and management specialist at Battelle Memorial Institute where he spent 13 years. Mr. Duncan's education includes receiving a B.S.M.E. degree from Case Institute of Technology, an M.B.A. degree from Harvard Graduate School of Business Administration, and a Ph.D. degree in Economics from Ohio State University. He also attended the London School of Economics.

KEY ECONOMIC ISSUES

With respect to the health of the U.S. economy, Mr. Duncan identified three key questions:

- Will there be a recession in the near future?
- Will activity continue in capital markets?
- Will Congress act to reduce the budget deficit?

Recession

In order to address the likelihood of a recession, one must address the health of principal components of the economy. These vital components are consumer spending--which makes up approximately two-thirds of the GNP--housing starts, business starts/failures, unemployment, capital spending, and inflation.

Consumer spending is expected to remain strong. Contrary to widely held beliefs, Mr. Duncan believes that consumers are not over-extended because monthly payments remain a small percentage of disposable income. The housing market appears to be garnering pent-up demand, as mortgage rates have remained at the pivotal 12 percent for some time now. Rates are expected to drift down below 12 percent, however, which should trigger a very strong housing market.

Business starts are at an all-time high. This bears no correlation to interest rates; rather, it is attributed to a more entrepreneurial spirit and willingness to take risks. While business starts are up, so too are business failures. There are several reasons for this: small businesses pay very high interest rates and are at high risk for failure. Also, liberalized personal bankruptcy laws have made it more acceptable to file bankruptcy claims.

Employment has grown continuously during the last five years. Import activity, which would seem to adversely affect the health of the economy, does, in fact, add jobs in the United States. Thus, import activity together with strengthened demand from overseas markets for U.S. exports, should be bolstered.

Capital Market Activity

Capital spending has been depressed due to uncertainty of its treatment under proposed tax reforms. Yet, Mr. Duncan believes that tax reform will not occur until 1987. Spending is expected to pick up in 1986, along with corporate profits. Corporate cash flow will be up 5 percent in 1985, while profits will be down 5 percent. Inflation will increase as well, but is not expected to exceed a 5 percent annual rate.

We believe that there are two sides to the U.S. economy: production, expressed as gross national product (GNP), and consumption, which we refer to as gross final domestic demand (GFDD). To get a good view of the economy, one should look at both. GFDD measures the strength of demand in the economy by factoring net exports and inventory change out of GNP: GFDD = GNP - change in inventory + imports - exports. As shown in Figure 1, the GFDD points to a healthy market with 3.3 percent growth between the fourth quarter of 1984 and the third quarter of 1985. Forecasts of real GNP identify growth of 2.7 percent for 1985, 3.5 percent for 1986, and 4.5 percent for 1987. Growth in GFDD is forecast to remain higher than GNP growth through the end of 1985.

Congressional Action

It is highly probable that the U.S. economy will not experience another recession until 1989. If Congress acts to pass a budget balancing bill, the economy should experience moderate growth for several years. However, if the deficit is not reduced, interest rates could start spiraling as early as spring of 1986, and a recession would soon follow. We believe Congress will act to balance the budget.

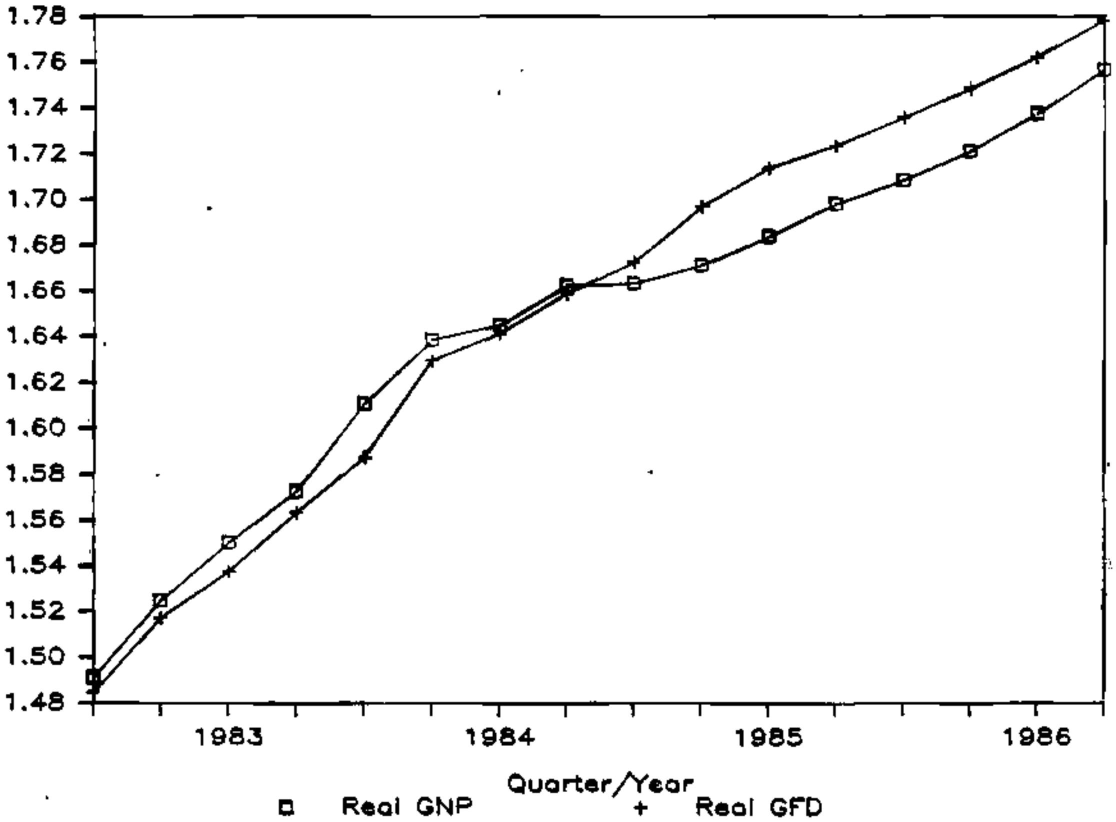
SUMMARY

Mr. Duncan identifies a healthy U.S. market. DATAQUEST concurs with his assessment and agrees that 1986 will be a healthy year. Our forecast for semiconductor growth assumes light growth in the first quarter of 1986 with more robust growth in the latter quarters. Our long-range forecast also identifies a recessionary period in 1989. While it is not clear that the semiconductor market clearly follows the GNP, we believe that the overall economy sets the general trend for the health of our industry.

Barbara A. Van
Patricia S. Cox

Figure 1

REAL U.S. GNP VERSUS REAL GROSS FINAL DOMESTIC DEMAND
(Trillions of 1972 Dollars)



Source: Wharton Econometric Forecasting Associates
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RESEARCH NEWSLETTER

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BIPOLAR PROM MARKET OVERVIEW

SUMMARY

DATAQUEST estimates that bipolar PROM revenues in 1984 totaled $441 million, and that in 1989 the market size will be $417 million. We estimate that U.S. vendors had 85 percent of the market share in 1984, Japanese companies had 14 percent, and European companies had 1 percent. Signetics was the leader of the participating vendors, with AMD close behind. DATAQUEST expects the market size to peak in 1988 and begin a slow decline thereafter, primarily due to the encroachment of competing MOS devices.

The biggest end market for bipolar PROMs is data processing; more than half of all PROMs went into that market in 1984. Government and military markets consumed 30 percent of all PROMs sold in 1984, with the percentage into this market expected to continue to increase to 1989. Currently, the biggest applications for PROMs are control store and programmable logic.

BIPOLAR PROM REVENUES

Table 1 shows bipolar PROM market revenues by density from 1980 to 1984, and estimated revenues for 1985 through 1989. ECL PROMs and registered PROMs are included in these numbers, as well as bipolar ROMs, which is currently a market of no more than $3 million to $4 million.

The total market in 1984, although it grew 41 percent over 1983, was still only 6 percent greater than the 1980 market. Although the market showed some year-to-year fluctuations, it remained essentially flat. (By comparison, the MOS read-only memory market in 1984 is estimated to have been 96 percent higher than the 1980 market.) In 1985, the bipolar PROM market is expected to drop more than 27 percent from its 1984 levels. (The MOS memory market was down approximately 40 percent in 1985 compared with 1984, but this reflects short-term cyclical adjustments. The CAGR for the MOS memory market is expected to be 30 percent between 1985 and 1990.)

Table 1

ESTIMATED BIPOLAR PROM REVENUES BY DENSITY
(Millions of Dollars)

Density	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
256	$ 24	$ 17	$ 12	$ 11	$ 13	$ 12	$ 12	$ 11	$ 11	$ 10
1K	53	42	29	27	32	27	25	23	22	16
2K	91	69	48	44	53	36	32	30	27	20
4K	110	98	67	57	72	46	45	43	40	28
8K	125	115	95	84	110	78	77	75	72	65
16K	14	24	41	78	122	86	105	125	116	94
32K	0	0	3	10	27	20	40	60	73	69
64K	0	0	0	1	12	15	30	46	62	80
128K	0	0	0	0	0	0	3	8	20	35
Total	$417	$365	$295	$312	$441	$320	$369	$421	$443	$417
Percent Change from Previous Year	0.0	(12.5)	(19.2)	6.0	41.3	(27.4)	15.3	14.0	5.2	(5.9)

Source: DATAQUEST
December 1985

Market Outlook

DATAQUEST does not expect to see significant growth in the bipolar market past 1988 or 1989. Revenues in 1988 are expected to be $443 million, and subsequent declines in market size of 2 to 3 percent per year are expected. The 5.9 percent decline between 1988 and 1989 is partially due to this gradual 2 to 3 percent shrinkage of the PROM market, caused by the encroachment of competing devices. Also contributing to this drop is an expected recession and pricing decline in 1989.

It is anticipated that demand will continue to be very close to present levels for at least the next four to five years, but that new PROM use will not counteract the decline due to shifts to alternative technologies.

Market Characteristics

The bipolar PROM revenue mix seen in Table 1 reflects some of the characteristics of this market. It is interesting to note that the lower-density parts seem to survive here much longer than they do in many other memory markets. Lower-density parts (256-bit, 1K, 2K, and to a certain extent, 4K) are used almost excusively as logic replacement.

Because of this, the shift to higher-density parts does not progress in an inevitable, stepwise fashion. Most logic functions that require high speed and can use PROMs effectively require only a few Kbits or less. The market sizes of the 256-bit, 1K, and 2K devices have remained fairly strong; we expect this to continue to 1989. There is also some price stability associated with the lower densities, especially as some vendors decide to drop out of that market because of low volumes and low ASPs. Thus, we believe that these lower-density markets will stabilize at some point and will continue to coexist with the developing higher-density markets, which are actually being used in memory applications rather than as logic.

Revenues associated with the higher-density parts reflect higher ASPs and lower unit volumes than those associated with the lower densities. The normally higher ASPs of the larger parts are strengthened by the fact that the military uses a proportionally greater percentage of the higher-density devices than they do the lower ones. There are some applications in which the military market requires large amounts of memory. In addition, military users will buy high-density devices when they are new and the ASPs are still very high, while commercial customers are not as willing to do so. This, combined with the normal phenomenon of military ASPs being three to four times the level of commercial ASPs, tends to elevate the average ASPs of the higher-density parts.

LONG-TERM OUTLOOK

Bipolar PROMs are the highest-performing and fastest nonvolatile memory device, which is the main reason for their survival in a market that is dominated by lower-powered, less expensive, but slower MOS devices.

However, the bipolar PROM market is not growing at the tremendous rates that make the MOS memory market so attractive. In fact, DATAQUEST estimates that the market for bipolar PROMs will peak in 1988. For this reason, it is particularly important to understand the end markets and applications of these devices, if one is to maintain a competitive position in this arena.

Replacement Issues

The applications in which PROMs have traditionally been used are expected to continue to increase in number and size, but the role of bipolar PROMs in the high-performance memory market is being challenged by high-performance, high-speed CMOS PROMs, EPROMs, and EEPROMs, as well as by fast static RAMs.

Unlike the ECL RAM market, where bipolar parts have a significant advantage over MOS devices in terms of speed, CMOS PROMs and EPROMs can already match the best performances of bipolar PROMs at some densities. Cypress Semiconductor offers 4K, 8K, and 16K CMOS PROMs at speeds that are as fast as or faster than bipolar speeds, with power savings as well. The potential for replacement of slower PROMs with CMOS devices is fairly great, and in some cases, fast PROMs will probably also be replaced. There may be replacement of fast parts with slower MOS devices in situations where speed is not as important as power and price.

The extent and rate of this displacement will depend upon several factors. The development of performance and speed of the MOS technologies, as well as reliability and production capability issues are critical. The requirements of the application for the relative advantages of bipolar versus CMOS devices is a consideration, as is price. Also important is the rate at which existing bipolar technologies are advanced to improve the performance specifications of competing bipolar parts. The new CMOS parts take advantage of new technologies and larger die sizes to achieve high speeds, while existing bipolar parts are generally older designs that use older technology. The argument can be made that all things being equal, bipolar can still outperform CMOS. This may be true, but within the industry, the tide seems to be turning toward CMOS. The start-ups are focusing on CMOS, and most R&D dollars are going in that direction. It is certainly possible for bipolar to be improved so that it can beat CMOS, but the industry does not seem to be doing that yet.

Replacement Barriers

Since bipolar PROMs were on the market before many other device types became available, they are designed into many applications and pieces of equipment where newer devices would work just as well. In many of these cases, the barrier to replacement of PROMs is inertia. With the next generation of end equipment and with the increasing use of MOS alternatives to PROMs, there will probably be some replacement of PROMs by the competing MOS devices once the MOS devices become price competitive. Wafer Scale Integration has recently introduced a 64K CMOS RPROM (reprogrammable read-only memory) that runs at 70ns and has significant power savings over bipolar devices. This part is aimed at the portion of the market that does not need sub-50ns speeds and that can benefit from the power savings and CMOS I/O levels. (An example would be parts used with high-speed, 32-bit MOS microprocessors.)

In the military marketplace, an additional barrier to replacement of PROMs is the question of qualifying parts. If a user wishes to replace a PROM with a MOS PROM, EPROM, EEPROM or fast SRAM, or even with a new bipolar PROM, the parts have to go through quals at the user location. Unless large numbers of parts are involved, it may be less expensive to continue using the current part even though a new device price may actually be lower, because the cost of qualifying the parts increases the total cost. Qualifying parts can also be a very long procedure, which may slow the replacement process even further.

Since PROMs and most replacement parts are programmable, before a user can begin using CMOS PROMs he or she must set up the programming device or system to program them. In many cases, if a user has a PROM programmer it takes only a software update to enable the device to program CMOS parts. The alternative for small companies, which might not own PROM programmers, is to buy PROMs from distributors in order to get the programming services that distributors offer. DATAQUEST estimates that about 25 to 30 percent of bipolar PROMs are sold through distributors.

Bipolar PROM Viability

It is apparent that the applications for PROMs are not going away. This newsletter addresses the bipolar read-only memory market, but eventually DATAQUEST will look at high-performance, nonvolatile memories and consider some MOS and bipolar devices as parts of the same market, forecasting the actual shifts in consumption among the various devices. This newsletter examines the trends in the market in terms of shifts to MOS, and the competitive advantages and disadvantages of the various devices participating.

There are other areas of bipolar PROM use where the end equipment requires radiation hardness or other characteristics in which bipolar devices still have an advantage. In these cases, the bipolar PROM will probably continue to dominate, since MOS devices cannot duplicate the radiation hardness and other advantages of bipolar devices.

MARKET SHARE ESTIMATES

Table 2 gives DATAQUEST's estimates of bipolar PROM market shares by company. Between 1983 and 1984, U.S. companies' market share went from 83 percent to 85 percent, the Japanese companies' share went from 16 percent to 14 percent (most of it sold in Japan), and Europe had 1 percent of the market in each year.

U.S. manufacturers have always dominated the PROM market. The Japanese entered the memory market much later than the U.S. vendors. When they did enter, they placed much of their emphasis on the emerging MOS memory market where they could use their processing capabilities, and limited their initial bipolar involvement to ECL memories, which have higher performance and fit better with their internal system demands. Signetics is currently the biggest PROM supplier, with Advanced Micro Devices (AMD) close behind. The highest-density device available today is 64K, but 128K devices should be available by next year.

Intel announced in 1982 that it was withdrawing from the bipolar PROM market, and Harris made a similar announcement this year. Both moves were reported to be part of strategies to focus these companies toward CMOS technologies.

Table 2

ESTIMATED BIPOLAR PROM MARKET SHARES
(Millions of Dollars)

Company	1983	1984
Advanced Micro Devices	$ 44	$ 88
Fairchild	10	13
Harris	36	44
Intel	2	0
Monolithic Memories	28	46
Motorola	8	13
National Semiconductor	12	21
Raytheon	6	10
Signetics	80	93
Texas Instruments	33	46
Total U.S.	$259	$374
Fujitsu	$ 30	$ 45
NEC	16	14
Other Japan	3	3
Total Japan	$ 49	$ 62
Europe	$ 4	$ 5
Worldwide Total	$312	$441

Source: DATAQUEST
December 1985

CONSUMPTION BY REGION

Bipolar PROM consumption by region is summarized in Table 3. The U.S. market was the largest market in 1984, consuming 55 percent of all PROM dollars. Europe consumed 23 percent, and approximately 20 percent of PROMs went into Japan. The remaining 2 percent was sold into Asia-Pacific and Rest of World (ROW).

These percentages may shift somewhat as MOS devices move into the PROM market and initially displace those parts in less performance-oriented applications. As a result, the somewhat less-vulnerable U.S. military market, the telecom market, and high-end computer applications are expected to increase as a percentage of the total over time, and consequently, the U.S. market may increase as a percentage of the total. Consumption in Asia-Pacific and ROW will probably not increase significantly over the next five years.

Table 3

ESTIMATED REGIONAL BIPOLAR PROM MARKET CONSUMPTION
(Millions of Dollars)

Region	1980	1981	1982	1983	1984	1985	1989
United States	$247	$203	$134	$142	$243	$141	$198
Japan	73	70	77	80	91	83	92
Europe	95	89	81	85	100	90	115
Asia-Pacific	2	3	3	4	6	5	9
Rest of World	0	0	0	1	1	1	3
Total	$417	$365	$295	$312	$441	$320	$417

Source: DATAQUEST
December 1985

END USES AND APPLICATIONS

Tables 4 and 5 show the estimated distribution of bipolar PROMs into the end-use markets and into various applications.

More than half of PROM dollars currently go into the data processing market, where the largest applications are control store and microprogramming. Fast static RAMs, and to some extent EEPROMs, are increasingly being used for writable control store, replacing PROMs used in control store applications. DATAQUEST estimates that the percentage of PROMs used in control store applications will decline between 1984 and 1989. However, microprogramming is forecast to increase as a percentage of PROM use.

A large application in the military market is look-up tables, an application that will probably grow over time as the military becomes a larger percentage of the total market. There will, however, probably be some countereffect from the encroachment of high-speed EPROMs and EEPROMs.

Telecommunications is a growing application for PROMs. This market demands high-speed, high-performance parts, and the ruggedness of bipolar is appreciated in the equipment environments. There is a possibility of some MOS encroachment here as well, especially in portables where low power is a great advantage.

Table 4

ESTIMATED BIPOLAR PROM END-USE MARKETS
(Percent of Dollars)

Market	1980	1984	1985	1989
Government/Military	28%	30%	34%	35%
Consumer	2	0	0	0
EDP	54	52	47	42
Telecom	5	8	10	13
Industrial	3	4	5	8
Automotive	8	6	4	2
Total	100%	100%	100%	100%

Table 5

ESTIMATED BIPOLAR PROM END USE BY APPLICATION
(Percent of Dollars)

Application	1980	1984	1985	1989
Control Store	41%	36%	35%	26%
Programmable Logic Element	33	30	28	27
Look-Up Table/Data Store	17	19	19	21
Microprogramming	5	10	12	18
Other	4	5	6	8
Total	100%	100%	100%	100%

Source: DATAQUEST
December 1985

Industrial applications are a fairly small percentage of the total, but here again, the ruggedness of bipolar provides an advantage over MOS. We expect this market to double over the next five years as a percentage of total bipolar PROM use.

To a large extent, the automotive industry has shifted away from PROMs. Traditionally, MOS ROMs, rather than PROMs, have been used for microcode storage. PROMs were programmed to allow communication between a particular automobile and engine type and a generalized processing system within the automobile. There has not been a real replacement of PROMs in that application with alternate devices, but rather a move to an alternative design system that does not require the communication link that the PROM provided. The PROMs that go into the automotive industry now are generally used as peripheral logic elements.

PROMs used as logic replacements probably account for 28 percent of PROM dollars in 1985, and an even greater percentage of units, since primarily low-density devices are used. Speed is very important in this application. It is unlikely that these parts will be replaced with programmable logic devices. The architecture of the PROM is such that a PLD would not be a satisfactory replacement for a PROM in a logic application. In fact, the percentage of PROM units used in programmable logic applications will probably increase by 5 to 10 percent in the next five years, although the percentage of dollars will be declining.

SPEED REQUIREMENTS OF THE MARKET

In applications where speed is critical, bipolar memories have traditionally been the device of choice. In the ECL RAM arena, this is still true and is being reinforced as time goes on, since the gap between CMOS and ECL speeds is still very significant. In the bipolar nonvolatile memory market, however, the gap is very definitely narrowing. Cypress Semiconductor offers 8K CMOS PROMs with access times of 30ns in commercial applications. It also offers a registered 8K CMOS PROM with a 15ns clock to output time. The power consumption of these devices is less than that of bipolar PROMs, although much higher than traditional CMOS devices, and the speeds are equal to or better than bipolar PROM speeds. While very new to the marketplace, such devices can potentially threaten even the very fastest PROM applications. This is a real concern for the manufacturers of the bipolar parts, especially given that there is some question as to how much of the existing bipolar PROM market is actually speed critical. Telecom and military applications tend to require high speed, as do the high-end computer markets. But some existing applications might be able to use slower parts.

The PROM market exists today because users need the speed and performance that they get from bipolar devices. The areas where PROMs will continue to survive will be those applications in which PROM performance outweighs the power and cost advantages of MOS devices.

ECL PROMS

The vast majority of bipolar PROMs are made with Schottky TTL I/Os. The ECL I/O PROMs currently available are all small densities, and can have access times as low as 12 to 15ns. Motorola offers 256-bit and 1K devices, Signetics has 256-bit, 1K, and 2K ECL PROMs, and Fairchild has several devices at the 1K density. These parts are primarily used as logic replacements in ECL mainframe and superminicomputer systems, where a small amount of very fast logic is needed. Some parts also go into the military marketplace. Larger ECL PROMs could be used in ECL machines for other applications, such as control store. This market is developing slowly. DATAQUEST estimates that the market size went from $4 million in 1980 to $8 million in 1984. The 1985 market is expected to be about $8 million, and by 1990, the market could be as big as $15 million to $20 million, depending on what the existing manufacturers and new entrants do in terms of developing it.

REGISTERED AND DIAGNOSTIC PROMS

Registered PROMs can provide significant speed advantages in systems where data is retrieved in a known sequence and is temporarily stored in a register. The register to output time in these devices can be less than half the access time of a standard PROM. This provides a significant speed advantage. In addition to having access times faster than standard PROMs, the access time is faster than that of a standard PROM plus register chip. When an external register is used, the communication link between the two chips can slow the access time for that combination, decreasing the speed advantage somewhat. Pipelining is the most common application in which registered PROMs are advantageous. Registered PROMs also save board space and power when compared with a standard PROM plus register. The registered PROM market is expected to grow significantly in the next five years.

Diagnostic PROMs are designed with shadow registers that have separate input and output lines. These separate lines can be loaded with diagnostic routines independent of the standard register. It is also possible to move data back and forth between the shadow registers and standard registers.

The advantage of these devices is that they greatly simplify system testing. However, designing a diagnostic PROM into a system involves some additional software and complicates the design process for the design engineer. Once the diagnostic PROM is designed in, it saves time and effort for the test engineer, but it does nothing to help the designer. The designer, who must do extra work to use the part, does not benefit directly from the new design, so there is no real incentive to use it. Therefore, the success of diagnostic PROMs is not certain.

AMD and Monolithic Memories are the major suppliers of registered and diagnostic PROMs today. DATAQUEST estimates that the registered and diagnostic PROM market went from $6 million in 1980 to $35 million in 1985. This market may be as big as $100 million by 1989, although more conservative estimates would be $60 million to $80 million. There will most likely continue to be new entrants and continuing process improvements in this market, since the potential for selling these parts into the high-performance market is quite substantial.

OUTLOOK

The PROM market is vulnerable to the onslaught of high-speed CMOS. There are already CMOS PROMs that can beat the speeds of many existing PROMs. However, PROMs are entrenched in many markets, including the U.S. military, and change is often slower than suppliers envision. Bipolar PROMs will probably persist for quite a while even without any dramatic revolutions in bipolar technology. But to prolong the life of the technology, and especially to allow for growth in the bipolar end of the nonvolatile memory market, research and improvements would be needed.

The short-term outlook is that PROMs will continue to give up market share to MOS devices, and within the bipolar PROMs market, shifts will be more dependent on encroachment from outside than from dramatic changes in the end markets.

Susan Scibetta

Nielsen Dataquest RESEARCH NEWSLETTER

SIS Code: 1984-1985 Newsletters: December

GATE ARRAY IMPACT ON THE ASIC MARKETPLACE

This newsletter covers the highlights of the Gate Array service section in the Semiconductor Industry Service (SIS) Products and Markets notebook.

OVERVIEW

The predominant message of the gate array marketplace is that everything happening is covered by one word--service. The phenomenal growth of gate arrays is in one way or another related to service. For instance:

- Merchant and captive suppliers must provide service.
- The competition must offer more service than their peers.
- Electronic design automation (EDA) provides service at a lower cost.
- Users measure the amount of service they receive from suppliers.

Each individual company must address the market by asking how it can provide its customers with the most cost-effective service.

DATAQUEST believes that service revenues can be substantial and include high margins. The successful companies in this business will make money on service. In the long run, it will not be possible to provide the service the market desires unless it is profitable. We believe that the users are willing to pay.

From its very modest beginnings in 1979, the gate array market grew at a compound annual growth rate (CAGR) of 66 percent through 1983. The MOS portion grew at a 78 percent CAGR and the bipolar portion at a 55 percent CAGR. But the most spectacular growth is yet to come. DATAQUEST believes that this market will reach $2.5 billion to

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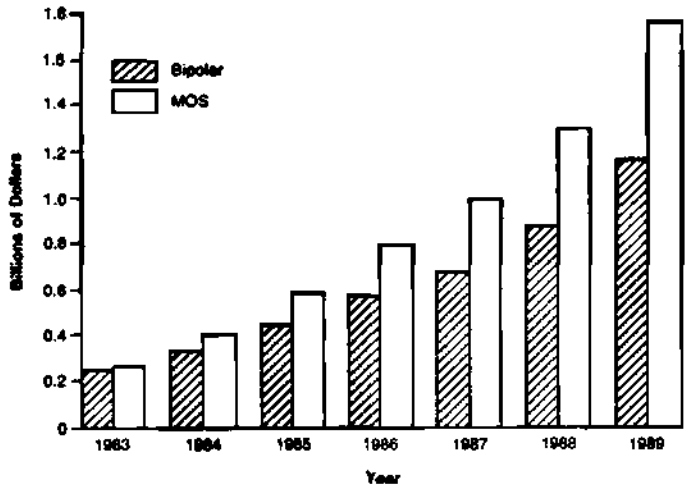
$3.5 billion by the end of the decade. The overall growth of the gate array market from 1983 through 1989 is illustrated in Figure 1.

Figure 1

ESTIMATED WORLDWIDE GATE ARRAY CONSUMPTION



Source: DATAQUEST
December 1984

TRENDS

Applications

Of all the ASIC product families, gate arrays are having the most comprehensive impact on the $184 billion electronic equipment industry. They offer a system manufacturer:

- Lower manufacturing costs through savings in assembly costs
- Lower power consumption
- Higher system reliability
- Design security
- Shorter time to market
- Low-cost incremental features

Supplier-User Interface

Gate arrays offer different expectations for suppliers and users. Both parties would like to have a standard product with the flexibility of gate arrays. The following items outline the different wants of both parties.

- User wants
  - Quick delivery of the prototype units
  - Easy-to-use EDA tools that require a minimum amount of time to learn
  - Prototype units that work the first time
  - Low development and production costs
  - Convenient design centers and training
- Supplier wants
  - Minimum user involvement
  - Maximum production volumes
  - Few design changes

The availability of friendlier EDA tools is resolving some of the differing expectations. It is also the driving force behind the 50 percent per year growth rate in the EDA marketplace.

Alternate Sourcing

DATAQUEST believes that there will be a constant stream of alternate-source agreements over the next three years. With more than 80 companies actively engaged in the gate array market, and with no dominant supplier, the need for a real alternate source will grow in importance. Unfortunately, there are real alternate sources and there are alternate sources that exist in name only.

TECHNOLOGY

Future Prospects

The gate array business has changed rapidly over the last three years. Products, technologies, and vendors have all mushroomed. Major portions of the user community have adopted gate arrays, while others are still wondering how serious and how real all of these new concepts are. Table 1 summarizes the three major technologies in terms of cost, speed, and power.

Table 1

GATE ARRAY TECHNOLOGY COMPARISON

Process Technology	Cost per Gate	Speed (MHz)	Power (Watts)
CMOS	$0.015 to $0.045	10 to 80	0.01 to 0.1
TTL	$0.02 to $0.05	30 to 150	0.1 to 1.5
ECL	$0.03 to $0.10	100 to 250	2 to 10

Source: DATAQUEST
December 1984

The MOS segment is expected to be the dominant technology, with more than 60 percent of the market by 1990. We believe that this rapid growth will fuel the following major trends:

- Merchant gate array suppliers will surpass the captive suppliers by adding design centers and other service-related features to their product lines.

- Captive suppliers will continue to grow and many will become merchant suppliers. For example, VTC Inc. recently became the merchant arm of Control Data Corporation's captive semiconductor activity. Other merchant/captive suppliers include: Fujitsu, Hitachi, Honeywell, NEC, Oki Electric, Plessey Ltd., Siemens, and Toshiba.

- The market will take on a worldwide scope:

  - The Japanese will become aggressive suppliers in both Europe and the United States.

  - The European suppliers will dominate the European market, with U.S. and Japanese suppliers taking moderate shares.

- There is currently a significant shift away from standard logic to gate arrays.

- Standard products will be embedded in gate arrays to achieve higher levels of integration.

- The use of third-party EDA workstations in the design process will continue to increase.

All this adds up to a unique set of opportunities and problems. The opportunity is that system manufacturing costs can be lowered considerably if designs are converted to gate arrays. The problem is that conversion is difficult and some companies may find themselves falling behind in the competitive race.

Table 2 shows the 1983 through 1989 forecasts of gate array consumption by region. Table 3 shows the top ten suppliers of gate arrays, who supplied approximately 61 percent of the market in 1983.

Katy Guill
Andy Prophet

Table 2

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

Region	1983	1984	1985	1986	1987	1988	1989
Worldwide Total	513.0	737.5	1,028.9	1,364.6	1,670.7	2,175.5	2,930.9
MOS	259.9	402.3	583.8	794.4	992.8	1,300.1	1,768.6
Bipolar	253.1	335.2	445.1	570.2	677.9	875.4	1,162.3
North American	280.5	384.2	524.6	695.6	802.0	1,000.5	1,345.8
MOS	147.2	203.6	263.9	364.5	441.1	553.3	757.7
Bipolar	133.3	180.6	260.7	331.1	360.9	447.2	588.1
Japanese	101.0	179.1	254.8	380.5	466.2	611.9	794.4
MOS	51.0	99.4	173.3	253.8	309.2	406.2	530.7
Bipolar	50.0	79.7	81.5	126.7	157.0	205.7	263.7
Western Europe	128.0	170.3	241.7	272.8	371.0	500.2	674.4
MOS	58.2	95.4	139.2	162.0	218.9	296.6	404.6
Bipolar	69.8	74.9	102.5	110.8	152.1	203.6	269.8
Rest of World	3.5	3.9	7.8	15.7	31.5	62.9	116.3
MOS	3.5	3.9	7.4	14.1	23.6	44.0	75.6
Bipolar	0.0	0.0	0.4	1.6	7.9	18.9	40.7

Source: DATAQUEST
December 1984

Table 3

ESTIMATED 1983 WORLDWIDE SHIPMENTS
TOP TEN GATE ARRAY COMPANIES
(Millions of Dollars)

Company	1983
Fujitsu	$64.6
Ferranti	$43.4
Texas Instruments	$43.0
LSI Logic	$32.4
NEC Electronics USA	$28.7
Interdesign	$26.2
Motorola	$24.1
Siemens	$18.1
Signetics	$17.9
Toshiba	$14.0

Source: DATAQUEST
December 1984